Natural Sciences Teacher's Guide

Grade 7-A (CAPS)

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basic education
Department:
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Periodic Table of the Elements

No
Element

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 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
55 Cs	56 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 Uuq	115 Uup	116 Uuh	117 Uus	118 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

- Transition Metal
- Metal
- Metalloid
- Non-metal
- Noble Gas
- Lanthanide
- Actinide

Natural Sciences

Grade 7-A

CAPS

developed by

funded by

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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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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:

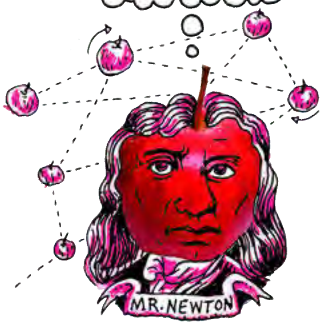
> *"We live in a society absolutely dependent on science and technology, and yet have cleverly arranged things so that almost no one understands science and technology. That's a clear prescription for disaster."*

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 Dysan 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."*

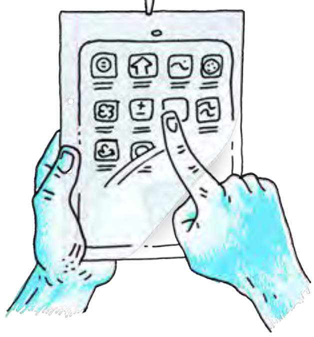
Science is relevant to everyone. Scientific principles, knowledge and skills can be applied in creative and exciting ways to solve problems and advance our world. It is not just a subject restricted to our classrooms, but reaches far beyond, and within. Ultimately, we also want learners to embark on 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."*

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.



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.

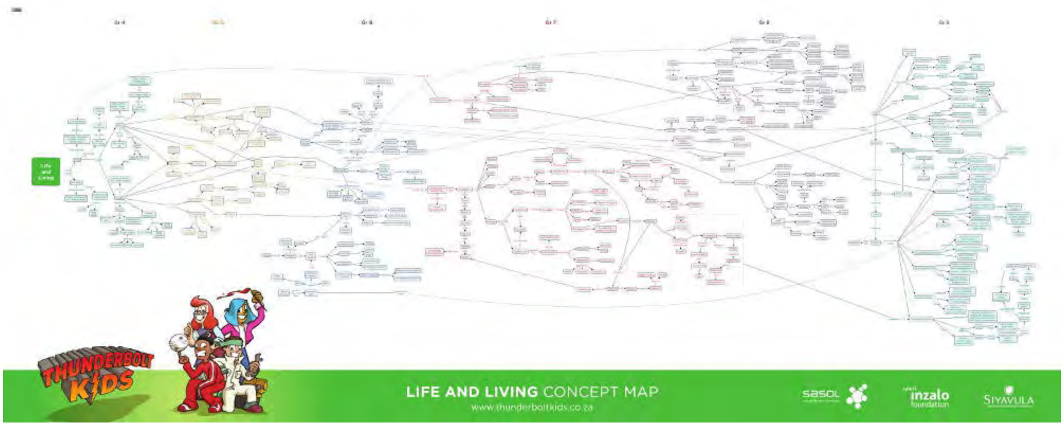
Natural Sciences Knowledge Strands
Life and Living
Matter and Materials
Energy and Change
Planet Earth and Beyond

VISIT

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

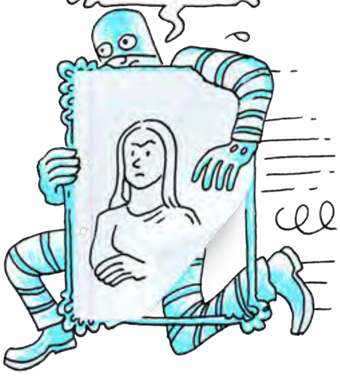
These knowledge strands follow on from Gr 4-6. The strands also link into each other, and these have been pointed out both within the learners' workbook and here in the teachers guide.

We have also produced **concept maps** which show the progression of concepts across the grades, within a strand, and how the 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

You can download the concept maps from our website, or order large printed versions for your classroom, as well as other **posters** to brighten up your classroom.



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 work will cover 9 weeks each with 3 hours (1 week) allocated to assessment within each of these terms
- Terms 2 and 4 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 7. This time allocation is a guideline for how how many weeks should be spent on each topic (chapter).

Life and Living

Chapter	Time allocation
1. The biosphere	1 week
2. Biodiversity	3.5 weeks
3. Sexual reproduction	3.5 weeks
4. Variation	1 week

Matter and Materials

Chapter	Time allocation
1. Properties of metals	2 weeks
2. Separating mixtures	2 weeks
3. Acids, bases and neutrals	2 weeks
4. The Periodic Table of Elements	2 weeks

Energy and Change

Chapter	Time allocation
1. Sources of energy	1 week
2. Potential and kinetic energy	2 weeks
3. Energy transfer: Heat	2 weeks
4. Insulation and energy saving	2 weeks
5. Energy transfer to surroundings	1 week
6. The national electricity supply system	1 week

Planet Earth and Beyond

Chapter	Time allocation
1. Relationship of the Sun to the Earth	4 weeks
2. Relationship of the Moon to the Earth	2 weeks
3. Historical development of astronomy	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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- **Revise** - the right to adapt, adjust, modify, or alter the content itself (for example if you want to modify an activity to suit your learners' needs o translate the content into another language)
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We encourage you to modify and tweak this content to suit your learners and your context. You just need to attribute Siyavula, as is specified in the Creative Commons license.

You can download a soft copy of the source files for these books from our website: `www.curious.org.za`

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:

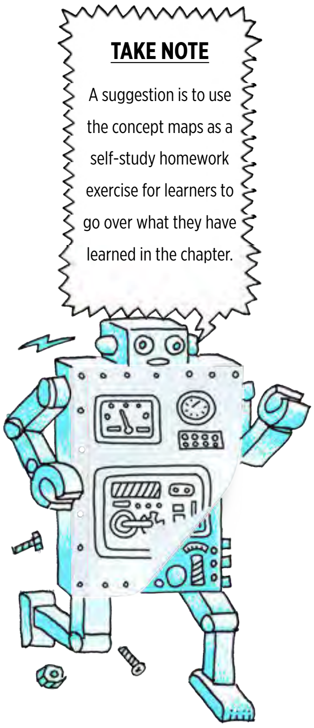
- Energy and Change
- Planet Earth and Beyond

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.

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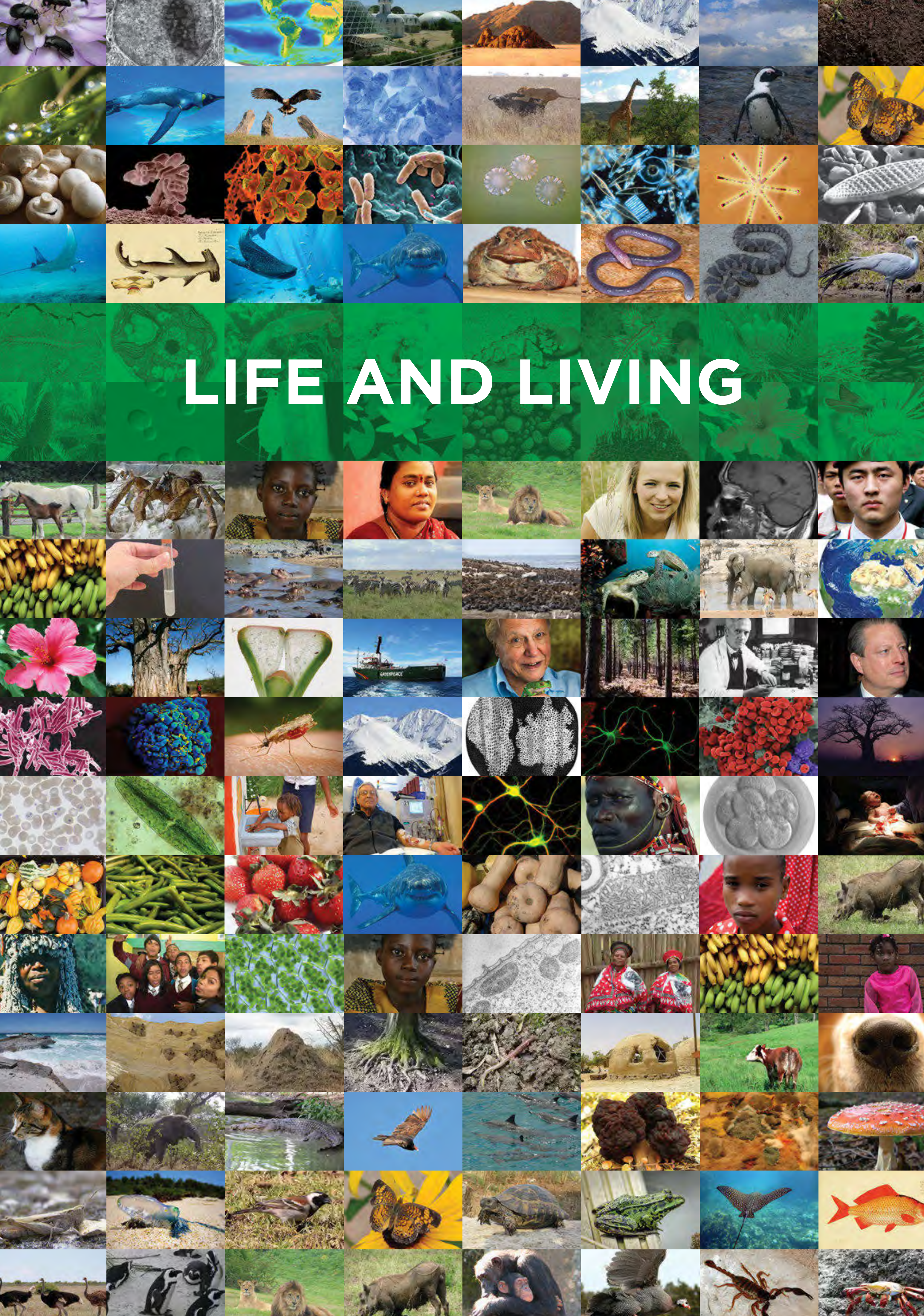
And sign up by following this link bit.ly/15eiA6u. Specify Gr 7-9 Natural Sciences to stay informed about this process going forward in the future.

LIFE AND LIVING



1 The Biosphere

TEACHER'S NOTE

Chapter overview

1 week

In this introduction to the biosphere learners are exposed to the components of the biosphere, namely the lithosphere, hydrosphere and atmosphere, as well as the organisms that live in each of these spheres. Learners are required to identify organisms that are specifically adapted to live in each of these spheres, in different temperatures and at different altitudes, and will learn how and why some organisms have developed specific adaptations to survive. They are then guided to distinguish between living and non-living elements of the biosphere, by identifying the seven life processes (a revision of Gr. 4 work). Having revised the seven life processes, they will then learn what is necessary to continue these seven life processes, by studying the requirements to sustain life and learning about adaptations that enable organisms to live in extreme environments. This links back to work done in Gr. 5 and 6 on the interdependence between living and non-living things in ecosystems and food webs. Learners will look at the biosphere again in Gr. 8 in the context of ecology, as well as in Earth and Beyond in Gr. 9, where there is a greater focus on the lithosphere and atmosphere.

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

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

1.1 What is the Biosphere? (1.5 hours)

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

1.2 Requirements for sustaining life (1.5 hours)

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

KEY QUESTIONS:

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

Let's start exploring the world around us and how it works! Remember that this is your book! You must use it to explore and ask questions about the world around you, and also to learn about yourself and who you are. Do not be afraid to take notes in the margins of this book - make your own scribbles and notes to yourself about points to remember or questions you would like to ask. Be curious! Explore and imagine the possibilities of what you can do with science!

TAKE NOTE

All the 'New words' listed in the boxes in the margin are defined in the glossary at the end of this strand.

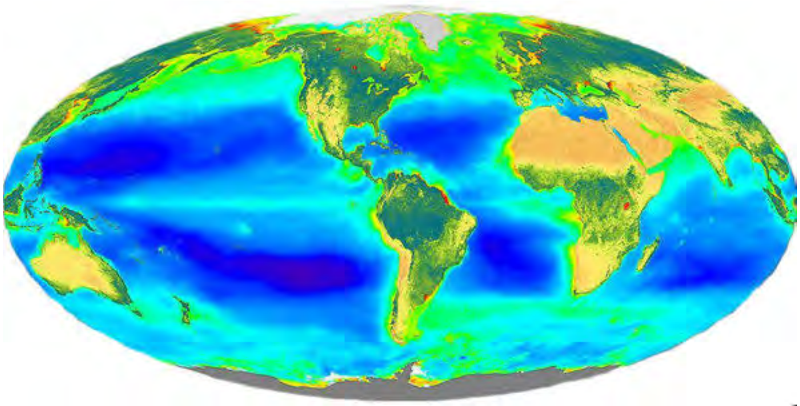
1.1 What is the biosphere?

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, visit: [1] bit.ly/16zEuUf

Have you heard the word 'sphere' before? Do you know what it means? A sphere is normally used when talking about a round shape (like a ball). Now, what do we mean when we talk about the **biosphere**? The prefix 'bio-' indicates something to do with life. For example, 'biology' is the study of living organisms. So, can you put these two meanings together to work out what 'biosphere' means?

The biosphere is the place where life exists on planet Earth. When we talk about the biosphere, we are talking about a huge system (the whole world!) and how all the different parts work together to support life. We will look at these different parts in more detail a bit later.



The biosphere is where life exists on our planet, including the soil and rocks, water and air.

VISIT

Learn more about Biosphere 2, a fascinating ongoing project to maintain a man-made biosphere

bit.ly/18cwCth

We can also use the term biosphere in different ways. When we speak of all life on Earth as it interacts with the non-living rocks and soil, water and air (**atmosphere**), we call this the biosphere.

Biosphere 2 is a man-made research centre in America, in the Arizona desert, where scientists have built a large enclosed artificial biosphere.

We can also call a specific part or region on Earth that supports life, a biosphere, especially when we refer to the living organisms and the **environments** in which they live.

ACTIVITY: Where do you think life exists on Earth?

TEACHER'S NOTE

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

INSTRUCTIONS:

1. The following table contains some photos of different places on Earth. Describe what each photo is showing.
2. Then decide if you think life exists there or not. If you do think so, list some of the organisms which you think live in this place.

A place on Earth	*What is this image showing?*	*Do you think there is life there? If so, what?*
	*A desert with rocks, some mountains and grass.*	*Yes, life exists here.* *Organisms include:* • *snakes* • *birds* • *grasses* • *cacti* • *insects* • *possibly buck, jackal, hares, etc* • *possibly humans (this is actually a photo from Namibia)*
	*A mountain range covered in snow.*	*Yes, life exists here.* *Organisms include:* • *trees (seen at bottom of photo)* • *possibly bears, snow leopards, rabbits, etc.* • *possibly humans*
	*The sky with clouds and some birds.*	*Yes, life exists here.* *Organisms include:* • *birds* • *insects*
	*Soil with grass growing on top.*	*Yes, life exists here.* *Organisms include:* • *plants (grasses and other shrubs)* • *insects* • *earthworms* • *microorganisms*

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.

After doing this activity, did you see that life exists everywhere on Earth? From the highest mountains to the deepest oceans, from the hottest deserts to the thickest jungles, there is life. Did you also notice that when describing the places on Earth where life exists, you used words such as soil, rocks, water, air? These are all part of the biosphere and have special names.

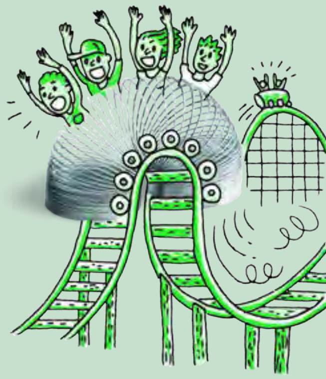
Components of the biosphere

In the previous activity we saw that life can be found in water, soil and rocks or the air around us. These **components** form part of the biosphere and have special names:

- **Lithosphere** which includes the soil and rocks.
- **Hydrosphere** which includes all the water.
- **Atmosphere** which includes all the gases.

The biosphere includes the lithosphere, hydrosphere and atmosphere. The biosphere includes all living organisms, and also dead **organic matter**.

ACTIVITY: Describe the components of the biosphere



INSTRUCTIONS:

1. Study the following photo that shows the components of the biosphere.
2. Identify and describe the elements of the lithosphere, hydrosphere and atmosphere that you can see in the photo.

The lithosphere, hydrosphere and atmosphere on Earth.

QUESTIONS:

1. Lithosphere:
   There are rocks. They are hard, sharp, porous in places, eroded by water. There is sand. It is grainy, rough, contains many small pieces of shell and rocks.
2. Hydrosphere:
   This is the seawater and sea spray. Some learners might mention the water vapour that evaporates from the sea. The water is clear and fast flowing, the sea water tastes salty, the sea foam forms on top.
3. Atmosphere:
   This is the gases. The air includes gases such as oxygen, carbon dioxide and nitrogen. Atmospheric gases are not visible, but the sky looks blue.
4. Even though you cannot see living organisms in this photo, there are many living and dead plants and animals that could live on a beach such as this one. Make about 10 plausible (believable) guesses of the types of organisms which would live in this environment. (Hint: think about what might be living in the sea, sand or air.)
   Learner-dependent answer. Learners should be able to imagine for example dolphins swimming in the water, or snails or mussels on the rocks, seaweed in the water and perhaps microbes in the sand. Other organisms could be: crabs, sea gulls and other birds, many types of fish, sharks and whales out at sea, corals, anemones, etc.

VISIT
A fun infographic about the atmosphere
bit.ly/132W0U0

TEACHER'S NOTE

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

Different organisms can exists in different places in the biosphere. Let's have a look at the different components of the biosphere and which types of organisms exist there.

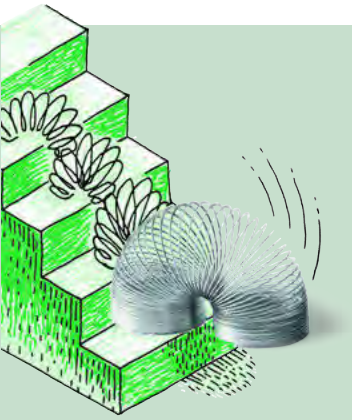
Atmosphere

VISIT

Our atmosphere is escaping!

(video) bit.ly/1beNzVB

The atmosphere is the layer of gases that surrounds the Earth. The three most important gases in the atmosphere are nitrogen, oxygen and carbon dioxide. The atmosphere is made up of several layers.



ACTIVITY: The atmosphere

TEACHER'S NOTE

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

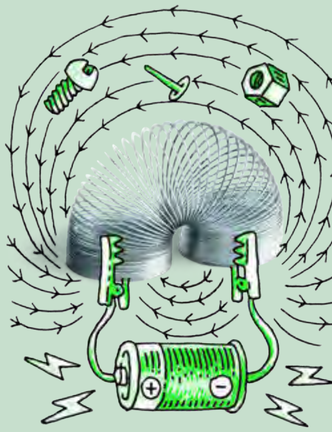
QUESTIONS:

1. Discuss with your partner whether you think organisms could live on Earth without the atmosphere. Explain why you think so.
   This questions is deliberately included to elicit debate. Without the atmosphere life as we know it would not be possible. The oxygen and carbon dioxide in the lower layers of the troposphere (that touches Earth) allow life to exist as organisms can respire and plants can photosynthesise. The atmosphere also helps to keep the Earth warm by trapping solar energy. The atmosphere protects life from too much UV radiation from the Sun. Earth is the only planet in our solar system that can support life, due in part to our atmosphere.

Hydrosphere

The hydrosphere consists of all water on Earth in all its forms.

ACTIVITY: The water cycle

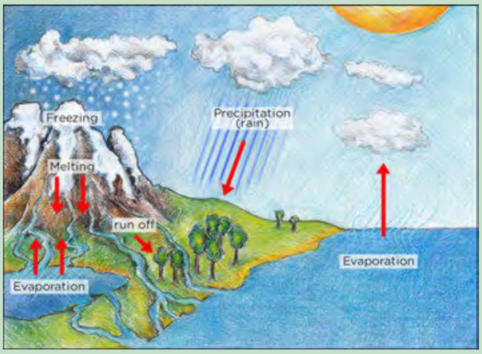


TEACHER'S NOTE

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

INSTRUCTIONS:

1. Study the following diagram describing the water cycle on Earth.
2. Answer the questions that follow.



TAKE NOTE

The word 'aquatic' is used to describe something to do with water. Therefore aquatic animals are animals that live in or near water. The word 'marine' describes organisms that live in saltwater or the sea. So someone studying the organisms in the sea is called a marine biologist.

QUESTIONS:

1. Do you remember learning about the different states of matter? The hydrosphere includes all water in all the states of matter. Look at the diagram of the water cycle and identify water in the different states of matter.
   Water is a liquid in the sea, dams, river, rain and dew.
   Water is a solid as snow on the mountains (or in hail).
   Water is a gas as water vapour in the air.
2. The water cycle shows different sources of freshwater and saltwater. Many plants, animals and microorganisms have adapted to live in an aquatic habitat. A very small percentage of the world's water sources are freshwater and the rest is saltwater. Write down as many different types of aquatic habitats that you can think of where different organisms exist.
   Aquatic habitats include: rivers, dams, lakes, ponds, marshes, estuaries, groundwater and aquifers. There are many different aquatic habitats in the sea, such as rocky shorelines and rock pools, deep water and polar ice caps.

Lithosphere

As we have said, the lithosphere includes the rocks, soil and sand on Earth. Organisms **depend** on the lithosphere in many different ways. We find out how in the next activity.

TEACHER'S NOTE

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

ACTIVITY: How do organisms depend on the lithosphere?

INSTRUCTIONS:

1. Below are several photos depicting different ways that organisms depend on and interact with the lithosphere.
2. Use these images to write a paragraph about how different organisms depend on the lithosphere in different ways.

Bird nests

A rock pool

A termite mound

A tree growing in the ground

TEACHER'S NOTE

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

An earthworm in soil

A mud hut

TEACHER'S NOTE

Some of the things which learners could note are:

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

We have now looked at the different parts of the biosphere and seen that there are many different types of organisms that exist. Each of the organisms that we have seen so far needs to be able to stay alive in those specific conditions. We say they need to **adapt** to live in their particular habitat. What does it mean to stay alive though?

Characteristics of living plants and animals

TEACHER'S NOTE

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

VISIT

Video about the seven life processes bit.ly/1cxrrZT

There are seven processes that all living organisms perform that determine whether they are alive or not. Let's have a look at the seven life processes:

1. All living things need to be able to **move**. Moving does not have to consist of big movements. Even plants move, for example as the flowers and leaves turn to face the sun during the course of the day.
   Learners may wonder about certain animals that don't move (are sessile) such as anemones, barnacles and corals. Usually these animals do move during some part of their life cycle and are sessile or stationary for the adult phase. In addition, even animals that stay in one spot can still moves parts of their body, such as barnacles which have feathery appendages which beat the water and bring food into the shell.
2. All living things need energy to perform the life processes. Organisms release energy from their food by a process called **cellular respiration**.
3. All living things need to be **sensitive** to their environment. Think of an example of why animals need to sense their environment and write it down below.
   For example, animals need to sense food and be able to find it. They also need to sense danger in their environment or sense temperature changes and respond to them.
4. All living things need to be able to **grow.**
5. All living things need to be able to **reproduce** so that they do not die out.
6. All living things need to be able to **excrete** waste.
7. All living things need **nutrition,** as they need to break down nutrients during cellular respiration to release energy.

TAKE NOTE

We will learn more about reproduction a bit later in Chapter 3.

Now that we can determine whether something is living or not, we can take a look at what living things need to survive. In other words, what are the requirements for life?

1.2 Requirements for sustaining life

After studying the seven life processes, we now know what animals, plants and other living organisms need to *do* in order to be classified as living. In order to stay alive these living organisms **require** (need) certain things or specific conditions. In this section we are going to study the requirements necessary to **sustain** life.

ACTIVITY: Identify the requirements for sustaining life

Imagine that you are the design team for the first International Moon Space Station, similar to the International Space Station already orbiting Earth, but situated on the Moon!

TEACHER'S NOTE

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

The international space station that orbits Earth, seen from above.

INSTRUCTIONS:

1. Work in groups of four.
2. What do you think the astronauts and plants living on the new Moon Station will need in order to live? Discuss the five most important requirements that you need to provide in order for the astronauts and plants to remain alive on your Moon Space Station.
3. Explain why your group chose these five requirements as the most important to sustain life. Write down your notes from your group discussion on the lines provided. Decide which member of your group is going to report back your findings to the rest of the class.
4. Have a class discussion after you have finished discussing this in your group.

   Learner-dependent answer

VISIT

Find out more about life on the International Space Station as astronauts perform their everyday tasks. bit.ly/178CXVe or bit.ly/1cfDcF7

TEACHER'S NOTE

When groups are finished discussing their most important requirements, let groups share their lists with the other groups and have a class discussion. List their answers on the board and make a tick for each one that is repeated - for example Food/ Oxygen/ Water might be repeated so each time it repeats make a tick next to it. This way they will quickly be able to see which requirements are most commonly repeated in the class. Learners might identify 'Food' rather than energy. Remind them that they also have to think about the plants which do not need to eat food. So ask the learners what term they could use as a more general term for food? This links back to nutrition in the seven life processes. The answer is that living things need a source of energy. If learners do not come up with the fact that living things need 'favourable/good/optimal temperatures', ask them some leading questions such as: 'Do you think the space station needs to be heated or cooled? Why? Will the humans and plants be able to survive at the temperature it is on the Moon? ' etc.

Living organisms require certain conditions or things to be able to stay alive. We say that these things or conditions sustain life.

You would have discussed some of these requirements in the last activity. Did you come up with the same or similar requirements? Living organisms require the following to survive:

- energy
- gases
- water
- soil
- favourable temperatures

VISIT

Learn more about the seven life processes bit.ly/16Cj2jz

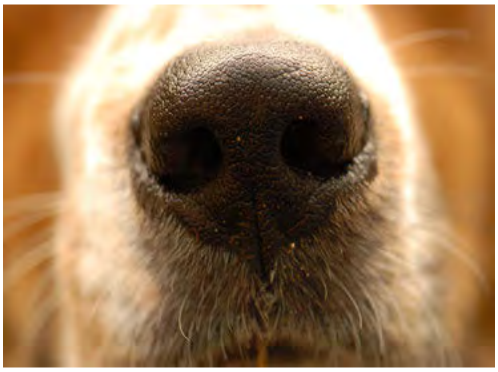
Next, we look at these in a bit more detail.

Energy: All living organisms need energy to stay alive and perform the life processes. Plants need energy from sunlight in order to photosynthesise. Other organisms get their energy from the food that they eat.

TAKE NOTE

'Sustain' means to keep things alive or in existence. We also use the word sustainable when we want to say that something can continue or be continued for a long time.

All living things need a source of energy. The grass and trees get their energy from the Sun to photosynthesise. The cow gets its energy by eating the grass.



All living things need oxygen to respire, such as this dog which is breathing air in through its nose.

Gases: All living things require oxygen for cellular respiration. Oxygen is used to release energy from nutrients and carbon dioxide and water is produced as a waste product of respiration. Green plants also need carbon dioxide to photosynthesise.

TEACHER'S NOTE

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

Water is vital to life. Every organism on our planet needs water to live.

Water is vital for life on Earth.

Most plants need soil to grow in.

Soil sustains life on Earth. Most plants depend on soil for support, minerals and water. Without the soil, plants would not be able to produce the food that animals and other organisms depend on.

Favourable temperatures: All organisms are adapted to live in a particular temperature. In general, our planet has favourable temperatures to support life. Earth is at an optimal distance from the sun so that it is not too hot, like on Mercury, and not too cold, like on Neptune.

TAKE NOTE

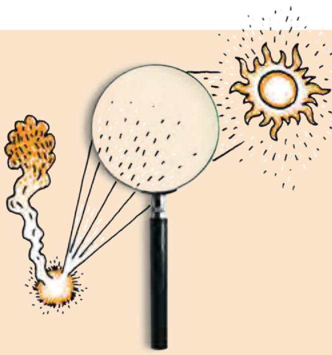
In Life Sciences, when we use the word 'favourable' we mean something that is advantageous, helpful, or optimal. For example, we can talk about favourable conditions for life.

Let's find out what the requirements are to grow seedlings. We will learn how to conduct a scientific investigation to do this.

TEACHER'S NOTE

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

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



TEACHER'S NOTE

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

In this investigation, we are going to germinate bean seeds (or any other seeds that your teacher provides you with). Each group in the class is going to be testing a different requirement for germination and growth of the seedling.

AIM:

A scientific investigation always has an aim or question that needs to be answered. What is the aim of this investigation? Write down what you aim to find out.

TEACHER'S NOTE

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

HYPOTHESIS:

A hypothesis is where you propose (suggest) what the outcome of the investigation will be. It is a prediction of what the results will be. Write a hypothesis for this investigation.

TEACHER'S NOTE

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

VARIABLES:

Scientists often use investigations to search for cause and effect relationships. This means that they design experiments to investigate how changes to one part will cause an effect on another. These changing quantities are called **variables**. There are usually three kinds of variables:

1. **Independent variables:** This is the thing that you are changing in the investigation. You are in control of the independent variable. For example, if you wanted to investigate if eating a lot of sugar makes you gain weight, then the amount of sugar you eat is the independent variable. You control how much sugar you eat. We want to achieve something called a FAIR TEST which means that only ONE independent variable is changed at one time. Once the independent variable has been changed the scientist then observes what the effect will be. In the example of investigating if sugar makes you gain weight, you cannot at the same time investigate whether exercise makes you lose weight. This would not be a fair test.

2. **Dependent variables:** The dependent variable is the thing that you observe in an investigation. You do not change it. The dependent variable will change depending on the independent variable. For example, in the investigation to see if eating a lot of sugar makes you gain weight, then the dependent variable will be how many kilograms you gain (or lose) as a result of eating sugar. How much weight you gain depends on how much sugar you ate. Dependent variables should be measured in an objective way using numbers as far as possible.

TAKE NOTE

A hypothesis is an educated guess about what the outcome of the investigation will be. The hypothesis is stated before starting the investigation and must be written as a statement and must be in the future tense.

TEACHER'S NOTE

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

3. **Controlled variables:** These are the quantities that a scientist wants to remain the same or unchanged throughout the experiment. The controlled variable needs to be carefully monitored to make sure that it stays the same. In the example to see if sugar makes you gain weight, you could have one person eat a lot of sugar and the other person eat no sugar and then see the changes in weight. There are some things that need to stay the same for both of these people so that it is a fair test. For example, both people must do the same amount of exercise so that this does not influence their weight. This is a controlled variable.

TEACHER'S NOTE

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

You can also do a control test. For example, in this investigation about the growth of plants, you will be taking away one of the requirements for growth. You need to do a control test where another plant is given all the requirements, including the one you took away in the other plant. You can then compare your plant where you took one requirement away to the control plant which has that requirement to see if there is a difference.

TEACHER'S NOTE

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

Identify the variables for this investigation.

1. **Independent variable**. What will you change?
   Learners need to explain that they will only change one factor, i.e. remove light from the plant (by putting it in a dark cupboard) or remove water (by not watering it), while keeping all the other factors constant.
2. **Dependent variable**. What will you measure to see the effect of the independent variable on the germination and growth of the plant?
   Learner-dependent answer
3. **Controlled variables and control group**. What will your control test be and what will you keep the same between the control plant and the tested plant?
   Learners need to explain how they will keep the other factors the same in each case but only change one at a time. It is important that learners understand and reflect on having a control group that has all the necessary factors/requirements to allow it to grow. We suggest that more than one control group be included.

TAKE NOTE

Remember your control group is a special kind of comparison group.

TEACHER'S NOTE

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

METHOD:

In your group, plan how you are going to do the investigation. Think about which requirement you are testing and how you will take this requirement away. For example, if you are looking at light, where could you place the seeds so that they do not receive light? Remember, if you are looking at light, then you need to make sure the control and test seeds both receive the same amount of water. Once you have planned the investigation on rough paper and discussed it with your teacher, write up the method below (in numbered steps) explaining what you will do.

TEACHER'S NOTE

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

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

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

MATERIALS AND APPARATUS:

Write a list of all the materials and apparatus that you will be using in this investigation.

Learner-dependent answer

RESULTS AND OBSERVATIONS:

Use this space to record the results for your investigation. If you are seeing whether plants germinate or not, then you need to draw a table to show this. If you are measuring how much the plants grow, then you will also need a table for this.

TEACHER'S NOTE

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

Table to show whether plants germinated or not

Requirement being tested	Did test plants germinate?	Did control plants germinate?
Light	Some did.	Yes
Water	No	Yes
Favourable temperature	No	Yes

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

Table to show growth of seedlings over time in light and in dark

Day	Average height of seedlings in dark (mm)	Average height of seedlings in light (mm)
0	0	0
1	0	2
2	0	5
3	1	10
4	2	15
5	3	22
6	3	30

ANALYSIS:

Once we have collected our results in a scientific investigation, we need to analyse them. This often involves drawing a graph. If you measured the growth of the seedlings over time, then you can draw a line graph to show this. If you have counted the number of seeds that germinated you can express this using a bar chart (provided you used the same number of seeds in each group), or you can express the percentage of seeds that germinated as a pie chart. Your teacher will help you do this.

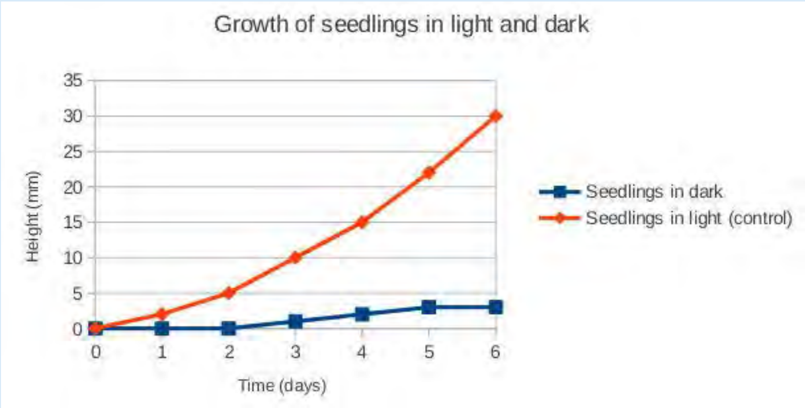
VISIT

Read more about the 'Goldilocks Zone'

bit.ly/13ITCQU and bit.ly/11OIY9R

TEACHER'S NOTE

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



VISIT

Watch a timelapse of bean plants growing.

bit.ly/1467Mlj

CONCLUSION:

After collecting all your results and drawing a graph using these results, you will need to use this to draw a conclusion about the requirements to sustain life in plants. The following questions will guide you in drawing your conclusion.

1. I found out...
   Learner-dependent answer.
2. I know this because...
   Learner-dependent answer.
3. The investigation was fair because...
   Learner-dependent answer.
4. I can trust the results because...
   Learner-dependent answer.
5. While I conducted (did) this investigation I also discovered that...
   Learner-dependent answer.
6. If I did this investigation again I could improve it by...
   Learner-dependent answer.

What did you learn from doing this scientific investigation?

Write 3 to 5 sentences explaining what you learnt from doing this scientific investigation following the scientific method.

Each organism is able to survive and continue to survive in their environment because they have acquired the characteristics that allow them to do things in a special way in their particular environment. We say they have adapted to life in their particular type of environment.

TEACHER'S NOTE

Learning about adaptations is a precursor to an understanding of the concepts of natural selection and evolution which will be introduced later in the term. Make sure that learners understand that organisms cannot will their bodies to change or learn to survive in a particular environment in a single generation (lifetime). These adaptations take place over many generations as a result of natural selection, in which organisms who are better adapted to their environment are more likely to thrive and have lots of off-spring. These offspring will have the genes of the parents, and will inherit the characteristics (adaptations) that made the parents better able to survive. Teachers do not need to go into any detail about natural selection yet, but should make sure that the learners are not under the impression that any organism can 'decide' to acquire an adaptation.

Adapted for life

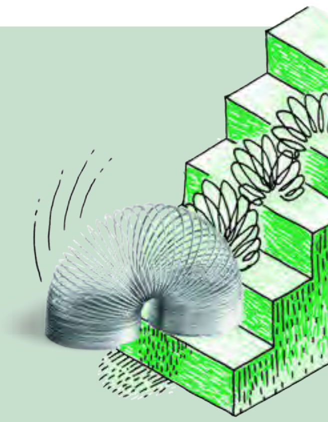
Do you think you could put a polar bear in the Kalahari desert or a gemsbok in Antarctica and they would survive? Why, or why not?

TEACHER'S NOTE

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

These animals are specifically adapted to live in their specific environments. All organisms are adapted to their specific environments. In the next activity we examine some more examples of how organisms are adapted to their environments.

ACTIVITY: Adaptations in organisms



INSTRUCTIONS:

1. Study the photos below showing different organisms in different environments.
2. Answer the questions.
3. You might need to do some extra research in books and on the Internet to complete your answers.

QUESTIONS:

Look at the photos of a penguin in the water and an eagle flying in the air. Both of these are birds, but they live in very different environments that make the penguin adapted for the water and the eagle adapted for flight.

A penguin in the water.

A flying fish eagle about to catch some food.

1. How do you think the penguin is adapted to swim in water? Hint: What are its wings used for? Does it have small or large feathers? How do you think this helps?
   The penguin is adapted to swim in water as it uses its wings as flippers to swim. The feathers are very small/fine which help make it waterproof.

TEACHER'S NOTE

Some additional adaptations to discuss: Penguins are able to hold their breath and dive deep underwater to catch food. Penguins are black and white which helps them to be camouflaged in the water and hide from predators (They look dark like the water from above, and light like the sky from below). Penguins have even adapted to drink salty sea water.

2. How do you think the eagle is adapted to fly and catch its prey? Hint: Look at its feathers and wings.
   Fish eagles have very long wings and long feathers to enable flight and to be able to soar in the air and then swoop down and catch prey.

TEACHER'S NOTE

Some additional adaptations to discuss: They have long talons/claws so that they can catch their food as they swoop down and grab it. They also have large tail feathers that they can fan out to help them control their speed when flying.

South Africa is home to two very skilled predators, the great white shark and the lion. Both of these animals are very skilled at catching their prey, but in very different environments.

3. What characteristics does the shark have that makes it adapted to living and feeding in the sea? Hint: Look at its streamlined body shape and sharp teeth.
The great white shark is adapted to move very fast through the water as its body is streamlined and it has fins and a tail to swim. It has sharp teeth to bite into prey.
4. What characteristics does a lion have that makes it adapted to living and hunting in the savanna? Hint: Look at the colour of its fur and the colour of the grass and its strong limbs.
The lion is a light brown colour so that it is camouflaged in the savanna/bush to sneak up on its prey. It has 4 strong legs with claws to chase and catch prey.

We have now looked at how a few of the animals on Earth are adapted to their environments. There are many, many more organisms with very unique and interesting adaptations. In the next chapter we will learn more about the diversity of plants and animals on Earth.

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 on our website!**

SUMMARY:

Key Concepts

- Life on planet Earth exists in the biosphere.
- The biosphere consists of the lithosphere, hydrosphere and atmosphere, as well as the many living organisms and dead, organic matter.
- Many different kinds of living organisms exist in the biosphere.
- Things can be classified as living if they perform the seven life processes:
  - Movement
  - Reproduction
  - Sensing the environment
  - Growth
  - Respiration
  - Excretion
  - Nutrition
- Living things need energy, gases, water, soil and a favourable temperature to survive.
- Living things are suited or adapted to the environment in which they live.

Concept Map

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 linkages between different concepts. Often a concept map has a 'focus question' around which the other concepts radiate from - in these books the focus question will be the main topic for the chapter. The relationships between different concepts are shown using arrows with linking phrases, such as 'results in', 'includes', 'can be', 'used to', 'depends on', etc.

As this year progresses, learners will have to start filling in more parts of the concept maps themselves, and then hopefully draw their own ones by the end of the year. This teacher's guide contains the full version of each concept map. Encourage your learners to study the concept maps and make sense of them at the end of each chapter before doing the revision questions. Help your learners to understand and 'read' the concept maps by constructing sentences from them. For example in this case you could read: 'The biosphere is made up of dead organic matter and living things. Living things can be plants, animals or microorganisms. Living things are adapted to their environment and carry out the 7 life processes. These are ....'

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

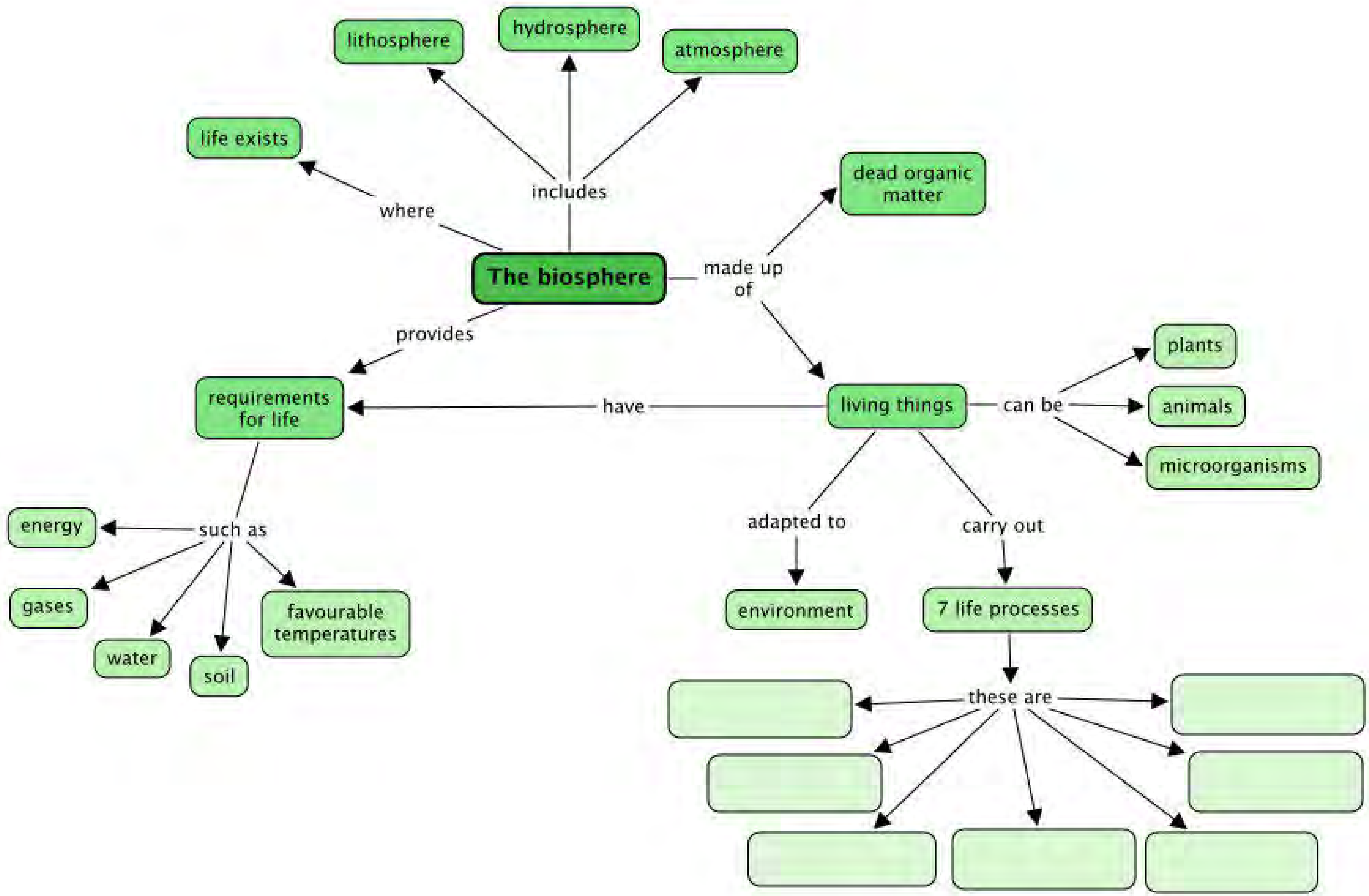
"Knowledge is real knowledge only when it is acquired by the efforts of your intellect, not by memory." - Henry David Thoreau

Do you know what a concept map is? This year in Natural Sciences, we are going to learn more about how to make our own concept maps.

Above you have the 'Key concepts' for this chapter. This is a written summary and the information from this chapter is summarised using words. We can also create a concept map of this chapter, which 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 summarising 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. These are useful skills to have, especially for later in high school and after school!

Have a look at the concept map for 'The Biosphere' on the next page. Complete the concept map by filling in the 7 life processes in the blank spaces.



The biosphere
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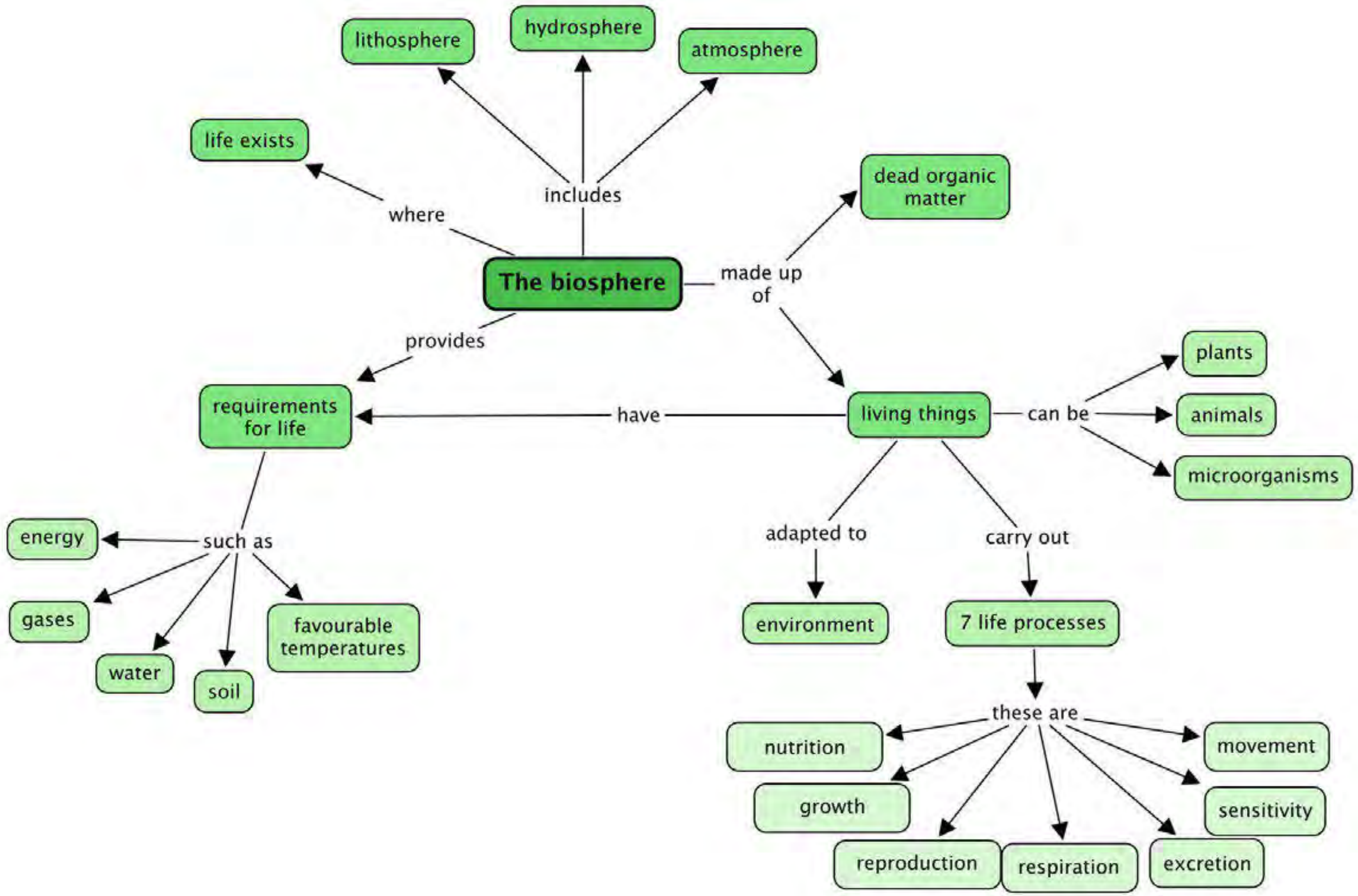
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sensitivity
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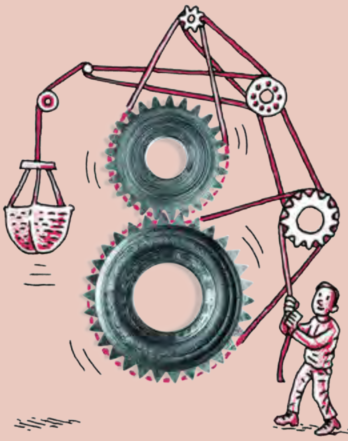
REVISION:



1. Explain what the biosphere is. [2 marks]
   The biosphere is where life exists on earth. It includes the atmosphere, lithosphere and hydrosphere.
2. Give an example of something that is found in each of the following: [3 marks]
   a) Lithosphere:
   b) Hydrosphere:
   c) Atmosphere:
   a) Lithosphere: Rocks or sand
   b) Hydrosphere: Water e.g., oceans and seas, lakes, rivers
   c) Atmosphere: Gases, e.g. carbon dioxide, nitrogen, oxygen
3. Discuss why the atmosphere is important for life on Earth. [2 marks]
   The atmosphere is the layer of gases around Earth. The atmosphere contains important gases that are key to life on Earth, namely oxygen for respiration in organisms and carbon dioxide for photosynthesis in plants. The layers of the atmosphere filter out harmful rays of the sun and hold the heat energy from the sun's rays in the atmosphere to help it maintain the necessary heat levels required for life. The weather changes occur in the lower part of the atmosphere allowing it to rain / snow / hail in order for the water cycle to get water to the plants on land.
4. Imagine an alien creature arrives on Earth attached to a meteorite (fallen space rock). You were tasked with deciding whether it lives in the conventional way that we understand organisms to live. Draw up seven questions to determine how this organism lives and whether it can be classified as alive. [7 marks]
   Learners need to be able to use their knowledge of the 7 life processes to ask these key questions in order to establish if this organism is living or not. Questions should include something as follows:
   - *Can it move?*
   - *Can it make more of it's own kind? How does this reproduction occur?*
   - *Can it sense changes in it's environment and respond to this?*
   - *Does this organism grow?*
   - *How does it get energy for movement, reproduction or growth?*
   - *Does it excrete waste products?*
   - *Does it get nourishment somehow?*
5. What are the requirements for sustaining life on Earth? [5 marks]
   Organisms require energy, gases, water, soil and favourable temperatures.
6. Look at the following photos of different organisms in their environments. Answer the questions about how they are adapted.
   a) Giraffe

   How are giraffe adapted to eat their food? Hint: They eat the leaves of trees. [1 mark]

b) A cactus

This cactus is adapted to live in hot environments? How do you think it stores water for long periods? Hint: Look at its leaves. [1 mark]
How do you think the cactus has adapted to prevent other animals from eating it? Hint: What is on the leaves? [1 mark]

c) A stick insect.

Can you see the stick insect in this photo? How do you think it is adapted, especially to hide away from predators? [1 mark]

a) Giraffe have very long necks so that they can reach the leaves at the tops of trees.

TEACHER'S NOTE

An additional adaptation which is not visible here, but you can mention, is that giraffe have very tough tongues so that they do not get hurt when pulling the leaves off branches covered in thorns.

b) The cactus has thick succulent stems which can store water for when there is none around.
The cactus leaves have long, sharp thorns to prevent animals from eating the leaves.

TEACHER'S NOTE

Additional adaptation to discuss: The stems have a thick waxy layer that prevents the loss of water.

c) This insect is very camouflaged as it looks just like the sticks around it. This helps to protect it from being eaten by predators.

7. Think back to the scientific investigation you did in this section. Evaluate how well you think you followed the scientific method to make your experiment fair or not fair. [2 marks]
Learner-dependent answer. Make sure that learners justify their answer.

Total [25 marks]

2 Biodiversity

TEACHER'S NOTE

Chapter overview

3.5 weeks

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

2.1 Classification of living things (3 hours)

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

2.2 Diversity of animals (4.5 hours)

Tasks	Skills	Recommendation
Activity: Classifying vertebrates and invertebrates	Identifying, classifying	CAPS suggested
Activity: Identify the five classes of vertebrates (Chordata)	Identifying, classifying, remembering	CAPS suggested
Activity: Identify defining features of fish	Observing, identifying, listing	Optional (Suggested)
Activity: Describing amphibians	Observing, identifying, explaining, hypothesising	Optional (Extension)
Activity: Reflect on reptiles	Drawing, labeling, identifying, classifying	Optional (Extension)

Tasks	Skills	Recommendation
Activity: Identify characteristics of birds	Group work, explaining, identifying, characterising, comparing	Optional (Extension)
Activity: Identify characteristics of mammals	Group work, brainstorming, remembering, listing	Optional (Extension)
Activity: Comparing vertebrates	Comparing	Optional (Suggested)
Activity: Classifying arthropods	Observing, describing, classifying	Optional (Extension)
Activity: Observing molluscs	Observing, identifying, describing, drawing, labeling	CAPS suggested

2.3 Diversity of plants (3 hours)

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

KEY QUESTIONS:

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

TEACHER'S NOTE

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

Over millions of years each species living today has changed and adapted to live in a specific type of environment in order to ensure the survival of that species. Biodiversityis a term used to describe the great variety of living organisms on Earth and their varied habitats.

There are just so many types of organisms. How can we make sense of all the organisms on Earth? We need some way to group them. This is called classifying. Let's find out how we do this!

2.1 Classification of living things

Grouping has been a common activity in humans for thousands of years as we make sense of the world around us.

ACTIVITY: Group some everyday objects

TEACHER'S NOTE

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

MATERIALS:

- objects from home
- shoe boxes/ ice-cream tubs

INSTRUCTIONS:

1. Work in groups of four.
2. Each member of the group should bring five items from home. Choose items that are easy to carry around and that will fit into a standard shoe box.
3. Carefully observe each of the items that everyone in your group brought.
4. Use the shoe boxes to group the items according to your observations.
5. Place all objects brought by the whole class on a display table in the front of the class.
6. Discuss the different grouping methods that each group has used as a class. Work towards a standard grouping or classifying method that you could use to **classify** ALL the items that you all brought to school.

TEACHER'S NOTE

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

QUESTIONS:

1. Draw a table in the space below and record all the items in your class in the groups you assigned them to.
   Learner-dependent answer.
2. How did your small group classify your items to begin with? What features did you use to classify the items?
   Learner-dependent answer.
3. Write three or four sentences about the standard classification method that you decided to use in your class. What **characteristics** of the items did you use to classify and group them? Were these different to what you used in your small group?
   Learner-dependent answer.

TAKE NOTE

When you observe you use your senses to tell you more about something. How does it feel or look? Does it have a special smell or taste? Is there a specific sound coming from it?

Plato and Aristotle in a famous painting by Raphael called "School of Athens".

Aristotle was a Greek philosopher and thinker who lived about 2400 years ago. Aristotle came up with the following grouping system that was used for almost 2000 years after his death!

- He divided all organisms into either animals or plants.
- Then he divided animals into those 'with blood' and those 'without blood'.
- Lastly animals are divided into three groups based on their method of movement: walkers, flyers or swimmers.

ACTIVITY: Aristotle's classification system

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Look at the following photos of different kinds of animals.
2. Use Aristotle's method of classification to group the animals based on the way that they move.
3. Draw a table of your groupings in the space provided after the photos. Give your table a heading.

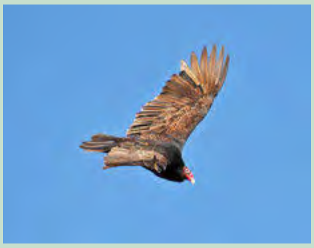
A penguin

A butterfly

A cat

An elephant

A crocodile



An eagle

A human

Dolphins

Bats

TEACHER'S NOTE

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

Classification of a group of animals according to Aristotle's method

Walkers	Flyers	Swimmers
Penguin, Elephant, Cat, Crocodile, Human	Eagle, Butterfly, Bats	Penguin, Dolphins, Crocodile, Human

QUESTIONS:

1. Were there any animals which you battled to classify into one group? Which ones were these?
   Difficult animals to classify are those which can fall into more than one group, such as the penguin, crocodile, human.
2. Do you think Aristotle's classification system has any problems? Explain any problems that you might find when using it.
   Possible answers might include: Some animals fit into more than one group (penguin, crocodile, etc.) because it looks more at what the animals do rather than what they are or similarities and differences between their forms.

As more and more animals, plants and microorganisms were discovered, scientists started questioning Aristotle's classification system. It was not working as well as everyone had believed it would. Why do you think it is important to evaluate *how* we classify things?

TEACHER'S NOTE

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

In the 1700s Carl Linnaeus developed the classification system that classified organisms according to their similarities, functions and relationships with other organisms.

Carl Linnaeus

TAKE NOTE

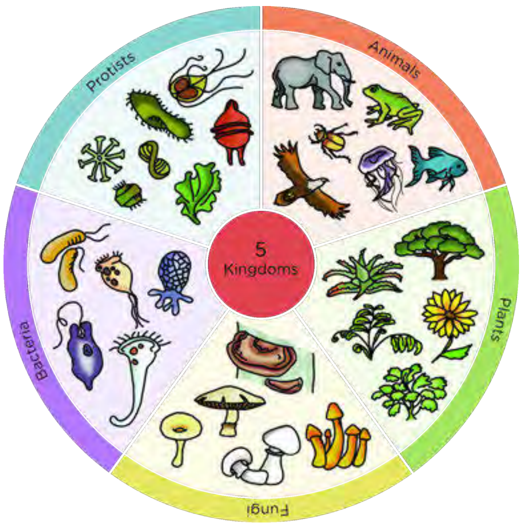
The kingdom Bacteria is often also referred to as **Monera**.

Today with the use of modern microscopes and genetics we can classify living organisms very accurately. In this way we are able to classify living organisms according to their shared characteristics.

Our classification system

All living organisms can be divided into five **kingdoms**:

1. **Animals**
2. **Plants**
3. **Fungi**
4. **Protists**
5. **Bacteria**



TAKE NOTE

Be careful to use these words correctly: one *phylum*, many *phyla*. Similarly, one *genus*, many *genera*.

What are humans? Which kingdom do we belong to?

TEACHER'S NOTE

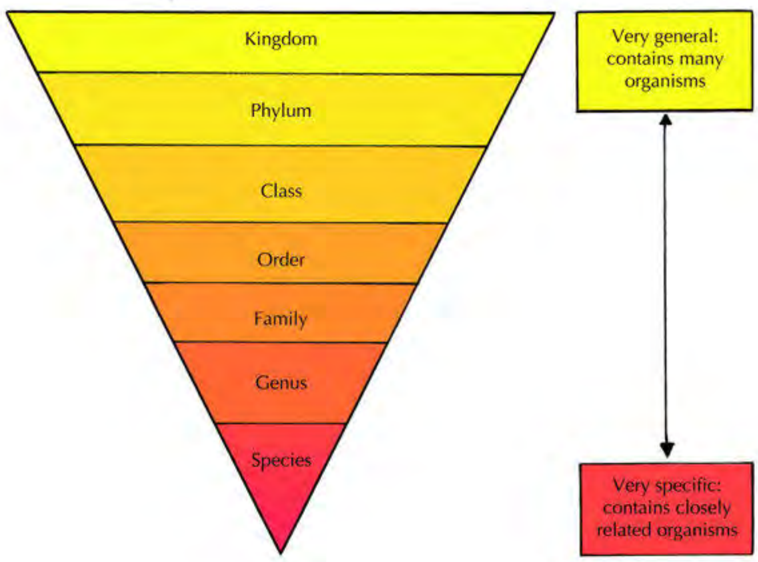
Since we know that we are not a fungi or plant, or a protista or bacteria (quite a bit bigger!) we belong to the animal kingdom.

Think back to the example of how we classify learners at school. First, school is divided into pre-primary school, primary school and high school. If we compare school to the way we classify organisms, we can say that the school system has three kingdoms. But, we need to divide learners up further. So primary school is divided into seven grades (Gr. 1-7) and high school is divided into five grades (Gr. 8-12). The classification system for organisms also needs to divide organisms up further as each kingdom contains thousands of different types of organisms.

Each kingdom is divided into smaller groups or divisions called **phyla**. Organisms with similar traits (characteristics) will occupy a similar phylum. In each phylum, smaller divisions called **classes** are found and each class is further divided into **orders**, **families**, **genera** and then **species**.

Think of your school again. Your primary school contains many learners. When you divide your entire school into grades, there are fewer learners in each grade. Your grade might be divided into different classes, and each class has fewer learners in it. When we classify organisms, the same thing happens. A kingdom is a very big group, whereas a species is a much smaller group.

Study this diagram to help you remember the order:



TAKE NOTE

A mnemonic takes the first letters of a group of terms to make a funny rhyme.

TAKE NOTE

Binomial comes from the Latin*bi-* two and *nomius-* names. Nomenclature comes from Latin words *nomen* - name and *calare-* to call. Binomial nomenclature therefore means calling things by two names.

King**P**hil **C**uts **O**pen **F**ive **G**reen **S**nakes

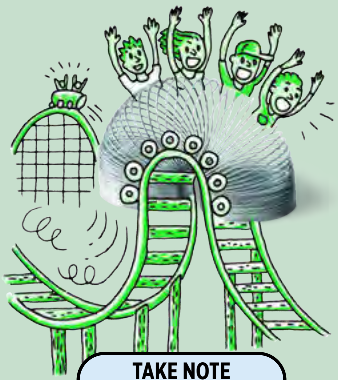
We need to be able to distinguish between organisms too. So how do we name organisms?

Carl Linnaeus designed a special naming system called the **binomial nomenclature** to name all organisms. All organisms are therefore given **two** (bi- means two) words in their name.

- The first part of the name refers to the genus that the organism belongs to. This is always written with a capital letter.
- The second part of the name refers to the species within the genus
- If you are typing you will put both these names in *italics* but if you are doing a handwritten piece you underline it. This shows that you are identifying the organism by its scientific name.

For example, the scientific name for the african elephant is *Loxodonta africana*. Humans belong to the genus *Homo* and to the species *sapiens* so we are *Homo sapiens*. Now that we have seen how to classify organisms, let's take a closer look at the differences between the kingdoms.

Plants and animals



TAKE NOTE

When we compare plants and animals we can often compare them based on the way that they move, what and how they get food or nourishment, and how they reproduce.

ACTIVITY: Comparing plants and animals

INSTRUCTIONS:

1. Study the diagram that shows the five kingdoms that we commonly use to classify organisms. Pay close attention to the plants and animals.
2. Answer the following questions.

QUESTIONS:

1. Study the organisms in the animal kingdom. What are some common features that you can see in all the animals?
   Learner-dependent answers. Might include: all these animals can move using a variety of methods or that all might have a special body covering. These animals all have to eat, either plants or other animals. They generally reproduce by mating with other animals of the same species. Animals drink water. Animals respire as they take in oxygen and give off carbon dioxide, often through breathing. Animals need to excrete their waste from their bodies.
2. Study the organisms in the plant kingdom. What are some features that are common to all plants?
   Learner-dependent answers. Might include: plants cannot move, they are rooted to one spot. Plants do not need to eat as they produce their own food by photosynthesis. They take in water. Plants also respire like animals but they also take in carbon dioxide for photosynthesis and give off oxygen as a by product. Plants' reproduction differs to animal reproduction in that many plants produce seeds while others produce other structures (like ferns) etc.
3. Draw a table in the space below and compare the characteristics of plants that make them different to animals. Discuss your plant and animal comparisons with your group and then with the class.
   Learners should compare the observable differences on the diagram / illustration between plants and animals. Some of these might include:

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

Fungi

Most people will not eat bread covered in bread mould but will eat at a plate of fried mushrooms, truffles and morels. These are all examples of fungi, including yeast.

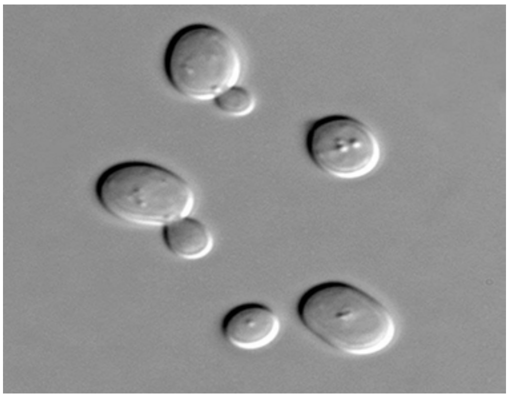
VISIT

Learn more about the kingdom Animalia bit.ly/18djDrj

Morel

A truffle

Bread mould



Yeast cells

A very poisonous mushroom

Button mushrooms (like we buy in the shops)

VISIT

The phylogame (a card game which could be played in class) bit.ly/14o3yPp

Fungi play a very important role in our biosphere since they break down dead organic material and return nutrients to the soil for plants to use. Some fungi cause diseases while others, such as penicillin (an antibiotic) are very useful to us. Yeast is used in many of our products, such as making bread rise and fermenting wine and beer.

Protists and Bacteria

TEACHER'S NOTE

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

We will look at Protists and Bacteria in more detail later on in Gr. 9. For now, lets look at some of the basic features of these kingdoms.

Organisms in these two kingdoms are microscopic which means you cannot see them with your naked eye. However we can see them if we look at them under a microscope.

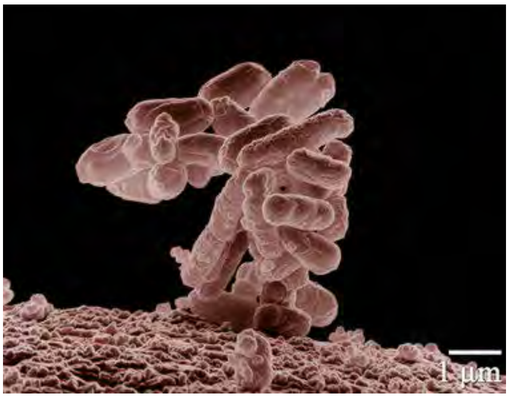
TEACHER'S NOTE

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

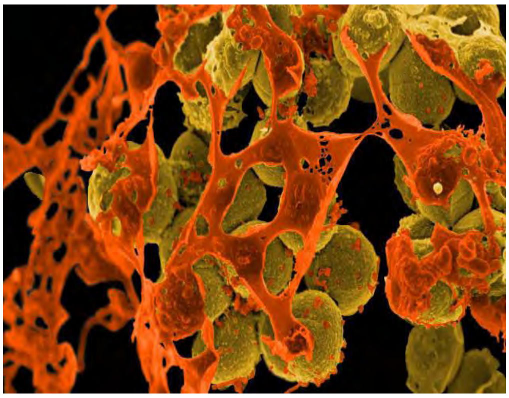
TAKE NOTE

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

Different bacteria:



Escherichia coli bacteria, commonly found in the intestines of animals

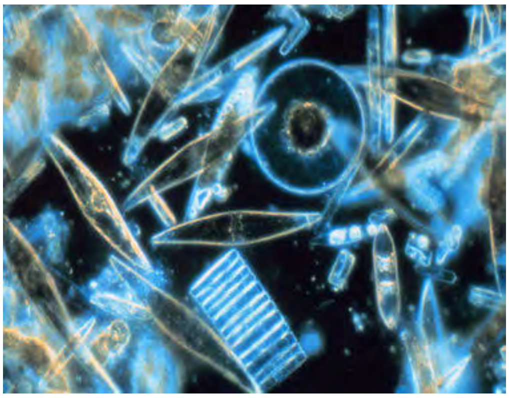


Staphylococcus aureus (yellow cells) often causes skin infections and pneumonia

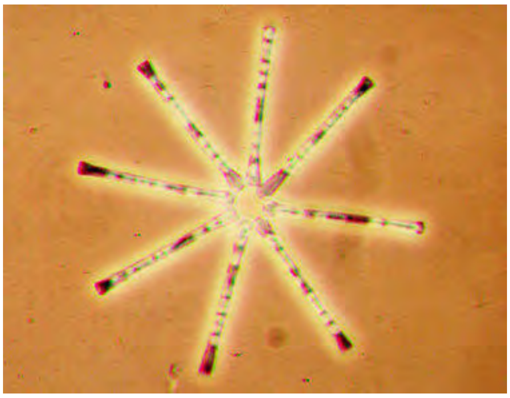
Pseudomonas aeruginosa is found in soil and water and cause infections in animals

Actinomyces bacteria which cause diseases in the mouth

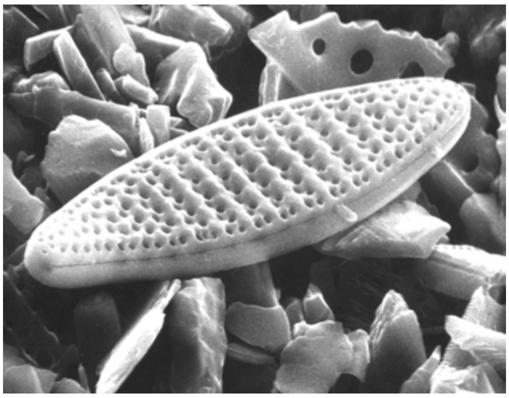
Different Protists:



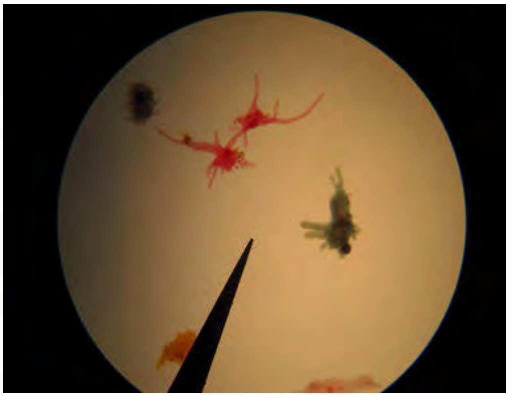
Phytoplankton from the Antarctic sea



Asterionella formosa



Nitzschia kerguelensis



Different coloured amoebas

Now we will look at the amazing diversity of animals and plants on Earth, and especially in South Africa.

2.2 Diversity of animals

TEACHER'S NOTE

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

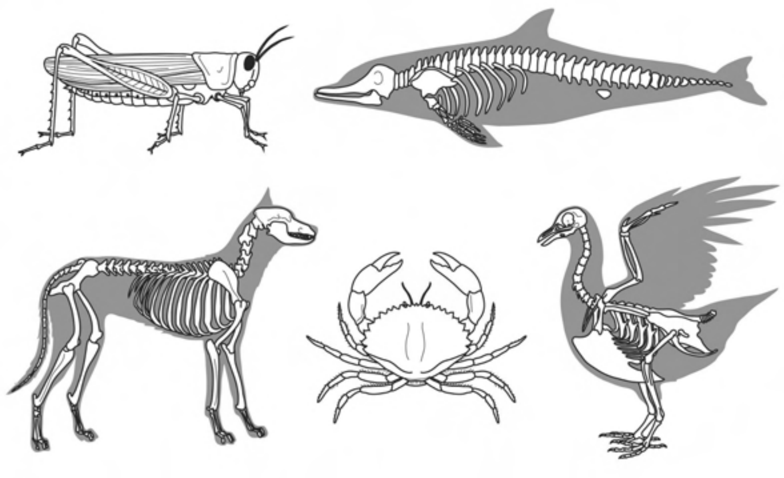
Some learners might ask "WHY" we classify and they should be praised for doing this. If this occurs point out to them that classification helps us to sort out ancestor / descendent relationships and we are therefore able to track the evolutionary history of all living organisms.Thus the presence or absence of one specific characteristic might show that an organism is related to others in in a specific genus, family or order and can also guide an investigation into the evolutionary history of these organisms. Many learners might for instance be unaware that lions, rhino and elephants are indigenous to Africa but are also found naturally in other parts of the world, like India, and through classification we are able to see how the Black Buck and the Koedoe, or the One-horned Rhinoceros of Asia and the South African black rhino are related.

Classifying animals

All the animals in the world form part of the animal kingdom.There are two distinct divisions or groups of animals within the animal kingdom: the **vertebrates** and the **invertebrates**. Can you remember what is used to classify an animal as a vertebrate or invertebrate? Look at these x-rays of animals for a clue.

TEACHER'S NOTE

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



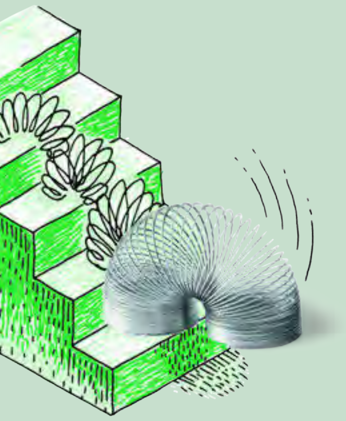
Animals that have a backbone with a hollow tube inside to hold the nerves are vertebrates. As we can see in the x-ray images of the dolphin, dog and goose, we can see the skeletons of these vertebrates. They are made of bone. We say that vertebrates have an endoskeleton.

What about the grasshopper and the crab? Why can we not see their bones? This is because invertebratesdo not have a skeleton made of bones. The grasshopper and crab have a hard shell covering on the outside of their bodies. This supports their soft bodies inside. We say they have an exoskeleton. But not all invertebrates have an exoskeleton.

What about a jellyfish? It does not have a backbone, so it is not a vertebrate, so it must be an invertebrate. Does it have a hard, outer covering called an exoskeleton? Discuss this with your class. Make sure to take note of the third type of skeleton in your discussion.

TEACHER'S NOTE

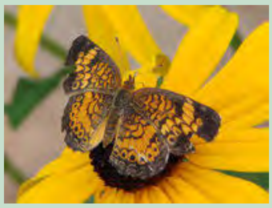
Invertebrates do not have a backbone, but this does not necessarily mean that they have an exoskeleton. Many invertebrates have a **hydrostatic skeleton**, like the jellyfish and earthworm. Some invertebrates such as like the snail and have an exoskeleton (shell) and a hydrostatic skeleton. Sponges actually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



ACTIVITY: Classifying vertebrates and invertebrates

INSTRUCTIONS:

1. In the table identify the type of skeleton that each animal has and write it down beneath each picture.
2. Write down whether the animal is an invertebrate or a vertebrate.

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

Animal	 *Tortoise*	 *Frog*
Type of skeleton	*Endoskeleton*	*Endoskeleton*
Vertebrate or invertebrate	*Vertebarte*	*Vertebrate*
Animal	 *Crab*	
Type of skeleton	*Exoskeleton*	*Endoskeleton*
Vertebrate or invertebrate	*Invertebarte*	*Invertebrate*

VISIT

A useful chart showing the classification system

bit.ly/178IzyU

The invertebrates are divided into five phyla. The invertebrate phyla are:

1. Sea sponges
2. Jellyfish
3. Roundworms
4. Molluscs
5. Arthropods

TEACHER'S NOTE

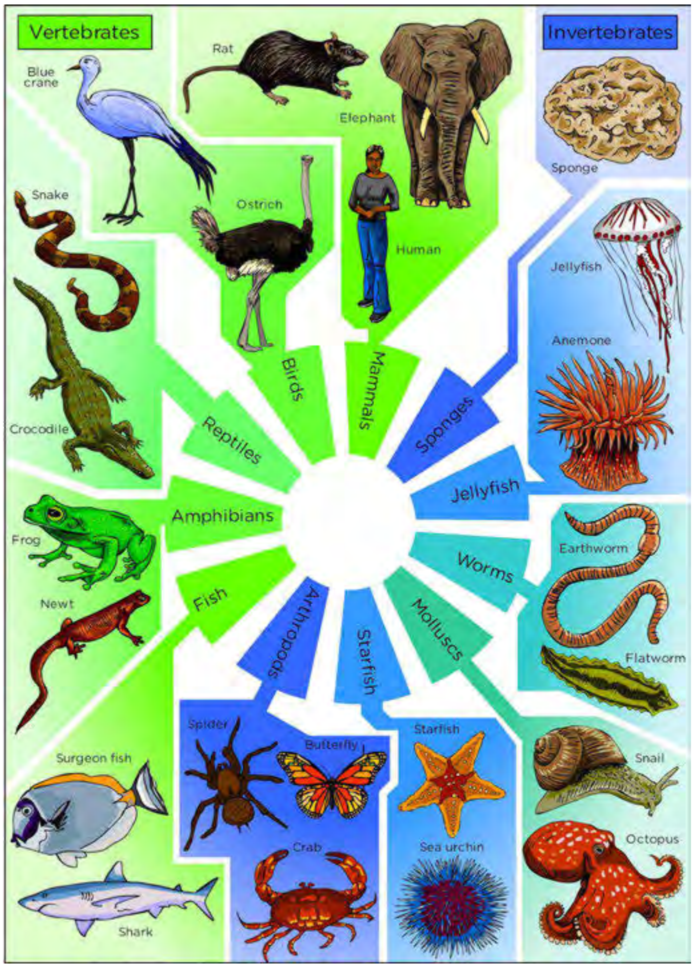
The five phyla making up the invertebrates have scientific names, but these are not necessary to know at this stage. We will only focus on the two phyla Arthropoda and Mollusca.

TAKE NOTE

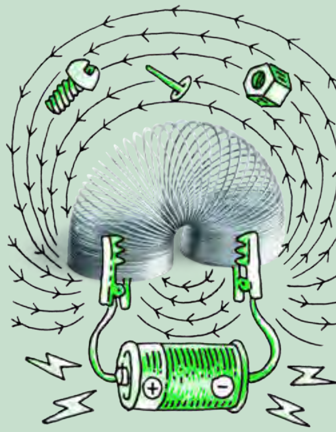
'Phylum' is the singular and 'phyla' is the plural use of the word.

All vertebrates belong to the phylum Chordata. Vertebrates are subdivided into five classes.

Have a look at the following diagram which shows the different classes of vertebrates and phyla of invertebrates. Remember, all vertebrates belong to the phylum Chordata.



ACTIVITY: Identify the five classes of vertebrates



INSTRUCTIONS:

1. Study the previous chart showing vertebrates and invertebrates and identify the names of the five classes of vertebrates. Write these on the lines below.
2. Use the pictures that you previously collected from magazines to find at least 5 examples of each of these classes of animals.

QUESTIONS:

1. Identify at least one distinguishing characteristic that each class shares or has in common (that makes that class different from other classes.) Write this on the line next to the classes that you identified above.
   a) *Fish - scales / gills / fins / etc*
   b) *Amphibians - soft moist skin / lungs and skin used for breathing / four limbs with webbed feet*
   c) *Reptiles - scaly skin / lungs used for breathing / four limbs with toes*
   d) *Birds - beak, feathers cover body / air sacs used for breathing / two scaly legs and two wings,*
   e) *Mammals - fur or hairy skin / lungs / four limbs / mammary glands, live birth*

TEACHER'S NOTE

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

Vertebrates

The five classes of vertebrates are:

1. Fish
2. Amphibians
3. Reptiles
4. Birds
5. Mammals

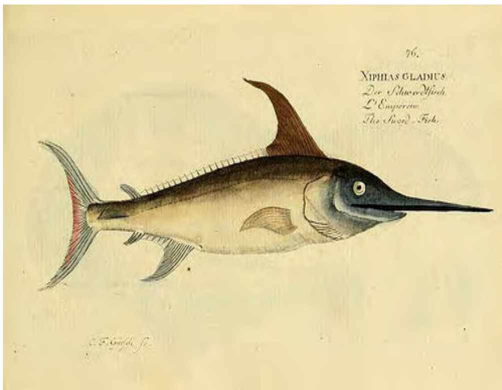
Fish

TEACHER'S NOTE

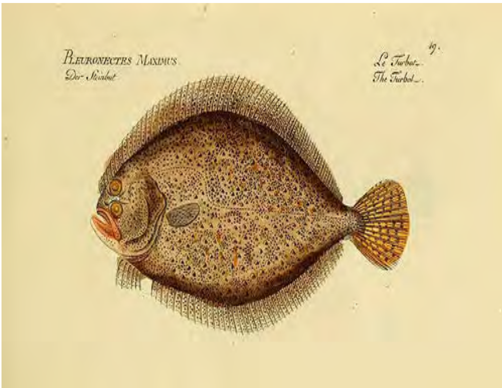
Visit [1] bit.ly/195EX30 for a teachers' support website on fish.

Fish come in all sorts of shapes, sizes and colours. There is huge diversity amongst fish. Have a look at some of the following drawings of different types of fish.

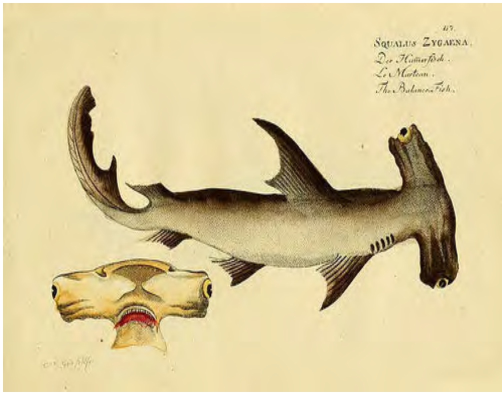
Scorpion fish



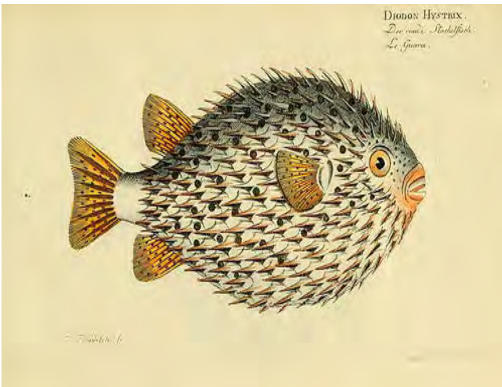
Swordfish



Sole Fish



Hammerhead shark



Puffer fish

Goldfish

VISIT

Unusual and weird deep sea fish (video) bit.ly/1460jZG

ACTIVITY: Identify defining features of fish

QUESTIONS:

1. Carefully study the drawings of the fish shown previously. Although they are different shapes, sizes and colours, you should be able to identify common features to all fish. List as many of the defining features of fish as you can.
   Features learners might list include: ectothermic, backbone, fins, gills, scales, living in water, breathing oxygen from water, streamlined body, lay eggs.
2. Some of the features that you listed might apply to other animals that are not fish. Look at your list again. Make a tick next to any of the features you listed that only apply to fish, or perhaps a combination of characteristics that only apply to fish.
   The combination of gills, fins and the fact that fish live only in the water are the main defining characteristics of fish and make fish different from all other animals.

When classifying fish we look closely at the material that makes up the skeleton of the fish. This leads us to divide fish into two main groups:

- **Cartilaginous fish** have skeletons made of **cartilage**.
- **Bony fish** that have skeletons made of bone.

Sharks, skates and rays are part of a group of cartilaginous fish because their skeletons are made of cartilage. These fish breathe using five to seven pairs of **gills**.

Manta ray

Spotted eagle ray

A whale shark surrounded by other fish

A great white shark

The largest group of all vertebrates are bony fish. Bony fish have a hard, bony skeleton.

Challenge question: Is a seahorse a fish? Search books and the internet to find out and explain why we can or cannot consider it to be a fish.

A sea horse.

VISIT

Watch this video of a male seahorse giving birth
bit.ly/15eTuEw

TEACHER'S NOTE

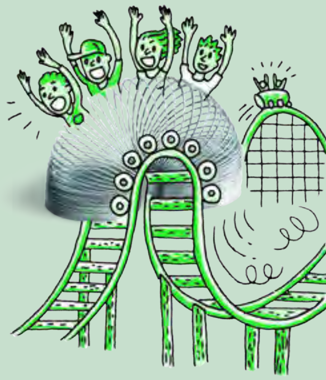
Yes a sea horse is in fact a fish. It breathes with gills, has a swim bladder to control buoyancy and a spine, and even though they don't have a tail fin they have four other fins that help them move. Unlike most fish, sea horses do not have scales, but skin.

Amphibians

Did you know that the word amphibia comes from two Greek words, *amphi* meaning both and *bios* meaning life? So an amphibian is an animal that has 'both lives'. What does this mean?

Amphibians are animals that include salamanders, newts, caecilians, frogs and toads. Let's find out what is meant by amphibians having 'both lives'.

ACTIVITY: Describing amphibians



INSTRUCTIONS:

1. Study the photos of different amphibians in the following table.
2. Answer the questions which follow.

Amphibian	Larva (young)	
Frog		
Toad		
Salamander		
Newt		

QUESTIONS:

1. What do you notice about the habitat of the young amphibians compared to the adult amphibians?
   The young larvae are all in water whereas the adults are on land or near water.
2. What do you think the larvae need to breathe underwater? What do the adult amphibians need to breathe when they are on land?
   The larvae needs gills to breathe in water, the adults have lungs to breathe on land.

3. Can you now explain why amphibians have a name which comes from two Greek words and means 'double life' or 'both life'? Write your explanation below.
   Amphibians have two stages in their life cycle. First, they have the larval stage where they are in water, and then they have the adult stage where they live on land (and also in or near water).
4. Amphibians are **ectothermic**. Explain how an amphibian keeps its body warm.
   They get heat from their environment and therefore need to live in areas where it is warm enough for them to have enough body heat to survive. If it gets very cold an amphibian will need to either find a space under a log or leaves, or else sit in the sun.
5. Most amphibians have a slimy, moist skin. Discuss possible reasons why they need to have this specific type of skin.
   Learners need to compile a plausible explanation or hypothesis. The correct explanation is: Glands in the skin secrete liquid to keep the skin slimy and moist as frogs may need to use the skin alongside the lungs and mouth for gaseous exchange.
6. Look at the following image of a caecilian. There is a debate going on in a Gr. 6 class. Some learners think this animal is a worm, making it an invertebrate. Others think it is a snake, making it a vertebrate. What do you think?

   A caecilian.

   The caecilian is actually an amphibian! What characteristics would you test or make sure this animal displayed to explain to the Gr. 6 learners that it is not a worm. Secondly, what would you need to find out and explain to the learners to explain that it is not a reptile (a snake) but an amphibian?
   In order not to be an invertebrate, like a worm, the animal needs to have a backbone. The caecilian does have a backbone and a skull. The caecilian is not a snake (it is not a reptile) as it has a larval stage which is born in water and it undergoes metamorphosis to become the adult caecilian. The larvae also have gills to breathe underwater. Caecilians also do not have scales like reptiles.
7. Amphibians lay their eggs in water, like this frog. Why do you think they need to do this? Give two reasons.

   A frog that has just laid its eggs

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

VISIT

Metamorphosis: Amphibians (full documentary)

bit.ly/14rZABn

Reptiles

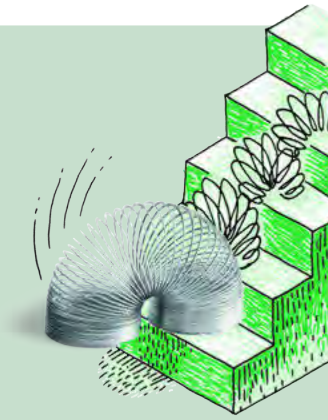
Reptiles have survived on Earth for millions of years. The first reptiles on earth lived 310 to 320 million years ago and included the dinosaurs.

Most reptiles live on land although some, like crocodiles, terrapins and turtles, and some snakes and lizards spend large portions of their lives in water. Reptiles are ectothermic. They cannot regulate their body heat but depend on their environment for heat.

A lizard lying in the sun to warm up

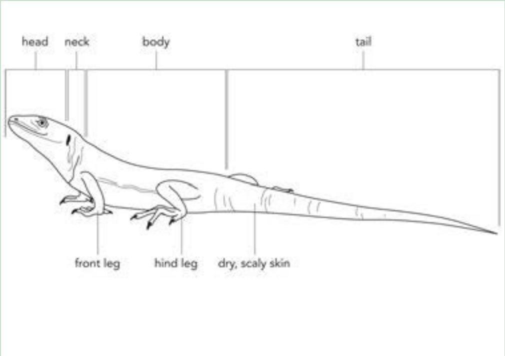
Reptiles are covered in dry scales. Reptiles reproduce by laying their eggs on dry land. The eggs are covered by a leathery or hard shell.

ACTIVITY: Reflect on reptiles



QUESTIONS:

1. Complete these sentences.
   a) Since reptiles all have a backbone they are one of the classes of ___________.
   b) Reptiles are ectothermic which means that ___________.
   a) chordata or vertebrates
   b) they cannot regulate their body temperature but depend on their environment for heat
2. Make a biological drawing with labels and a heading of the lizard lying in the sun in the previous photo.
   Learner-dependent answer



VISIT

Learn more about the boa constrictor which keeps its eggs inside its body until they are ready to hatch

bit.ly/1331Bd1

3. We can divide reptiles into four main groups. Each of the photos in the table below shows an example of a reptile from each of these groups. Try to identify the four groups based on the animal in the photo.

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

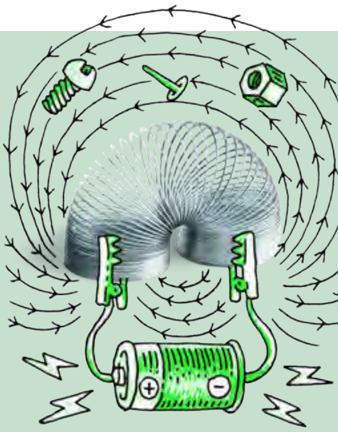
Birds

TEACHER'S NOTE

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

The blue crane is South Africa's national bird.

ACTIVITY: Identify characteristics of birds



INSTRUCTIONS:

1. Work in groups of three.
2. List the identifying characteristics of birds following these steps:
3. Do you remember learning about birds in previous years? Work with a different group and brainstorm identifying characteristics of birds. Study the photo of the blue crane above for some clues.
4. Use one specific colour to list the characteristics that your group can think of.
5. As you learn more about characteristics of birds add these in a different colour to help you remember the new characteristics.

TEACHER'S NOTE

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

QUESTIONS:

1. Birds are one of the five classes of vertebrates. Write a sentence to explain what all vertebrates have in common.
   All vertebrates have a backbone with a hollow tube running inside it carrying the nerves.
2. Just like mammals, birds are also **endothermic**. What does this tell us about their bodies?
   This means that birds can control or regulate their body temperature and can therefore keep warm in very cold climates and keep cool in very hot temperatures.
3. What type of body covering do all birds have in common?
   Learner-dependent answer. ***Note:****Although almost all learners will say that all birds have feathers, not many will be able to identify that birds' feet are covered in scales like those on reptiles. If you are able to go outside to look at some birds, try to see if you can take note of their legs and feet.*
4. Is it accurate to say that birds have wings and can therefore fly? Explain your answer. What would be a better way to write this statement?
   Learners are required to evaluate a statement and give an explanation for their evaluation. It is in fact incorrect to say that birds have wings to fly since not all birds' wings are used for flying and many flightless birds exist. Think of the emu, ostrich, penguin, cassowary, kiwi and rhea. A better statement would be: Birds that can fly have wings to do so.
5. Study the pictures of these flightless birds and compare them with the flying birds in the next column. Use the pictures to write a paragraph explaining the observable differences between flightless and flying birds and why you think these characteristics help some to fly and others not.

Flightless Birds	**Flying Birds**
 Ostriches  Penguins	 An albatross  A hummingbird

The ostrich is very big and has a heavy body with long legs. Its long legs help it to run fast on land. It has wings, but its wings are small in comparison to its big heavy body. The albatross is also a big bird but it has a very large wing span relative to its body. The feathers in the albatross are also small and lie close together to help the bird to fly. Whereas the ostrich has many feathers, but they are big and loose and will not catch the updraft of the wind. The penguin also has a body shape which is not designed to help it fly, but rather to swim. It has short, stubby wings, which are not strong enough to lift it off the ground, but are useful for swimming. It is quite fat and heavy, but this helps to keep it warm in the water. The hummingbird is very light and has small wings which beat extremely fast, allowing it to fly and hover. The hummingbird has wings designed to flap quickly in the wind as they are narrow and light, while the penguin has fatter wings shaped like a paddle which are rather used for swimming.

VISIT

An application for a smart phone which helps you to identify all birds in South Africa. bit.ly/178KinL

Mammals

Lions are mammals

A warthog is a mammal

ACTIVITY: Identify characteristics of mammals

INSTRUCTIONS:

1. Work in groups of three to four.
2. You might have learnt about mammals in previous years. Work with your group to brainstorm as many identifying characteristics of mammals that you can think of. Study the diagram of the lion above for some clues.
3. List the characteristics that you can identify in the space below using one specific colour.
4. As you learn more about mammals, add what you have learnt to this list in a different colour. This will then provide a summary on mammals when you have completed the section.

TEACHER'S NOTE

Learner-dependent answers. **Note:** After learners have generated their lists, you should ask groups to share their characteristics with the rest of the class in order to insure that no false characteristics are included (although these would provide a foundation for discussion as to why they are not identifying characteristics for instance). Some characteristics that learners might identify are: warm-blooded (endothermic), four limbs, sexual reproduction, live young, hair on bodies.

TAKE NOTE

'Thermic' means to do with temperature and 'endo' means inside, so mammals are endothermic as they can regulate their body temperature from the inside.

Mammals are vertebrates meaning they have a backbone. Almost all mammals are endothermic. This means they are also able to maintain (keep) their body temperature at a constant level.

Mammals give birth to live young which are fed milk. The milk is produced by the mother's **mammary glands** (in the teats or breasts). Mammals also have hair on their bodies. This varies greatly between mammals. Mammals also have teeth that look different in different parts of the mouth.

Kittens drinking milk from the mother cat.

A seal pup suckling from its mother.

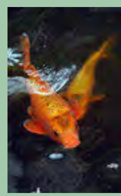
All mammals breathe using lungs. Many mammals therefore live on land. Those mammals that do live in water, like whales and dolphins, have to come to the surface of the water to breathe.

Dolphins surfacing to breathe air

ACTIVITY: Comparing vertebrates

INSTRUCTIONS:

1. Use the table below to compare the vertebrates shown in the photos based on the features in the first column.

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

Now that we have looked at all the classes of vertebrates, let's have a look at the invertebrates.

Invertebrates

What should you look out for when you have to decide if an animal is an invertebrate?

- All invertebrates lack a backbone. They either have a hard outer shell or a fluid-filled structure that acts as a skeleton (for example jellyfish and slugs).
- All invertebrates are ectothermic.

Did you know that 97% of the animals on Earth are invertebrates? Due to the huge diversity in the invertebrates, it can sometimes make classifying them a bit tricky. The invertebrates are divided into several phyla. Some of the invertebrate phyla are:

1. Molluscs (for example snails and octopuses)
2. Arthropods (for example insects, spiders and crabs)
3. Echinoderms (for example sea urchins and starfish)
4. Cnidaria (for example jellyfish)
5. Porifera (sponges)
6. Annelids (segmented worms)
7. Platyhelminthes (flatworms)

VISIT

Find out more about the other phyla of invertebrates

bit.ly/178L1FG

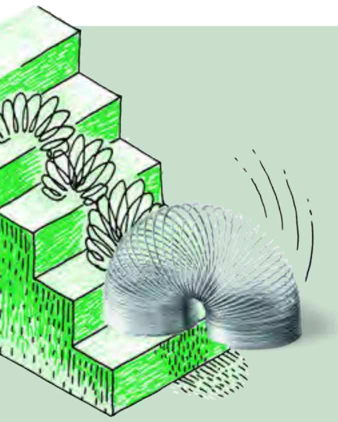
There are some other phyla too. As you can see, the invertebrates are a very large and diverse group of animals. We are mostly going to focus on the two phyla Arthropods and Molluscs.

The word arthropod comes from two greek words *arthron* meaning 'joint' and *podos* meaning 'leg', so together it means 'jointed legs'. Arthropods have an **exoskeleton** and they have jointed (segmented) limbs.

Let's now find out more about Arthropods!

Arthropods

The invertebrates that fall into the phylum arthropoda, all have a hard outer covering called an **exoskeleton**. The exoskeleton protects the animal and provides a place for its muscles to attach and function.



ACTIVITY: Classifying arthropods

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Study the photos of different arthropods below
2. Answer the question that follow.

A spider

A prawn

A butterfly

A scorpion

A millipede

A dung beetle

A crab

A grasshopper

A crayfish

A centipede

QUESTIONS:

1. Study the bodies of each of these animals.
   a) Describe how the bodies of the different arthropods look and if you could touch it, what do you think it would feel like?
   b) Do you think their bodies would be warm or cold?
   a) They have hard shell-like bodies that look sturdy and inflexible; it would possibly feel hard and would crunch if broken.
   b) Their bodies would feel similar to the temperature of their environment.
2. Study the legs of the different arthropods.
   a) Describe how the legs of the different arthropods look in general.
   b) How are the legs able to bend?
   c) One way to classify an arthropod is to count its legs and to group these animals according to this. Count the legs on each of these arthropods and write their names in the appropriate column below to see to which group they belong.
   a) The legs are made of different parts that are joined together and are mostly covered in the same hard exoskeleton as the body.
   b) Where the pieces of the leg come together they form a flexible joint that allows the leg to bend and move.
   c) The learners' tables must look like this:

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

3. As you probably noticed, an arthropod's body is covered by a hard exoskeleton. Explain how you think an arthropod can grow and get bigger since the hard exoskeleton cannot grow with it.
   *It sheds the hard exoskeleton (outer skeleton) in a process called **moulting**.*
4. What habitat would you say most crustaceans live in? How does this differ from the habitat of the other classes of arthropods?
   Most crustaceans are aquatic, either marine or freshwater. The other classes mostly live on land, although many live near water.
5. Which class of arthropods has wings? Do all of the animals in the class have wings?
   Insects have wings. No, not all insects have wings.

Molluscs

Molluscs are a very diverse phylum of invertebrates. They have a huge range in body shapes and sizes. Molluscs are often given a general description which is that they have internal or external shells and a single muscular 'foot'. However, there are lots of molluscs which do not strictly fit this description, such as slugs.

The group of molluscs include snails, squid, octopuses, periwinkles, abalone, mussels, oysters and other soft-bodied animals.

A reef squid

An octopus

TAKE NOTE

mollusc is Latin for "soft" which refers to the soft bodies of molluscs.

A sea slug (nudibranch)

The Blue Dragon nudibranch

VISIT

Video on nudibranch sea slugs bit.ly/1euVRIX

A cuttlefish

Limpets in a rock pool

VISIT

Video on Cuttlefish: The chameleons of the sea bit.ly/178LRIG

An abalone

A garden snail

ACTIVITY: Observing molluscs

INSTRUCTIONS:

1. Carefully study the above photos of different animals that form part of the phylum mollusca.
2. Answer the following questions.

QUESTIONS:

1. Identify some characteristics that molluscs have in common.
   Molluscs have soft bodies, which are often slimy to touch. Most molluscs have one or two hard shells to protect their bodies, sometimes the shell is inside, like that of the cuttlefish, squid and octopus. Molluscs live in moist environments, mostly in the sea.
2. Most of the molluscs shown in the photographs live in the sea. What do you think would happen if these molluscs were exposed to the air for a long time?
   They would dry out and die.
3. Walk through the school garden and see if you can find any garden snails. If you do, or perhaps you have seen them elsewhere before, think about their habitat. Describe the areas where you found snails.
   Learner-dependent answers - they might say that they found more snails in low-traffic areas and in shady, less-exposed places, often where it is damp or under foliage.
4. If possible, collect a few snails to study in class. If you have a glass terrarium or an old aquarium, keep the snails in there, or else keep a few in large clean glass jars.
   Note:*In the last section of this term's work learners are going to study variation and survival of the strongest / fittest. They will need snails for that activity too, so if possible keep the snails from this activity for then. Just make sure the lid is securely shut on the terrarium as snails will escape and arriving to a slime-covered desk / class before school is no fun at all!*
5. Carefully study their bodies and especially their long, slimy foot.
   a) What do you think the slime is used for?
   b) Describe how the snail moves.
   c) How many tentacles (**antennae**) does the snail have? What do you think these are used for?
   d) What markings are on the shell? Why do you think the shell is marked

in this particular way?

e) Try and see if you can find male and female snails. What conclusion can you draw from this.

a) As the snail moves it leaves behind a trail of slime to make it easier for the rest of the body to slide or glide over. This allows it to move easily over any type of surface.

b) Muscles in the foot of the snail contract and relax causing it to move along.

c) Snails can have one or two pairs of tentacles (antennae) depending on the species (however they may be retracted). One pair of light-sensitive eyes are usually on the longest pair of antennae and the other pair of antennae are used for smell and touch.

d) The snails' shells are marked to blend into their environment and to break the outline of their shape to help to camouflage them.

e) Learners should say that they cannot see any difference and should be able to conclude that either they only collected one sex or that snails do not have a male and a female snail (which is in fact the truth). Most land snails have both male and female parts. They are hermaphrodites. When they meet with other snails during mating they will both conceive and lay eggs, so double the number of offspring are formed.

6. Make a drawing of a snail. Include the following labels: hard shell, foot, head, mouth, tentacle, eyespot.
   Learner-dependent answer

2.3 Diversity of plants

In this section we will take a closer look at the organisms in the **plant kingdom**. So how do we classify plants?

TEACHER'S NOTE

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

Classifying plants

TEACHER'S NOTE

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

VISIT

If you would like to join and become a research scientist yourself, visit the iSpot website bit.ly/1beUSg3

We can easily compare plants based on their characteristics. For example, their leaf size and shape, whether there are flowers or not and how the petals look, the length and depth of the **roots** and the type of root system, and many others.

One particularly useful way is grouping plants according to how they reproduce sexually. If we group plants based on the way that they sexually reproduce we can quickly see two distinct groups:

- Plants with **seeds**
- Seedless plants

A common fern in South Africa

The structures that produce and release spores on the underside of a fern leaf

TEACHER'S NOTE

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

Plants that do not produce seeds include ferns, mosses and algae. These plants produce **spores**. The spores often develop in structures found on the underside of the leaves or fronds. The spores grow into new plants.

The photo on the left shows a close up of the underside of a fern leaf. Can you see the clusters of capsule-shaped structures that form the tiny spores?

TEACHER'S NOTE

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

The close up photo on the right shows a moss sporophyte. This contains the spores of the moss plant.

Moss growing on the forest floor

Close up of a spore-producing moss plant

Do you know what lichen is? You often see it growing on rocks and tree trunks. Do you think lichen is a plant? Look at the photos of lichen below.

Lichen growing on a tree

Lichen growing on an old tin drum

Lichen actually consist of two different organisms growing together! A fungus and a green alga grow together in a **symbiotic** relationship. The fungus absorbs water from the environment and provides the algae with an environment to grow in. The green algae photosynthesizes, providing food for the itself and the fungus. Why can the fungus not make its own food? Is the fungus a plant? Can you come up with a definition for a symbiotic relationship? Discuss this with your class and take some notes.

TAKE NOTE

Plants can also reproduce asexually by making a clone or copy of themselves. In this way new plants can grow from cuttings and tubers (like potatoes), from**bulbs** and **rhizomes**, or from **shoots** and side branches.

TAKE NOTE

Alga is singular and algae is plural!

TEACHER'S NOTE

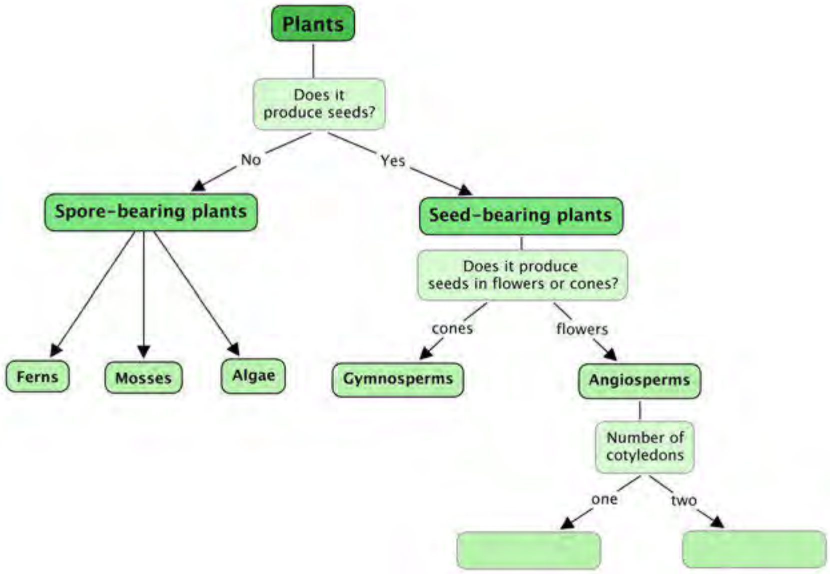
Discuss this with your learners. Encourage them to take notes in the margins of their workbooks. A fungus is not a plant. Fungi are one of the five kingdoms of organisms. Fungi do not contain chlorophyll and cannot photosynthesize. They therefore need to obtain their nutrients from elsewhere. Ask your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

The other group of plants produce seeds. These plants can either produce seeds in flowers or they can produce seeds in cones. Most plants that you see around you, produce seeds. Plants that produce seeds in flowers are called **angiosperms** and plants that produce seeds in cones are called **gymnosperms**.

This is a gymnosperm plant as it produces seeds in cones.

This is an angiosperm plant as it produces seeds in flowers.

We can therefore classify plants as follows:



Come back to complete this diagram once we have learned more about angiosperms.

TEACHER'S NOTE

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

Seed-bearing plants

Gymnosperms

Have you ever seen a living prehistoric plant? If you thought about it, you probably have without even realising it!

In South Africa we have plants called cycads that are often referred to as 'living fossils'. Cycads grew in great numbers during the Jurassic period. They have not been around for as long as ferns and algae, but they have been on Earth for longer than all flowering plants. Flowering plants (angiosperms) evolved after gymnosperms.

A cycad with cones.

Cycads at Kirstenbosch Gardens in Cape Town.

VISIT

More information on cycads: bit.ly/16CqjQu

Can you see the large cones in the photo of the cycad above? They are in the centre of the plant. The cones are made up of many individual seeds. Look at the following close up images of cones.

A cycad cone.

A cone from a pine tree.

The word gymnosperm means 'naked seed'. Gymnosperms are considered to have naked seeds as the seeds are not covered in a fruit, like we will see in angiosperm plants.

Another gymnosperm which is native to South africa, and grown a lot in the Cape is the Mountain Cypress, as shown in the photo. They grow especially well at high altitudes, such as in the Cederberg Mountains.

A Mountain Cypress.

There are several species of gymnosperms which are *not* indigenous to South Africa. What does this mean? Let's find out.

ACTIVITY: Invasive plants in South Africa

INSTRUCTIONS:

1. Study the following photograph of an invasive gymnosperm plant in South Africa.
2. Answer the questions that follow.
3. You will need to do some research in books and on the internet.

Pine trees in Tokai Forest, Cape Town.

QUESTIONS :

1. Find out what it means if a plant is indigenous to South Africa. Some examples of indigenous plants in South Africa are aloes, acacia thorn trees, strelitzia flowers, rooibos and the the king protea. Write a description below.
   An indigenous plant is one which occurs naturally in a particular geographical such as South Africa.
2. What is an alien species? Why do we call it invasive? An example is the Jacaranda trees with the purple flowers which are very common in Pretoria.
   An alien species is one which is not indigenous to South Africa, or a particular geographical area. It has been brought in by humans from another part of the world. They are said to be invasive as they invade (take over) the areas in which indigenous plants grow.
3. How do gymnosperm plants reproduce?
   They reproduce by making seeds in cones.
4. In many parts of South Africa, plantations of pine trees are regulated so that they do not impact on the biodiversity of the indigenous plants. But, there are some forests of pine trees which are not used for timber anymore. The Tokai Forest in Cape Town is one of these. Many mountain bikers and runners enjoy doing their activities in this forest. The city of Cape Town started to clear these trees in 2011 so that they could get natural, indigenous fynbos to grow again. There was an outcry from some people as they said their shady riding spot had been ruined. What are your thoughts on this? Do you think Cape Town should be cutting down these trees or not? Give reasons for your answer.

Learner-dependent answer. Learners may either disagree or agree. There are many viewpoints on this at the moment. Perhaps they feel that this is one area which mountain bikers should be allowed to enjoy as a forest as the rest of Table Mountain is covered in fynbos. Alternatively, they may agree that we need to re-establish the local flora and fauna, and although it may take time for a forest and shade to regrow, it will be better in the long run from an ecological point of view.

VISIT
Pretoria's Jacaranda trees are an 'alien' problem.
(video) bit.ly/16HN2ss

Let's now take a look at the other group of seed-producing plants, angiosperms.

Angiosperms

Angiosperms are flowering plants. They produce flowers which develop into seeds that can grow into new flowering plants. We will learn more about reproduction in angiosperms in the next chapter. Most of the plants that you probably see around you in the gardens are flowering plants.

TEACHER'S NOTE

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

We can group flowering plants into two major groups:

- **monocotyledons**
- **dicotyledons**

All the angiosperm plants that we are studying have the following characteristics in common:

- roots
- stems
- leaves
- flowers
- fruits
- seeds

A huge thorn tree does not look anything like a maize plant, yet they are both flowering plants. They both have roots, **stems**, leaves and their flowers produce seeds. So why can we group the one as a dicotyledon and the other as a monocotyledon? Let's find out!

TEACHER'S NOTE

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

ACTIVITY: Discovering the differences between monocotyledons and dicotyledons

INSTRUCTIONS:

1. Study the photos of South African monocotyledons and then dicotyledons.
2. Answer the questions which follow about each group.

Monocotyledons:

Maize

Sugar cane

Agapanthas

Bull rushes

QUESTIONS:

1. Describe the leaves of the monocotyledons in the photos. How would you describe the veins in the leaves? Make a drawing to accompany your description.
   Learner-dependent answer. The leaves are generally long and narrow. The veins run parallel down the length of the leaves.
2. Describe the stems. Are they woody stems or green (**herbaceous**) stems?
   The stems are all green, with no wood. They are herbaceous.
3. Look at the following photos of typical monocotyledonous flowers. Count

how many petals are on each flower. What can you generalize about the number of petals (and other flower parts) in monocotyledonous flowers?

A disa

Agapanthus flowers

The agapanthus flowers also have six petals, the disa has three petals. We can say that in general, monocotyledonous flowers have parts in multiples of three.

4. Many of the crops that we grow are monocotyledons, such as maize and sugar cane. Name two others.
Some examples include: wheat, rice, oats, barley, sorghum.

Dicotyledons:

Plumbago bush.

A geranium.

Fig tree.

Protea bush.

QUESTIONS:

1. Describe the leaves of the dicotyledons in the photos. How would you describe the veins in the leaves. Make a drawing to accompany your description.
The leaves are varied in shape and size. They are generally broad and the veins form a branching network across the leaves.

2. Describe the stems. Are they woody stems or green (herbaceous) stems?
The stems are varied, some are green and some are woody, for example in the tree species.
3. Look at the following photos of typical dicotyledonous flowers. Count how many petals are on each flower. What can you generalize about the number of petals (and other flower parts) in dicotyledonous flowers?

Geranium flowers.

Plumbago flowers.

VISIT

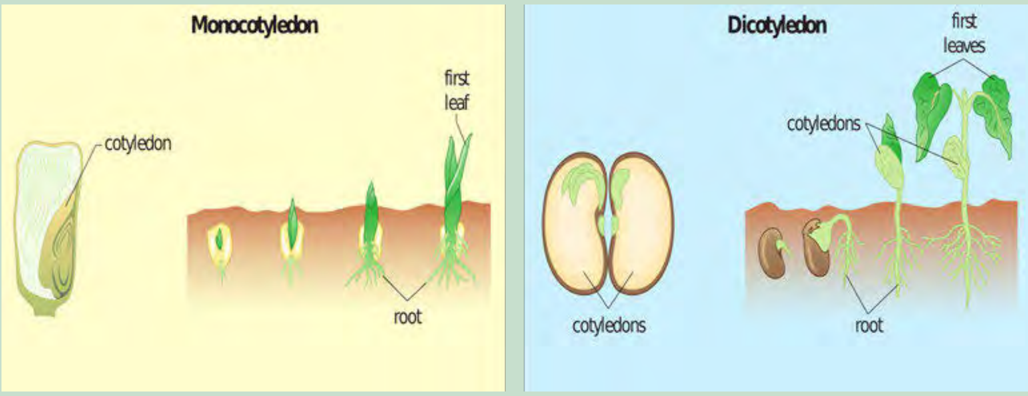
Find out which of South Africa's plants are most threatened and closest to extinction bit.ly/16x8r7H

Hibiscus flower.

Hydrangea flowers.

The geranium flowers have ten petals, the plumbago flowers have five petals, the hibiscus flower has five petals, the hydrangea flowers have four petals. We can say the dicotyledons have flowers with parts in multiples of four or five.

4. Look at the following image which shows the difference between monocotyledonous seeds and dicotyledonous seeds. Monocotyledons have one **cotyledon** and dicotyledons have two cotyledons.



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

5. Using the information you have discovered in this activity, complete the following table to summarize the differences between monocotyledons and dicotyledons.

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

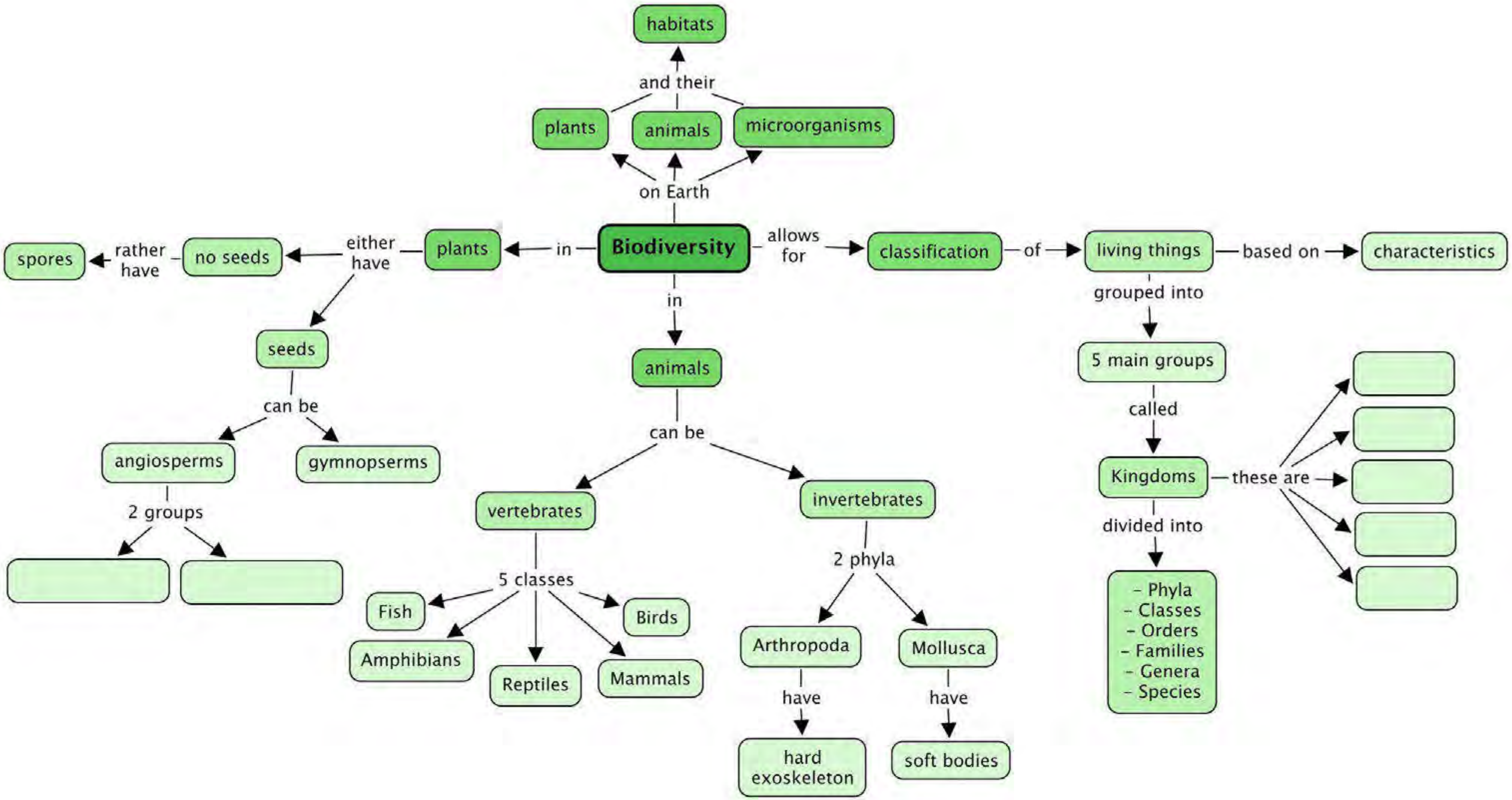
SUMMARY:

Key Concepts

- All the plants, animals and microorganisms and their habitats make up the total biodiversity of planet Earth.
- Living organisms are sorted and classified according to their shared characteristics.
- We use a classification system that groups living organisms into five main groups or kingdoms: Bacteria, Protists, Fungi, Plants and Animals
- All living organisms have to perform the seven life processes and the way in which they perform these help us to classify them into different groups, putting plants into one group and animals into another for instance.
- We can divide a kingdom into smaller and smaller groups, in this order: phyla, classes, orders, families, genera and species.
- In the kingdom of animals, we can get two main groups of animals - this with a backbone called vertebrates, and those without a backbone called invertebrates.
- The vertebrates are divided into five groups: Mammals, Birds, Reptiles, Fish and Amphibians.
- The invertebrates make up the largest group of animals and there are many thousands of species. We also divide the invertebrates into different groups or phyla like the arthropods, molluscs, sponges and jellyfish, and many others.
- Arthropods all have a hard exoskeleton and jointed legs, such as insects, arachnids (spiders) and crustaceans (crabs).
- Molluscs have a soft body with or without a shell, such as snails and octopuses.
- In the kingdom of plants we also get two main groups: plants that produce seeds and plants that do not produce seeds but spores.
- Seedless plants produce spores - like ferns and some mosses.
- Seed producing plants can be further divided into angiosperms (seeds in fruit) and gymnosperms (seeds in cones).
- Angiosperms can be divided into monocotyledons and dicotyledons.
- Monocotyledons have seeds that only have one part or cotyledon. Their stems are herbaceous. The leaves are simple, long and narrow and their flower parts are arranged in multiples of three.
- Dicotyledons have seeds with two parts or cotyledons from which their **tap root** grows deep into the soil. Their stems can be woody or herbaceous. The leaves are varied in shape and size and have a network of **leaf veins**. Flower parts are usually arranged in multiples of four or five.

Concept Map

This concept map shows how the concepts in this chapter on Biodiversity link together. Complete the concept map by filling in the five Kingdoms that living things are classified into, and also giving the two major groups of angiosperm plants. Can you see how the arrows show the direction in which you must 'read' the concept map?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either
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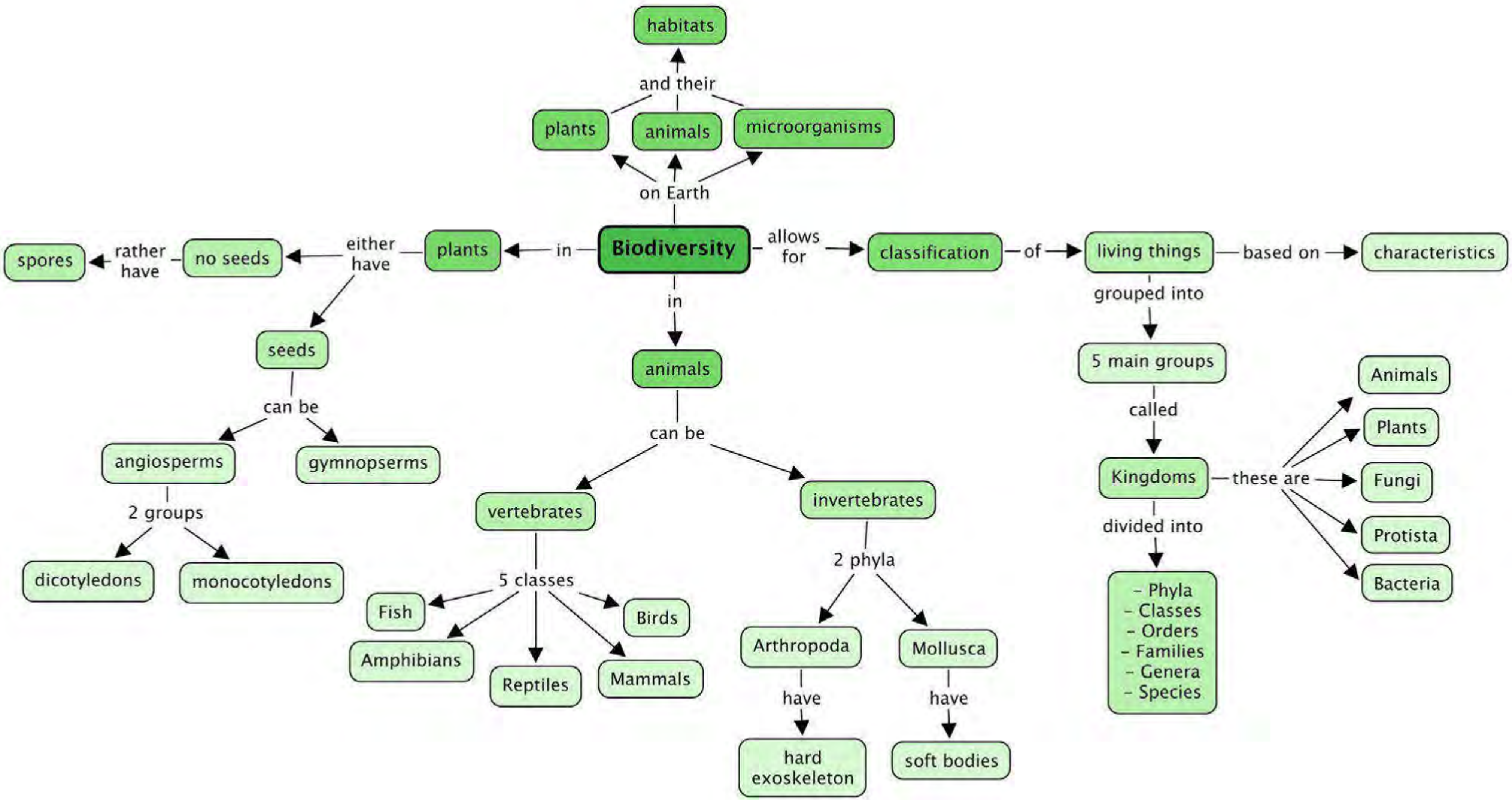
angiosperms
gymnopserms
2 groups
in
animals
can be
vertebrates
5 classes
Fish
Amphibians
Reptiles
Mammals
Birds
invertebrates
2 phyla
Arthropoda
have
hard exoskeleton
Mollusca
have
soft bodies
allows for
classification
of
living things
based on
characteristics
grouped into
5 main groups
called
Kingdoms
these are
divided into
- Phyla
- Classes
- Orders
- Families
- Genera
- Species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animals
can be
vertebrates
5 classes
Fish
Amphibians
Reptiles
Mammals
Birds
invertebrates
2 phyla
Arthropoda
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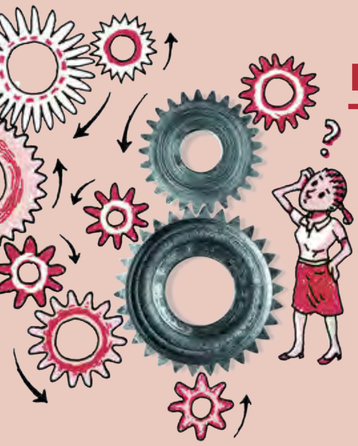
hard exoskeleton
Mollusca
have
soft bodies
allows for
classification
of
living things
based on
characteristics
grouped into
5 main groups
called
Kingdoms
divided into
- Phyla
- Classes
- Orders
- Families
- Genera
- Species
these are
Animals
Plants
Fungi
Protista
Bacteria

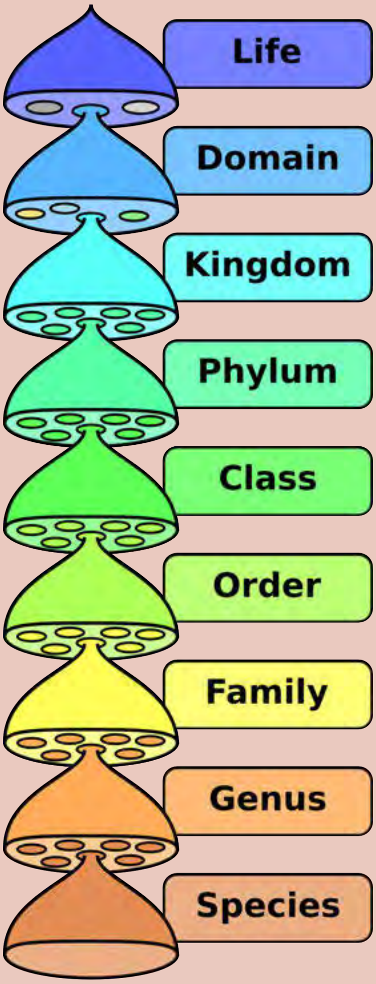
TEACHER'S NOTE

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.



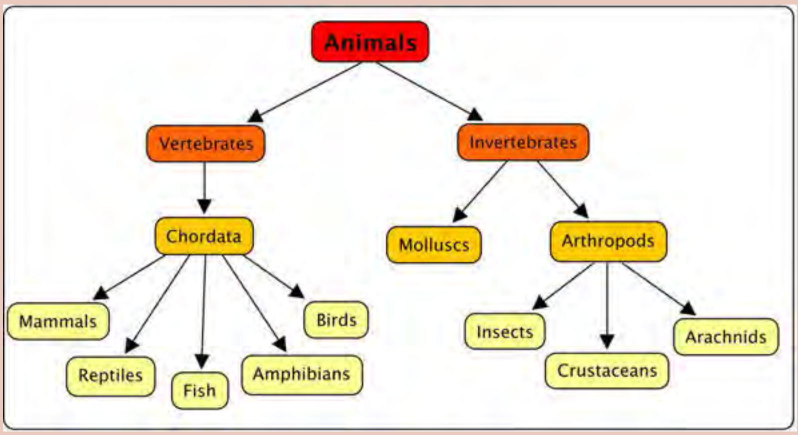
REVISION:

1. Use the following diagram to fill in how we classify organisms. The first 3 have been filled in as we did not discuss domains in this chapter. You will learn more about domains in later grades. [6 marks]



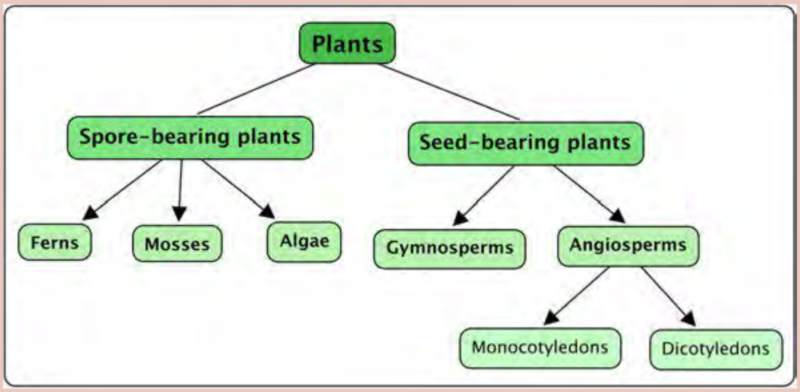
2. Which two levels of classification do we use to name an organism. What is the correct way to write the scientific name of an organism? [3 marks]
We use the Genus and Species name. The correct name is the Genus must have a capital letter and the species a small letter and it is in italics if typed or underlined if handwritten.
3. Why was Aristotle's method of classifying animals as walkers, swimmers or flyers not very effective? [2 marks]
As more animals were being discovered it became obvious that many animals can fall into all of these classes and thus it was not a very accurate method of classification.

4. Use the following space to draw a classification diagram of the animal kingdom. It has been started for you. You only need to include the phyla and classes that we studied in detail. [11 marks]
Learner-dependent answer.
The following gives an example of the animal classification learners could have drawn.



5. Give one word for the following or complete the sentence required:
   a) The existence of a large number of different kinds of plant and animal species which make a balanced environment. [1 mark]
   b) The animal kingdom can be divided into two main groups. [2 marks]
   c) The five classes of vertebrates are: [5 marks]
   d) The phylum of animals that have a hard exoskeleton. [1 mark]
   e) The phylum of animals that have a soft body often protected by a shell. [1 mark]
   a) biodiversity
   b) vertebrates and invertebrates
   c) fish, amphibia, reptiles, mammals, birds
   d) arthropods
   e) molluscs
6. Write true or false next to each of the following sentences. If the sentence is false, rewrite it so that it is true. [10 marks]
   a) A small percentage of the living organisms on Earth are invertebrates.
   b) Invertebrate animals do not have a backbone.
   c) Spiders are examples of arthropods.
   d) All molluscs have exoskeletons in the form of shells.
   e) Birds only have feathers as their body covering.
   f) Endothermic animals need to keep very still when it is cold.
   a) False - A large percentage of living organisms are invertebrates; OR A small percentage of the living organisms are vertebrates.
   b) True
   c) True
   d) False - Molluscs typically have a hydroskeleton and only some have shells.
   e) False - Birds have feathers but also have leathery scales covering their legs. (A body covering encompasses the entire body of the animal.)
   f) False - An advantage of being endothermic is that the animal is able to move when it is very cold unlike cold-ectothermic animals.

7. Look at the following sentences and underline the one that *best* describes mammals. [1 mark]
   a) Mammals are animals that breathe, move, eat, reproduce and excrete.
   b) Mammals are animals that can regulate their body temperatures.
   c) Mammals are warm blooded animals that feed their young, have special organs for breathing and a backbone.
   d) Mammals are warm blooded animals with mammary glands, a hairy body, lungs and a backbone.
   e) Mammals give birth to live young, can be found living on land and in water, and can sense their environment with well defined smell and touch senses.
   a) Too broad - all animals should be able to fulfil these if they are alive.
   b) Too vague - birds and mammals can regulate their body temperatures.
   c) Too vague - this can easily describe birds as well.
   d) Learners should underline d.
   e) Could describe a boa constrictor as well.
8. Describe how the seeds of angiosperms differ to those produced by the cycads. [2 marks]
   Seeds in angiosperms are enclosed in fruit; seeds of gymnosperms are 'naked' or on the cone itself.
9. Use the following space to draw a classification diagram of plants. [10 marks]
   Learner-dependent answer
   Learners could produce something like the following.



Total [55 marks]

Sexual reproduction

TEACHER'S NOTE

Chapter overview

3.5 weeks

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

3.1 Reproduction in Angiosperms (5 hours)

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

3.2 Human Reproduction (5.5 hours)

Tasks	**Skills**	**Recommendation**
Activity: What happens during puberty?	Identifying, listing	CAPS suggested
Activity: Draw a timeline of your life	Thinking, remembering, drawing, presenting	CAPS suggested
Activity: Conduct a survey	Reading, communicating, recording, discussing	CAPS suggested
Activity: Write a letter	Thinking, writing	Optional (Suggested)

KEY QUESTIONS:

In angiosperms

- How do plants make seeds?
- What is the role of flowers in reproduction?
- Flowers come in so many different colours, shapes and sizes. So, are there some structures that are common to all flowers?
- What is a 'pollinator'? Why are pollinators also important to humans? Is the flower on a rose the same as the flower on a sweet pea or on a daisy bush?
- Why are seeds in different shapes and sizes, or contained in fruits? Does it have something to do with the way seeds are spread to new areas?
- Does fertilisation mean the same things in plants as it does in animals?

In humans

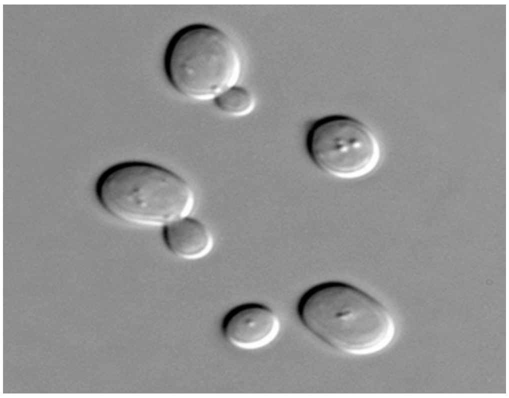
- Why is your body starting to change?
- What is puberty and what does it mean when we "reach puberty"?
- How is it possible that we all go through puberty at different times and rates?
- What changes take place inside our bodies during puberty?
- What do our reproductive organs look like when they are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

VISIT
A video on asexual reproduction bit.ly/18dp5dE

All living organisms on Earth need to be able to reproduce so that their species does not become extinct. There are two basic ways in which reproduction can take place:

- asexual reproduction
- sexual reproduction

Asexual reproduction occurs when one parent organism makes offspring which are identical to the parent. The parent organism therefore does not need to **mate** to produce new organisms. Archaea, Bacteria, Fungi and Protists reproduce asexually. Many plants and algae reproduce asexually and also some animals, such as some species of insects, reptiles, sharks, snails and crustaceans.



These yeast cells are undergoing budding, a type of asexual reproduction. Can you see the smaller offspring 'budding' off the parent?

A mother aphid with offspring which were produced asexually or sexually, depending on the conditions.

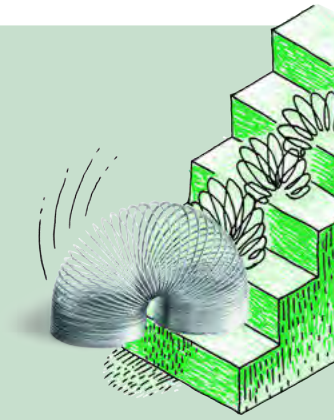
In this chapter we are going to learn about **sexual reproduction** where two parent organisms mate and their **genetic information (DNA)** combines to make offspring which look similar, but they are not identical. Sexual reproduction takes place in most plants and animals. We will look at flowering plants (angiosperms) as an example of sexual reproduction in plants and at human reproduction as an example of reproduction in animals.

3.1 Reproduction in angiosperms

TEACHER'S NOTE

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

How do plants make new plants? In this chapter we will learn about how **angiosperm** plants reproduce. Sexual reproduction in angiosperms results in the formation of seeds. Under the right conditions, these seeds will germinate and grow into a new plant.



ACTIVITY: Growing a bean plant

MATERIALS:

- bean seed
- paper towel, toilet paper or tissue
- glass jar (or transparent plastic tub/ jar)
- water
- measuring tape or ruler

INSTRUCTIONS:

1. Place some kitchen roll, toilet paper or tissue in your transparent jar.
2. Insert the bean into the paper and place it against the side of the jar so that you can observe the changes that occur.
3. Add a little bit of water so that the paper towel is damp.
4. Place in an area which gets sunlight.
5. Add a little sprinkling of water every day to keep the paper towel damp.
6. Each day, starting on the day that you plant your seed, measure the length of the bean or height of the bean plant and record it in the following table.

Day	Height of plant (cm)	Comment/ notes
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

7. Take notes of your observations from day to day. For example, on what day did your bean start to grow roots? On what day did the stem sprout? When did you see the first leaf (or leaves)? How many were there and what did they look like?

QUESTIONS:

1. What is the term for when a seed starts to grow?
   Germination
2. What are the requirements for a seed to grow?
   Moisture (water), warmth and light
3. Use your table of measurement to draw a graph of plant growth (height) over the 14 days of your investigation.
   Learner-dependent answer

VISIT
Watch a bean plant germinate and grow.
bit.ly/14GGtYn

Now let's learn how plants make seeds. In sexual reproduction, half of the male's and half of the female's genetic material (DNA) fuses (combines) to create a new individual with the combined genetic materials of the parent plants or animals. In most animals we can usually easily identify two sexes of animals: a male or a female animal, which each have male and female parts. In angiosperm*s,* the flowers are the sexual organs of the plant. The flowers produce male and female structures that can either be on the same plant or can be on two separate plants. Let us have a closer look at the structures of flowers.

Flower structures

Flowers are the sexual organs of angiosperms. Many plants have both the male and female reproductive organs in the same flower although some may have male and female structures on different plants all together.

Flowers come in many different shapes, sizes and colours, as in the photographs in the next activity illustrate, but there are components which can usually be identified in all flowers. These are:

- peduncle
- receptacle
- petals
- sepals
- the male structures
- the female structures

Flowers are typically set on a stem which may be long and rigid like a rose or agapanthas stem, or short and flexible like those on a petunia. The stalk or stem of a flower is called the **peduncle**.

The **receptacle** is the top part of the flower stalk where the different flower parts attach.

While the flower bud is forming, small green leaves protect and enclose the young bud. These are the **sepals**. The sepals are often green and look like small leaves, and since they are green they can also photosynthesise. Sometimes the sepals may be the same colour as the petals, like in lilies or tulips.

Flower **petals** are usually the brightly coloured parts of the flower. They attract

pollinators, such as insects and birds and also bats and mice. We will look more at **pollination** a bit later. In some plants the petals are very small and may even be absent. This is often because these flowers depend on the wind to carry the **pollen** away and therefore do not need petals to attract animals, such as grasses.

TAKE NOTE

Plants can be broadly divided into gymnosperms and angiosperms. Remember that angiosperms produce flowers, and their seeds are within a fruit, whereas gymnosperms produce seeds in cones.

Grass flowers.

ACTIVITY: Identify the outer structures of flowers

Rose.

Water lilies.

Petunias.

QUESTIONS:

1. What do we call the part of the stalk where the flower petals and sepals attach to the flower stalk?
   Receptacle.
2. Explain why the petals on some flowers are brightly coloured while on other plants we can hardly see the petals, and sometimes they are absent altogether.
   The brightly coloured petals attract pollinators. Plants pollinated by wind do not need to attract insects or animals to pollinate them and thus do not need brightly coloured petals. By not producing petals they can invest in producing more pollen instead.
3. Study the photos of the different flowers above. Describe the outer structures of each of these flowers based on their peduncles (stalks) and receptacles, and their sepals and petals.

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

The structures of the flower that we have discussed here are on the outside. The reproductive structures of the flower are in the middle of the flower. Flowers can contain either male structures or female structures, or both.

Male reproductive structures

TEACHER'S NOTE

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

TAKE NOTE

What are cells? Cells are the smallest building blocks of organisms. There are many different kinds of cells, for example, cheek cells, muscle cells and nerve cells in some animals; or leaf cells, root cells or petal cells in plants.

In this section, we will be talking about sex cells. These are either male or female sex cells and only carry half the genetic material (DNA) of a typical cell. When these sex cells fuse the two halves from the male and the female organism make a new organism with the combined genetic material (DNA) from both.

The **stamen** is the male part of the flower. There are two parts to the stamen: the **anthers** and the **filaments** on which the anthers rest.

Anthers produce the pollen that contain the male reproductive sex cells. The male cells in the pollen is carried to the female sex cells and when they fuse they will create a seed which can grow into a new plant.

Filaments are stalk-like structures that support the anthers. In some flowers the filaments may be long and in others relatively short.

The male structures are clearly seen in this close up photo of a flower with the anthers covered in pollen and supported by the stalk-like filaments.

TAKE NOTE

Each carpel consists of a stigma, style and ovary. Some flowers have one carpel, and some have many. Therefore in some flowers, the carpel and the pistil are the same thing, but in others, many carpels make up one pistil!

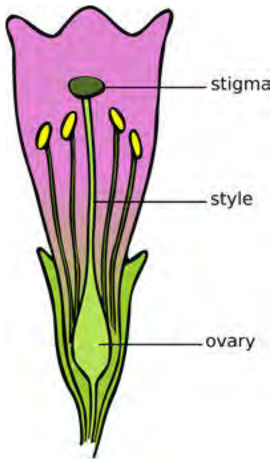
Female reproductive structures

The **pistil** is the female organ of the plant and is usually at the centre of the flower. It consists of a stigma, style and ovary. All the parts of the pistil work specifically to help the plant receive pollen, transport it and have it fertilise the **ovules** (that contain female sex cells). Ovules become seeds after **fertilisation**.

The **stigma** is the structure that receives the pollen during pollination. It is on top of a long narrow style and when it is ready to receive pollen it becomes sticky providing a place for the pollen to stick to.

The **style** is a long tube that connects the stigma with the ovary and the ovules. The style supports the stigma and holds it in the best possible position to receive the most pollen grains. After the pollen has landed on the stigma, the pollen grows long tubes called pollen tubes down through the style from the stigma to the ovules in the ovary.

The **ovary** is the enlarged structure at the base of the pistil. It may be divided into different parts (or locules) and produces the ovules that contain the female reproductive sex cells. Within the ovule is the **embryo sac**. The embryo or tiny seed will develop in here.



The female flowers parts making up the pistil.

ACTIVITY: Flower dissection

MATERIALS:

- dissecting needle
- dissecting knife
- petunia or hibiscus flowers

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Study the following diagram of a flower. Use your understanding of the **outer structures** of a flower to add the following labels: petal, sepal, receptacle and peduncle. Once we have done the dissection, we will come back to label the inner structures.

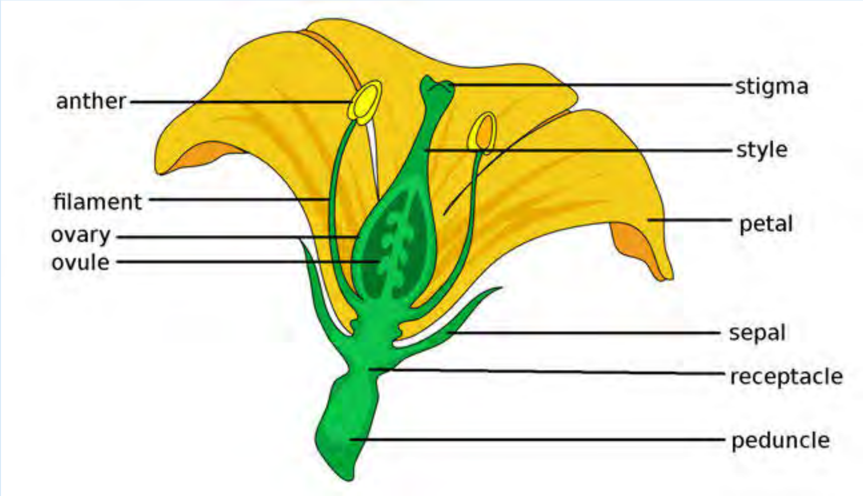
VISIT
Watch a flower dissection.
bit.ly/15yql7o

TEACHER'S NOTE

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

TEACHER'S NOTE

A labelled diagram should look as follows:



2. Go out into your garden or explore the school grounds and surroundings and select a flower of your own to dissect. If your teacher has petunias or hibiscus flowers, dissect one of those.

   a) First remove the outer sepals.
   b) Then remove the petals. You have now exposed the ovary.
   c) Identify the male and female structures. Label these on the diagram above.
   d) Using your dissecting knife or scalpel, cut the ovary in half.
   e) Use the dissecting needle to carefully open up the ovary. See if you can identify the ovules.
   f) Label the ovary and ovule on the above diagram.

Now that we have learnt about the structures of flowers, let us take a look at how flowers are pollinated.

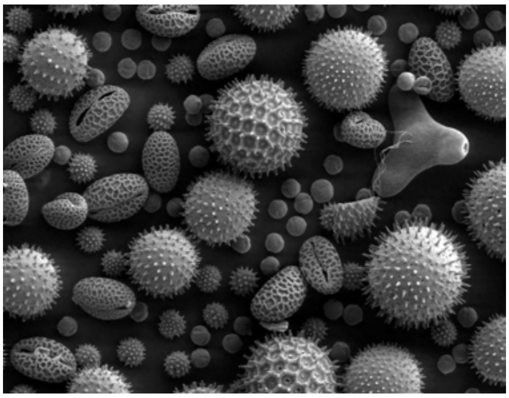
Pollination

TEACHER'S NOTE

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

In order for a flowering plant to reproduce sexually, the male sex cells need to fuse (join) with the egg inside the ovules. The stamen produces pollen that contain the male sex cells. The pollen grains are usually very small - about the size of a speck of dust.

This person's hand is covered in millions of tiny grains of pollen.



A photograph of a variety of pollen grains from different plants taken under a very strong microscope.

TEACHER'S NOTE

The image of pollen here is taken using a scanning electron microscope. You can mention this to learners, but they will only formally learn about different microscopes in Gr. 9 Life and Living.

VISIT

Watch some fascinating videos about pollination bit.ly/18dpxZf or bit.ly/148pQjS

Pollen from the stamen needs to be transferred to the stigma of the flower, either on the same plant or another plant of the same species. This process is called **pollination**. If pollination does not occur, there will be no fertilisation and the plant will not be able to produce seeds or fruit.

Generally plants produce a large amount of pollen to maximise the chances of the pollen being transferred to as many different stigmas on as many different flowers (of the same species) as possible.

Can you identify the stamens covered in pollen and the stigma in this hibiscus flower?

TEACHER'S NOTE

There are numerous stamens covered in yellow pollen and the four 'stalks' with rounded heads sticking out the top are the stigma.

TAKE NOTE

An adaptation refers to the way a behaviour or particular structure of the plant has changed (evolved) over time to best perform its function.

Pollination involves the pollen moving from the stamens to the stigma of the same or another flower. There are different ways that pollination of flowers can take place. For example, flowers can be pollinated with the help of the wind, water or animals. Angiosperm flowers have special adaptations which help a specific type of pollination. Let us look at some of these methods for pollination and how flowers are adapted to promote pollination.

Pollination by animals

Animals that pollinate flowers are called pollinators. These animals come to flowers to feed on the nectar produced by the flowers. As they are feeding, pollen sticks to their bodies. When they move on to the next flower to feed, some of the pollen rubs off onto the new flower parts. We call this process pollination.

Can you see this bee has been covered in pollen as it is feeding on the nectar?

Since pollinators feed on specific plants, they usually travel from flower to flower of the same species, therefore pollinating them effectively.

ACTIVITY: Identifying pollinators

INSTRUCTIONS:

1. There are many different types of pollinators, some of which are shown below. Identify the pollinator in each photo in the table and write the name on the line below. Answer the questions that follow.

	
Moth	*Sunbird*
	
Honey bee	*Beetles*
	
Butterfly	*Bat feeds on nectar*

QUESTIONS:

1. What do you notice about most of these pollinators? (Which type of animal is most common?)
   They are mostly insects.

2. What do you think these pollinators are getting from the flowers that they visit?
These pollinators are mostly feeding on the nectar, and also on the pollen in some cases.
3. What do you think attracts insects to flowers? In other words, how do you think flowers are adapted to attract pollinators to them? See if you can think of three adaptations and list them below.
Flowers have large colourful petals to attract pollinators.
Flowers have sweet nectar for pollinators to feed on as a reward.
Flowers have a sweet scent to attract pollinators.
Note: *A common misconception among learners is that they think flowers make pollen for the insects. Insects, such as bees, do collect the pollen and use it for the manufacture of the wax in their hives, but this is not why flowers make pollen. Also, flowers do not make nectar for the bees, rather you must stress that the nectar is made as a reward system for the pollinator.*

4. Flowers are also adapted so that when the pollinators visit them, they make sure the pollen rubs off onto the pollinator to be transferred to another flower. Look at the following image of a bird visiting a flower to drink nectar. How do you think this flower is adapted to make sure that it is pollinated by the bird?

A bird drinking nectar from a flower.

The flower is long and thin so that the bird has to stick its beak down the flower and then it will rub its head against the stamens containing the pollen. The stamens and stigma are long and sticking out the top of the flower so that they brush against the head of the bird when it is drinking nectar and the pollen then either sticks onto the bird's head or some from another flower is rubbed off onto this flower. The flower stem needs to be strong to support the bird.

5. The following flower is called a Voodoo Lily. Unlike the flowers we have looked at so far which give off a sweet scent to attract pollinators, this flower gives off a really bad smell, like rotting meat or cow dung. The colour of the petals are also dark, like meat. This shows that different flowers have adapted to different pollinators.

A Voodoo Lily.

What types of pollinators do you think will pollinate this flower? Hint: Think of which insects you normally find when there is rotting food around.
Flies are attracted to rotting meat and so the most likely pollinators of this flower are flies.

6. **Work in pairs for the next 4 questions.** Take a walk around your school and identify plants that you think are pollinated by pollinators. Make a drawing of at least 3 of these.
Learner-dependent answer.

7. Identify the common names of these plants and try to find the correct scientific name.
   Learner-dependent answer. ***Note:*** *If possible, invite the school's maintenance personnel to help learners identify the names of these plants. Let them do an Internet search to find the scientific names or have gardening books available in class for them to search in.*
8. Explain how each of these plants' flowers have been adapted to be pollinated by pollinators.
   Learner-dependent answer. Learners might refer to the brightly coloured petals, strong scent, the specific length of the stigma, stamen, nectar pouch, etc.
9. How could you easily distinguish which plants used pollinators to pollinate them?
   Learner-dependent answer. Answers should include an explanation that these plants have brightly coloured flowers to attract certain insects for example, a strong odour or perhaps a long nectar producing pouch.

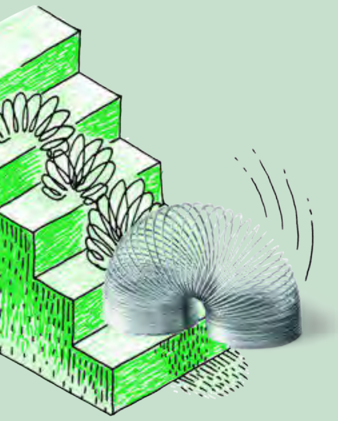
Pollination by wind and water

Many flowers are pollinated by animals, as we discussed in the last section, but wind and water can also help pollination. Do you think plants that are pollinated by the wind or water need colourful, sweet-smelling flowers with nectar? Why do you think this?

TEACHER'S NOTE

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

There are some challenges that plants face if they rely on the wind or water for pollination. These plants have adapted to overcome these challenges so that they can be pollinated by the wind or water.



ACTIVITY: Studying the flowers of wind and water pollinated plants

TEACHER'S NOTE

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

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

INSTRUCTIONS:

1. Study the following photos of the flowers of different types of grasses that are pollinated with the help of the wind.
2. Answer the questions which follow.

In this grass plant you can see the small yellowish flowers attached to the green stem.

These white, feathery ends are the flowers of this grass.

Can you see the small, brown flowers sticking up from the maize plants? These

This image shows the silky female flower of the maize plant.

TEACHER'S NOTE

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

QUESTIONS:

1. Write a description of the flowers in the photos. Your description must show that you have observed the colour of the flowers, the size, the shape and how many there are on each plant.
The flowers are not colourful like the flowers that are pollinated by animals. They are dull in colour (whites, browns and greens). The flowers are quite small, but there are many flowers per plant. The flowers are mostly long and slender and quite flimsy (loose). There are large number of anthers which hang out of the flower so the pollen can easily be swept away by the wind.
2. Why do you think these flowers are not colourful like the flowers in the last activity?
These flowers do not need to attract animals with their colourful petals as they rely on the wind for pollination.
3. Do you think the flowers in wind pollinated plants produce nectar? Why do you say so?
Generally these flowers do not produce nectar as they do not need to attract animals to feed on them in order to pollinate them. They rely on the wind.
4. What types of plants are generally pollinated by the wind?
Mostly grasses and reeds, and also many trees.
5. The flowers in these photos generally produce a huge amount of pollen. They produce much more pollen compared to the flowers pollinated by animals. Why do you think this is so? Hint: Think of the chances of a flower being pollinated by an animal which visits it to drink nectar, compared to the chances of being pollinated by pollen that is carried in the wind.
Learners may battle with this question so you could discuss it as a class. These flowers produce large amount of pollen as they cannot predict which way the wind will blow, so the more pollen the greater the chances that pollen will land on other flowers when carried in the wind. In flowers that are pollinated by animals, the animals transfer the pollen directly from one flower to the next, so they can produce smaller amounts. In flowers that are wind pollinated, they have to rely on the chance that the wind will blow and that it will blow in the right direction. The more pollen there is the greater the chances of pollination.
Note: *At this point you can also point out to learners that plants that are wind pollinated often grow in large populations where the huge numbers of plants increase the chances of these plants being pollinated (think of fields of grasses or reeds or forests of trees).*
6. In animal pollinated flowers, the pollen is often sticky and clumps together. This is so that it sticks to the animal which is visiting the flower for nectar and can then be carried to the next flower. In wind pollinated flowers, the pollen is very different. The pollen is smooth and not sticky. It is also very light and small. Why do you think this is so?
In wind pollinated flowers, the pollen needs to be carried by the wind as it blows. Therefore, the pollen cannot be sticky, otherwise it will not be blown off the flowers when the wind blows. it also must not clump or stick together otherwise it will not be carried in the wind. The smaller and lighter the pollen grains are, the further the wind can carry it.
7. The structures of the male and female parts in wind pollinated and animal pollinated flowers are also different. For example, in wind pollinated plants,

the stamens (male structures) often have much longer filaments and the anthers hang down and can move easily. The stigmas (female structures) are also often large and look like feathers, as you can see in the photos in this activity. How do you think these adaptations of the stamen and stigma help the flowers to be pollinated by the wind?
The long filaments of the stamens enables the anthers to be exposed to the wind so that the can blow and move in the wind and easily release the pollen. The stamens are large and feather-like so that they can 'catch' the pollen in the air as it blows through. They are still light so that they can blow and wave around in the wind.

8. Fill in the following table to compare the structures of wind pollinated plants and pollinator (animal) pollinated plants.

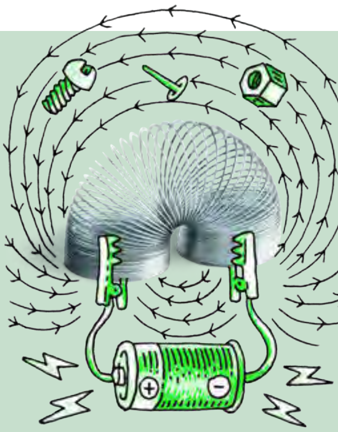
Structure	***Wind pollinated plants***	***Pollinator pollinated plants***
Petals	*Very small or absent petals that may be brown or dull green - do not need to attract insects.*	*Large, brightly coloured petals to attract insects*
Scent	*No scent - do not need to attract insects.*	*Often specific scent to attract specific pollinator.*
Nectar	*No nectar - do not need to attract insects.*	*Many produce nectar to attract insects.*
Amount of pollen	*Very large quantities of pollen produced as there is a lot of wastage.*	*Smaller amounts of pollen produced because there is less wastage than in wind pollinated plants.*
Structure of pollen	*Pollen light and smooth to travel on the wind and not clump together.*	*Pollen often sticky or spiky to attach to pollinators.*
Anthers	*Anthers loosely attached and dangle down (mostly) to release pollen easily into the wind.*	*Anthers firmly placed inside flowers to brush against pollinators.*
Stigma	*Stigma is large and feather-like to filter the air and catch the drifting pollen.*	*Stigma is inside the flower where the pollinator will brush up against it and has a sticky coating that the pollen sticks to.*

Plants that are pollinated with the help of water usually live in water. We say they are aquatic. When pollen is released it floats on the surface of the water. The stigmas of the receiving plant are generally close to the water surface. This is so that they can be pollinated when the pollen in the water washes up against them.

Pollinators and us

Pollinators play an extremely important role in the life cycle of flowering plants. These flowering plants include the crops that farmers grow for us to eat, such as maize and sunflowers. Since angiosperms produce a very large amount of the world's food crops, without pollinators, we would be without most of the food crops produced for us to eat.

ACTIVITY: Article from "The Earth Times"



INSTRUCTIONS:

1. Imagine it is the future - it is the year 2056!
2. Read the following article from a newspaper called "The Earth Times".
3. Answer the questions that follow.

Loss of pollinators lead to crop destruction - third year of famine

23 May 2056

The loss of pollinators in Southern Africa, specifically wild bees and butterflies, has lead to further crop failures three years in a row. Very few viable seeds remain to plant the next crop. The next crops planted might be the last ones unless another means of pollination can be found.

The entire region has been severely affected by the sudden death of large swarms of bees and butterflies in the past 5 years. Bees and butterflies, that were once so common, are almost extinct.

One group of researchers have been working to preserve the last remaining colony of bees. It was found hidden away in the mountains of the Helderberg Nature Reserve. So far they report that the colony is doing well and have added 127 new worker bees this week. It is hoped more colonies will be found in other remote mountain regions.

The researchers are still trying to identify the cause of the extinction of these insects. They think that the huge increase in air pollution and acid rain has affected the wings and flight of these insects. They are therefore not able to fly to food sources, such as the nectar of flowers, and then die.

The lead researcher, Dr Wimple, has indicated that they have wild bee larvae from other parts of the world which were frozen several years ago to preserve them. The team is now close to reintroducing these bee larvae into the remaining colony. They hope this will increase the diversity of the population. Dr Wimple's team is working closely with other similar teams around the world to find a possible solution.

The team is also looking at ways to modify the crop plants to increase how efficient they are at being pollinated by the wind, for example maize crop plants. They hope that this will increase the production of maize. They need to do this by changing the DNA of the existing crop plants. This is called genetic modification. "It's a long shot but one we hope will bear fruits" commented Dr Wimple.

Bees, and other pollinators, are dying due to air pollution.

VISIT
Pollinators and us. (video)
bit.ly/14J8Ms6

QUESTIONS:

1. Find the following words in the article and underline them. Then look up a definition for each word and write it down. Identify whether the word is a noun, verb, adverb or adjective. Do not copy the definition word for word, but write it in your own words.
   a) famine:
   b) failure:
   c) severely:
   d) extinct:
   e) preserve:
   f) remote:
   g) diversity:
   h) modify:

   a) (noun) extreme hunger, starvation or lack (scarcity) of food.
   b) (noun) when something does not work, and in this case, it specifically refers to crops which have produced a small amount or not produced at all
   c) (adverb) very badly, or harshly
   d) (adjective) the species has ended or died out, there are no more left
   e) (verb) to keep something alive or make it last
   f) (adjective) far away, out-of-the-way, away from human habitation
   g) (noun) something that has variety and differences
   h) (verb) to change

Write down the title of this article.
Loss of pollinators lead to crop destruction - third year of famine

3. What is the message that is brought across by the title and article?
The loss of the wild bees, butterflies and moths has caused major food shortages because they usually help pollinate the food crops; the message might also be a warning to us to value our bee and butterfly populations more, and to reduce air pollution.
4. Explain what the link is between the loss of pollinators and crop failures.
The pollinators are not around to pollinate the flowers of the crop plants. Therefore, the flowers are not fertilised and can then not produce seeds. There are then no seeds to plant the next crops for the next year, and therefore there is less food for humans.
5. Which specific pollinators were lost?
Wild bees, butterflies and moths.
6. What reason did the article provide for the loss of these pollinators?
The air pollution and resulting acid rain damaged the wings of the pollinators, who could not fly to reach nectar and therefore died of starvation.
7. Explain at least two ways in which wind pollinated plants' structures are adapted for wind pollination.
Learners could mention:
    - *Anthers are carried on long filaments that hang down. This allows the wind to move and carry away the pollen easily.*
    - *Pollen grains are light and dry to prevent them clumping together and are easily carried on the wind.*

   Female stigma is feathery and branched and acts as a filter trapping the pollen that is blown through it.
8. How do you think the researchers could modify the crops' flowers so that they are able to be pollinated more efficiently by wind?
Learner-dependent answer. Learners should make reference to the above adaptations in plants which are already adapted to be pollinated with the help of the wind.
9. Do you think the situation described in this article could happen in the future? Write a paragraph where you explain your reason why.
Learners can either agree or disagree that this could happen in the future. Their reasoning is important in this question. For example, they could reason that it might happen as there is already lots of air pollution and it is not decreasing so it could get to a level where it affects pollinators. Or else, they could say that they do not think air pollution will get to the level where it affects the flight of pollinators, or there could be other pollinators that might not be affected, etc.

VISIT
Watch this video about the mysterious disappearance of bees bit.ly/195ITRh

Fertilisation

We have now looked at pollination, but what happens next? What happens after the pollen lands on the stigma of the flower?

Do you remember that the pollen grains contain the male sex cells, and the ovary contains the ovules or female sex cells. The male and female sex cells each contains only half of the genetic material (DNA) from the parent plant. After pollination, the male sex cell in the pollen grain needs to fuse with a female sex cell in the ovary to produce a fertile seed. This is called fertilisation.

TAKE NOTE

An ovary can contain more than one ovule. If each ovule is fertilised, then the fruit will contain more than one seed. For example, think of an apple which has a few seeds inside the fruit.

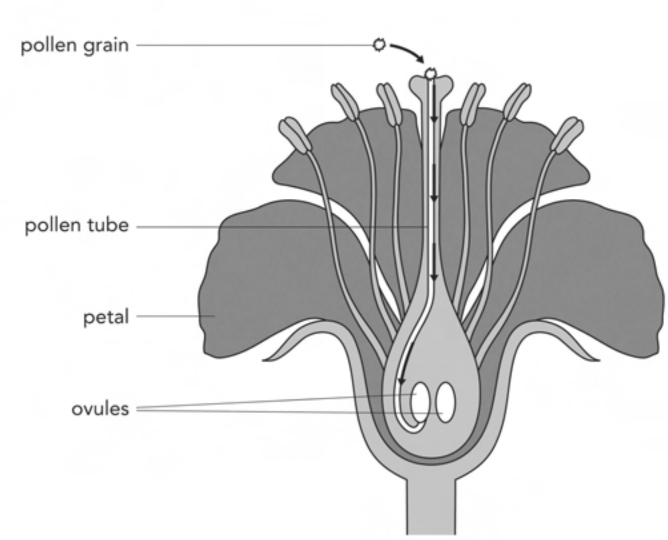
VISIT

A simple animation of fertilisation. bit.ly/17lTvt1

In angiosperms, each pollen grain contains two male sex cells. See if you can identify the reason for this as you read through the steps for fertilisation.

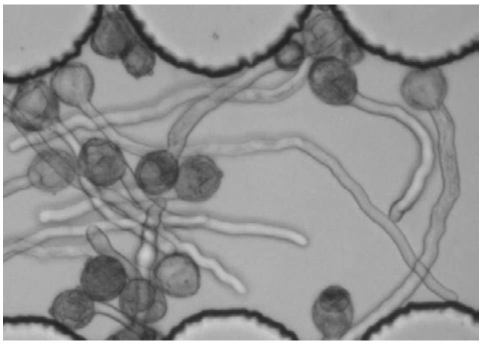
The process of fertilisation in plants occurs in clearly defined steps:

1. After the pollen grain lands on the mature stigma of a flower from the same species, the pollen produces a tube.
2. This **pollen tube** starts to grow from the stigma and down the style. This transports the male sex cells to the ovules.



The pollen tube growing down the style to the ovary.

3. There is a small structure inside the ovule called the **embryo sac**. When the pollen tube bursts into the ovule, one of the male sex cells fertilises the female sex cell in the embryo sac.
4. This fertilised egg develops into a seed.
5. The other male sex cell joins with another cell in the embryo sac to form the **endosperm**. The endosperm is the starchy food that is stored in the seed once it has ripened. Later this food is used to feed the germinating seed until it has formed leaves and can produce its own food through photosynthesis.
6. The ovary then starts to swell and enlarge, and becomes a fruit.



Can you see the pollen tubes growing here from individual pollen grains?

After fertilisation, the ovule inside the ovary starts to develop into a seed and the ovary wall becomes the rest of the fruit. There is huge variety in the types of seeds and fruit in the world.

This is one seed from the Coco de Mer plant and it has been cut in half.

Seeds from different orchid species. They are really small - like dust particles.

Think about all the different fruits that you can buy in the shops - there are many different shapes, sizes and colours!

There are many colours, shapes and sizes of fruit!

So why do plants have so many different kinds of seeds and fruit? This is because the seeds need to be spread to other areas to grow into a new plant. The shapes and structures of seeds help with this, and so too does the fruit. We say the fruit and seeds are **dispersed**. Let's look at some ways that seeds can be dispersed.

VISIT
Interactive website on the life cycle of plants
bit.ly/15R4ZYX

Seed dispersal

Plants use different methods to disperse their seeds as far from the parent plant as possible. Why do you think seeds need to be dispersed? Discuss this with your teacher and your class and take some notes.

TEACHER'S NOTE

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

Some points for the discussion:

- It is important that seeds are moved to different habitats than those directly around the parent plant.

- If the seeds that are produced by the parent plant germinate and start to grow directly under it, in some cases it may replace aging plants, but in most cases it would be in direct competition with the parent plant for light, minerals and water.
- When seeds grow too close to others, they grow long and spindly to reach enough light, making them weak and poor fruit producers.
- Therefore, in order to avoid being in competition with the parent plant and to produce stronger plants, the seeds are dispersed away from the parent plant with the hope that they will land in a 'better' habitat where they will receive enough minerals, light and water.

Different plants have different ways of dispersing the seeds and fruit. Let's have a look at some of these.

Gravity: Fruit can fall off a tree and roll as far as possible from the parent tree. When the fruit has fallen it can then be taken further from the parent plant by water, by rolling along the ground or by animals.

Animals: Animals may eat the fruit from the plant or the fallen fruit, and carry the seeds in their digestive systems. The seeds have a tough outer covering so that they are not digested by the animal. Some seeds also have spiky structures that can stick to the fur of animals. They are then carried along as the animal walks and drop off later.

Many wild animals love to eat the fruit from the marula tree, such as this elephant, which has pushed the tree over to get to the fruit. The seeds are dispersed later far away in the elephant's dung.

Explosive force: In some plants their seed capsules mature and then 'explode', shooting the small, light seeds far away from the parent plant.

TEACHER'S NOTE

The cells along the opening are specially designed so they rip open with force. (Three thickened walls and one very thin wall.)

The seed pods of jewelweed (shown on the left) explode when they are touched (shown on the right) and shoot out the seeds to disperse them.

VISIT
Video showing how ripe yellow woodsorrel pods explode to release their seeds bit.ly/14Apbii

Wind: Wind dispersal requires very light, small seeds that can be carried on the wind. Some seeds have 'wings' like dandelion seeds that can be carried across great distances by the wind.

Dandelion seeds are dispersed by the wind.

Water: Plants that grow in or near water use the water to disperse their seeds. Mangrove seeds start to germinate while still on the parent plant, then drop into the ocean and wait until the sea washes them onto a shore where they can continue germinating and growing.

A mangrove seed floating in the water.

VISIT
Review all of the different ways that plants can disperse their seeds bit.ly/1bfInzm

Do you remember how we spoke about the different flower structures and how they are adapted for pollination by either animals or wind or water? In the same way, the seeds and fruit are adapted for their method of dispersal.

ACTIVITY: Studying different kinds of seeds

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Look at the following table which contains different kinds of seeds. Each one is dispersed in a different way.
2. In the second column, state how the seed or seeds are dispersed (for example, by an animal, by the wind, by water etc.)
3. In the third column, write a couple sentences describing how you think this seed is adapted for dispersal. You need to think about what would most help this seed to be dispersed.

VISIT
Watch a video that illustrates the different ways that plants can disperse seeds bit.ly/178UyMS

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

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

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

We have now finished looking at how angiosperm plants reproduce. We are now going to look at how animals reproduce. Specifically, we are going to look at how humans reproduce so that we can learn about our own bodies and how they function.

3.2 Human reproduction

TEACHER'S NOTE

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

Some tips for teaching human reproduction:

1. Respect your learners' questions and concerns. Some of them may not have had an opportunity before to ask questions about reproduction, especially if their parents have not felt comfortable discussing this with them. This is a sensitive topic, and learners might be embarrassed to ask questions. Encourage your learners to ask questions and not be inhibited or embarrassed.
2. Discuss processes openly so that learners are comfortable within the classroom environment to talk and learn about reproduction and how it influences their lives. Discourage and discipline any laughing or disrespectful behaviour from other students. Insist that learners use the appropriate scientific terms when asking questions and having discussions, as this should prevent some learners from being intentionally vulgar.
3. Possibly bring in a guest speaker. Learners might feel more comfortable asking a stranger questions. Also, if you bring in an expert, such as a gynaecologist or midwife, learners might take the subject more seriously. It may be helpful to have someone from FAMSA come in and talk to the learners. Trained FAMSA facilitators will divide the class into smaller groups so that it is easier to ask questions.
4. If necessary, you can separate boys and girls. For example, if you are showing a graphic video about the female reproductive organs, it might be useful to have the boy watch a similar video in another room that explains the male reproductive organs. It may be very helpful to divide the classes into boys and girls at least once during the section so that learners can feel comfortable asking questions that they do not feel comfortable asking in front of their opposite-sex classmates.
5. Avoid portraying the reproductive system in a negative light or "forbidden" as this will only add to some of the discomfort that learners might already feel. At this stage in their lives, learners are already very interested in reproduction and the changes that their bodies are going through. This is natural and should be embraced so that they are educated and can make informed choices about their sexual health going forward.
6. Here is a website to do some further reading: bit.ly/1cfWcTS and some extra resources and pdfs can be accessed at bit.ly/19PWW09

If you look around at your Gr. 7 classmates, you will probably notice that your friends, and you, have changed quite a bit since you started Gr. 1. Apart from growing taller, changing hairstyles or changing the way you dress, your bodies are changing and growing up. We say you are **maturing**.

Understanding the changes that occur in your body and more specifically understanding why they occur, will help you to manage and cope in the next few years until you become a young adult.

TEACHER'S NOTE

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

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

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

Why do humans need to reproduce?

Humans need to reproduce to have children to continue the existence of our species. As with angiosperm plants, humans reproduce sexually. This means that human reproduction requires a male and a female and a new human being is formed by combining the genetic material (DNA) from the parents. The child will have half its genetic material (DNA) from its mother and half from its father. In order for this to happen, the **sperm** (from the male) has to combine with the **egg cell** (from the female) to produce a baby. Our sexual organs are adapted for these functions.

Our sexual organs need to reach maturity. This takes place during a stage in our life called **puberty**.

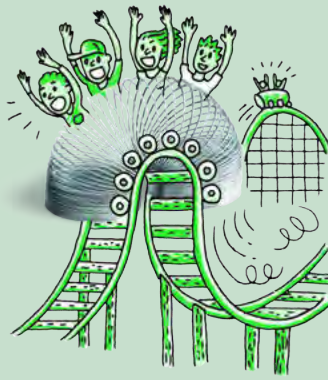
Puberty

When a boy or girl reaches a certain point of growth and development, the sexual organs in the body also start to mature. Girls and boys do not, generally, go through puberty at exactly the same time:

- Girls go through puberty between 10/11 - 14/15 years of age
- Boys go through puberty between 12/13 - 15/16 years of age

During puberty, you will experience different physical and emotional changes as your body develops towards sexual maturity and adulthood. Let's take a look at some of these changes that take place during puberty.

ACTIVITY: What happens during puberty?

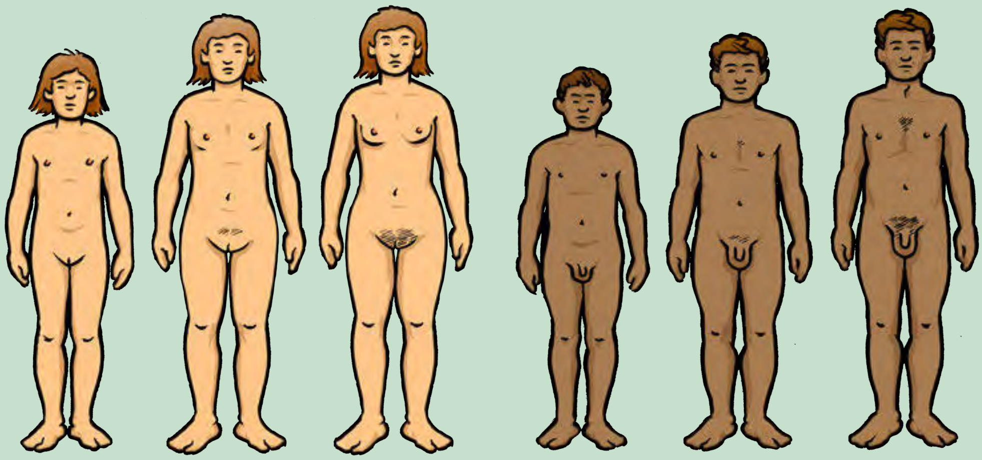


INSTRUCTIONS:

1. Study the images above of a girl at 10, 12 and 17, and of a boy at 10, 12 and 17.

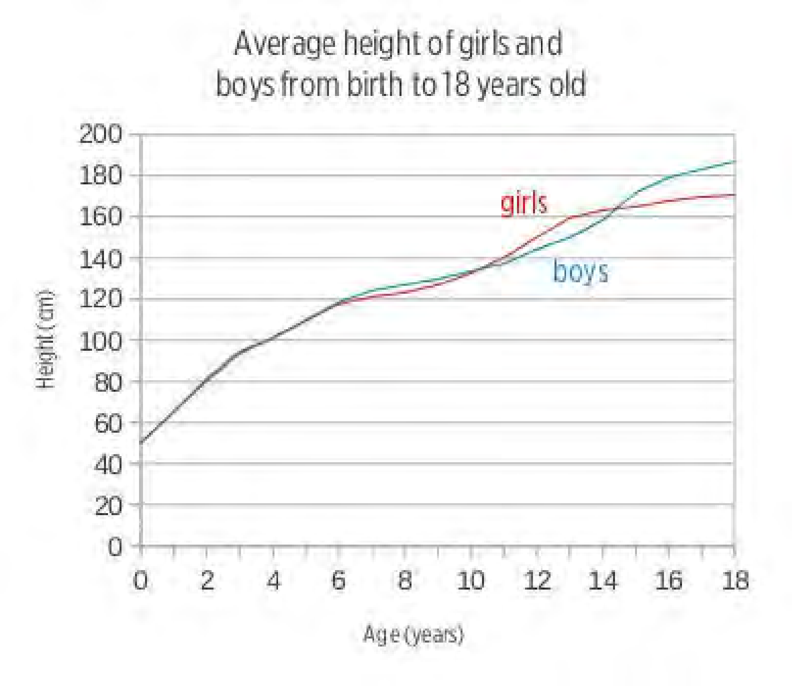
QUESTIONS:

1. Identify the changes that both go through during puberty and fill these into the table.



Changes in the girl	***Changes in the boy***
Changing body shape and figure Body fat increases Breasts start to develop Facial features more mature Hair growth under arms and on legs Pubic hair starts to grow (Acne / pimples in some individuals)	*Changing body shape and figure More muscular Penis grows bigger Facial features more mature Hair growth under arms, legs, face, chest Pubic hair starts to grow (Acne / pimples in some individuals)*

2. Study the following graph and answer the questions that follow.



What type of graph is this?

A line graph (or a growth curve graph)

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

3. What information is this graph providing?
   The average increase in height of boys and girls between birth and 18 years of age.
4. In a graph, there are two variables. The independent variable is placed along the horizontal x-axis. The dependent variable is the variable that changes according to the independent variable. It goes along the vertical y-axis. Identify the independent variable and the dependent variable that was used in this study based on the graph.
   Independent variable: the age of the boys and girls
   Dependent variable: average height increase
   Note: *You can explain to learners that the height depends on the age of the boys and girls and so the height is the dependent variable. As children grow older, they also grow taller, so height is dependent on age.*
5. What is the unit of measurement that height is recorded in? What is the unit of measurement for age?
   Height is measured in centimetres (cm) and age is measured in years.
   Note: *Point out to learners that the axes of graphs must always have labels and if there is a unit of measurement, this must always be included in brackets after the heading.*
6. Explain in words what you think this graph is telling us about how boys and girls grow from 0 to 18 years old. Compare the two different lines for boys and girls and see what you can tell from the average heights as they grow older. Answer the following questions to help you interpret this graph.
   a) There are two lines on this graph. What does each line represent? Use the colours in your answer.
   b) Why are the graph lines for boys and girls overlapping from 0 to 6 years old? What does this tell us about the height of boys and girls up

until 6 years old?

c) After 6 years old, and until 10 years old, the graph lines for boys and girls split. Which line is on top? What does this tell you?

d) At what age are boys and girls on average the same height again? How can you tell this from the graph?

e) At age 18, are boys or girls generally taller? What is the average height of boys and of girls at 18 years old? Read this off the graph.

Note: *Interpreting graphs is a crucial skill in Natural Sciences. Learners might find it hard to explain what they are seeing in this graph, so go through the following steps in interpreting a graph.*

a) The blue line represents the average change in height of boys as they grow older. The red line indicates the average change in height of girls as they grow older.

b) This means that boys and girls are on average the same height up until 6 years old.

c) The graph line for boys is on top. This tells us that between age 6 and 10 years old, boys are generally taller than girls.

d) Around age 10, boys and girls are roughly the same height again. This can be read from the graph where the two lines cross (we say they intersect). At around age 14 and a half, boys and girls are the same height again.

e) Boys are generally taller than girls at age 18. The average height of boys at 18 years is about 187 cm and the average height of girls is about 171 cm.

Note: *You may need to help learners and show them how to read the values off the graph. They should use their rulers and draw a line across from 18 years old to the y-axis to see where it intersects and make an estimate of the height of boys and girls.*

7. A growth spurt is when children grow quite rapidly over the years, faster than over other years. Answer the following questions to help you understand this.

   a) What can you use to identify a growth spurt in the graph? Hint: A growth spurt means that the boys' and girls' height is increasing faster than at other times.

   b) On the graph, we can see that there is a growth spurt for girls and a growth spurt for boys. Do the growth spurts take place at the same age for boys and girls?

   c) At what ages do the growth spurts take place for boys and girls?

   d) Why do you think these growth spurts took place when they did? Hint: Think back to the ages of puberty for boys and girls and how they differ.

   a) A sharp incline in the line of the graph indicates a growth spurt.

   b) No.

   c) Boys show a growth spurt between the ages of about 14 and 16. Girls show a growth spurt between the ages of about 11 and 13.

   d) These growth spurts correspond to the ages when girls and boys go through puberty. Girls go through puberty slightly earlier than boys and so the growth spurts take place at different phases.

8. Make an X on the graph to indicate where you are in this process according to your age.

   Individual learners to mark this on the graph.

9. Using the data on the graph, what changes in your height can you expect to experience if you were to follow the typical growth trend?

   Learner-dependent answer.

10. Based on your family history and the height of other members of your family, predict whether you will 'follow the curve' or whether you will be shorter or taller than the average person your age?

    Learner-dependent answer.

TEACHER'S NOTE

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

VISIT

Learn more about puberty for girls bit.ly/13J6Pcd

The following table summarises some of the physical changes that occur during puberty.

Physical changes in girls during puberty	Physical changes in boys during puberty
• The **sexual organs** (vagina, uterus and ovaries) start to mature. • **Pubic hair** starts to grow on the genitals. • **Menstruation and fertility**: girls have their first menstrual bleeding. **Menstruation** is a sign that the ovaries have started secreting **hormones** and releasing eggs, and is therefore a sign that the girl is now fertile (able to fall pregnant). • **Body shape**: changes occur, such as the waist becomes more defined and hips widen (to make space for childbirth). There is an increase in body fat. • **Breasts** start to develop • **Body odour** is typically part of puberty as the skin produces more oils and the smell of sweat changes. • **Acne and pimples** can occur due to changes in hormones and increased oil secretion from the skin.	• The **sexual organs** (testicles and penis)start to mature. • **Pubic hair** starts to grow on the genitals. • **Fertility**: the testicles start to produce sperm that can fertilise a female egg during sexual intercourse. • **Body shape:** changes occur as the bones and muscle increase to give the young man a stronger, more muscular look. • **Voice changes** occur becoming deeper and lower. • **Body odour is** typically part of puberty as the skin produces more oils and the smell of sweat changes. • **Acne and pimples** can occur due to changes in hormones and increased oil secretion from the skin.

VISIT

Learn more about puberty for boys bit.ly/1cNfFZQ

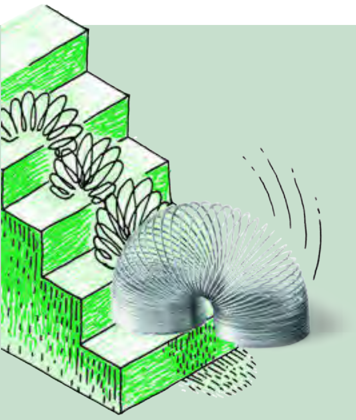
During puberty, many young people have commented that their emotions are like a roller-coaster. This time in your lives is not only about growing up and maturing physically, but also emotionally.

TEACHER'S NOTE

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

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

Many events are taking place in your life, so let's draw a timeline to show this!



ACTIVITY: Draw a timeline of your life

TEACHER'S NOTE

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

A timeline shows us a representation of how time passes and the events which take place.

INSTRUCTIONS:

1. Draw a personal timeline of your life so far.
2. You can include photos and pictures.
3. You can possibly include:
4. Your birth - where and when
5. Your first tooth, first word, first first step that you took, etc
6. Your different birthdays - perhaps you have some photos you can stick on for some of your birthdays.
7. Your first day at school, playing a team sport, on stage as a performer, etc
8. Celebrations and memorable events in your life.
9. Locate puberty on your timeline.

Let us now take a closer look at the male and female reproductive organs that mature during puberty.

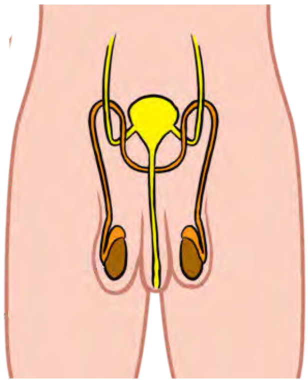
Human reproductive organs

Puberty is a time when the human reproductive organs start to develop, maturing about 5 - 6 years after puberty started.

In males, the reproductive organs include the penis and two **testes** hanging in a pouch or bag of skin called the **scrotum**.

- At the start of puberty the scrotum starts to grow larger and pubic hair starts to appear. The penis also grows bigger.
- Inside the scrotum, the testes mature and start to produce sperm.

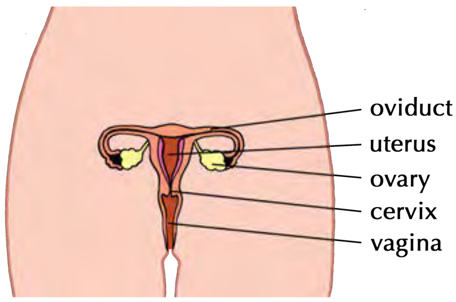
When the male reproductive organs are mature in an adult, they will look as they do in the following diagram:



The female reproductive organs include the **vagina**, **uterus**, two **fallopian tubes** (**oviducts**) and two ovaries.

- Inside the girl's body the uterus becomes longer and the lining of the uterus becomes thicker.
- When a girl is born she already carries millions of eggs (also called ova) in two organs called the ovaries. During puberty, the ovaries mature, and start to release one mature egg each month. This is called **ovulation**.
- Two tubes connect the uterus with the ovaries - these are called the fallopian tubes or the oviducts.

When the female reproductive organs are mature in an adult, they will look as they do in the following diagram:



We now know more about the male and female sexual organs and how these organs mature during puberty. Let's take a closer look at human reproduction and the different stages.

Different stages in human reproduction

Although you are not ready for the responsibility of having a baby and parenthood, your body starts to prepare itself for reproduction during puberty. The main purpose of the human reproductive organs is to produce a mature sperm or egg that can fuse and create a new human baby.

Ovulation

Once a month, one of the ovaries in a girl or woman's body will release a mature egg into the fallopian tube (oviduct). From here it moves to the uterus. During this time the uterus develops a thick lining of blood in preparation for the possible arrival of a fertilised egg.

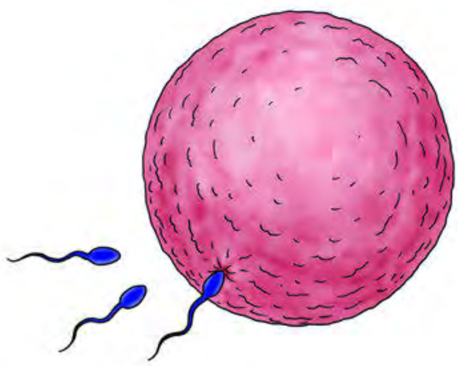
Fertilisation and pregnancy

In order for a baby to develop in the mother's uterus, the egg needs to be fertilised. During **sexual intercourse**, the male **ejaculates** (releases) millions of sperm into the woman's vagina. From the vagina, the sperm travel into the uterus and up into the oviducts and to the egg cell.

The sperm reach the egg cell, and only one of them enters through the outer layer of the egg cell. The layer then hardens and no other sperm are allowed to enter. This moment, when the male sperm and the female egg cell fuse is referred to as the moment of **conception**, or **fertilisation**, and this leads to pregnancy as the baby starts to develop.

TAKE NOTE

You are 100% unique - there is no one like you on Earth!



Only one sperm will fertilise the egg cell. The other millions will not be able to enter.

Once the egg cell is fertilised, it continues its journey to the uterus. When it arrives in the uterus, it is safely attached in the thick lining of the uterus. The foetus starts to grow and develop. An **umbilical cord** grows between the foetus and the uterus. A placenta forms to supply food and oxygen to the developing baby and to remove waste. The developing foetus receives food and oxygen from the mother through the placenta and umbilical cord.

A baby developing inside the mother's uterus. Can you see the umbilical cord?

TAKE NOTE

If the mother consumes drugs and alcohol while she is pregnant, these harmful substances will also pass through the placenta to the baby. They can cause serious damage to the baby. For example, if a pregnant mother drinks alcohol, the baby can develop Foetal Alcohol Syndrome (FAS).

At the end of pregnancy, the mother gives birth to the baby through the vagina. Sometimes there are complications and the doctors perform a Caesarean section. this is a surgical procedure where a cut is made in the mother's abdomen and the baby is removed.

As we have seen, if the egg is fertilised after sexual intercourse, the mother falls pregnant. But what happens to the egg if it is not fertilised?

Menstruation

After ovulation, if the egg in the oviduct does not fuse with a sperm and fertilisation does not take place, then the egg cell will still travel down to the uterus. But instead of implanting into the uterine wall, the unfertilised egg cell will be discarded through the vagina, together with the thick blood-rich uterus lining that had developed in case of fertilisation. This is called menstruation.

Do you know what a myth is? A myth is a story that may or may not be true. Often, myths are quite old stories that are passed down from one generation to the next. Myths are often told and people believe them even when there is no proof that they are actually true.

One such Greek myth is about a lady called Medusa. She had hair made of real snakes and could turn anyone into stone if they looked directly at her. One day, the hero Perseus fought her and rather looked at her reflection in his shield. He was protected from her deathly stare and managed to cut off her head and kill her.

Do you think the myth about Medusa is true?

There are many myths about menstruation and sex which are told by people in our society. A lot of these myths are not based on proof. Now that you know more about human reproduction, you need to decide if these stories and myths are true or not. Let's discuss this some more.

ACTIVITY: Conduct a survey

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Read some of the following comments people have made about menstruation and sex.
2. As a homework assignment, read these to at least five separate members of your family and friends.
3. Make a small cross if the person thinks it is not true and tick if they think it is true or correct.

Myth	Responses (tick or cross)
"Women who are menstruating are dirty and unclean."	
"During your period you should never have cold food or walk with bare feet. If you get cold your period will be worse."	
"Exercise is bad for you when you menstruate."	
"Don't ever swim when you are having a period!"	
"Virgins cannot use tampons - they will lose their virginity."	
"It is unhealthy to have sex at the time of the month when you are menstruating."	

Myth	**Responses (tick or cross)**
"You cannot fall pregnant during your period."	
"You cannot fall pregnant or make someone pregnant if you have sex in water."	
"Women are always moody and irrational during menstruation."	
"Drinking and drugs make sex more fun."	
"If you have a shower after sex, you will not fall pregnant."	
"You cannot fall pregnant if it is your first time."	
"Everyone is having sex."	

QUESTIONS AND DISCUSSION:

TAKE NOTE

A virgin is someone who has not had sexual intercourse.

1. How many people in the homework survey believed that the comments were in fact true?

Most believed they were true	About half believed they were true and the other half believed they were not.	None believed they were true

2. Discuss with your class which of the comments were most widely believed to be true by the people you surveyed. Take some notes on the following lines.
   Learner-dependent answer.
3. Which of these comments had the strongest reaction from the people you surveyed? (Either positive or negative reaction.) Discuss their reactions with your class. Take some notes on the following lines.
   Learner-dependent answer.

4. Did anyone laugh at any of the comments? Which ones? Did they tell you why they laughed? Share this with the class.
   Learner-dependent answer.
5. Which of these statements do you think are true? Discuss this with your class and take some notes on the following lines.
   Learner-dependent answer.

TEACHER'S NOTE

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

"Women who are menstruating are dirty and unclean ."

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

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

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

"Exercise is bad for you when you menstruate."

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

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

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

"Virgins can not use tampons - they will lose their virginity."

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

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

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

TEACHER'S NOTE

"You cannot fall pregnant during your period."

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

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

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

"Women are always moody and irrational during menstruation."

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

"Drinking and drugs make sex more fun."

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

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

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

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

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

TEACHER'S NOTE

"Everyone is having sex."

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

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

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

Ways to prevent pregnancy and STDs

As we discussed above, your body prepares itself to reproduce during puberty. However, you are in control of your body and can make the decision when you are ready to become a parent and to fall pregnant.

If you decide to become sexually active, it is important to think very carefully of two risks involved in sexual activity:

1. Pregnancy
2. Being infected by a Sexually Transmitted Disease (STD) like HIV/AIDS, Herpes or Syphilis.

TEACHER'S NOTE

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

There are different things that you can do to prevent pregnancy.

Contraceptives

To avoid falling pregnant, you can use **contraceptives**. There are different contraceptives available today. They prevent the sperm from reaching the egg and thus prevent fertilisation from taking place. Or else, they can prevent the fertilised egg from implanting in the uterus wall.

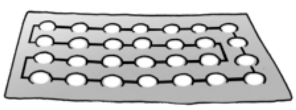
TAKE NOTE

'Contra-' means against, so contraception means against conception

Male condoms are rubbery sheaths that are placed over a man's erect penis before sex, and are worn during sexual intercourse to prevent the sperm from entering the woman's vagina. Condoms also help to prevent the spread of STDs.

Female condoms also prevent the sperm from reaching the egg. However these are placed in a woman's vagina to act as a barrier to the sperm, and are much less commonly used.

Oral contraceptive pills are used by many women today. Many of these prevent ovulation. Pills need to be taken at the same time every day, otherwise they are not effective. If the woman has an infection with a high temperature, or is on antibiotics, this may also reduce the pill's effectiveness. While the pill is excellent at preventing pregnancy, it offers NO protection against STDs.



Sexually Transmitted Diseases (STDs)

There are various very dangerous and harmful diseases that are spread from one person to another during sexual intercourse. Some of these are life-threatening, like the Human Immunodeficiency Virus (HIV), while others cause very painful and long-term symptoms.

You can prevent yourself from being infected with an STD by doing the following:

- Get the facts: Make sure you know up-to-date information about STDs and how they are spread, their symptoms and how you can protect yourself during sexual intercourse.
- Take control of your sex life: The more sexual partners you have, the higher your risk will be of contracting an STD.
- Be faithful: If you or your partner has sex with someone else you risk infecting the other person with the STD.
- Using condoms significantly reduces the risk of contracting STDs.

TEACHER'S NOTE

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

It is your decision whether you want to participate in sexual intercourse with a romantic partner or not. There are two very important points to remember here:

1. No one, no matter who they are, has the right to force you or pressure you to have sex with them or with anyone else. Therefore you are the only one who should be permitted to decide when you are ready to have a sexual relationship.

TEACHER'S NOTE

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

2. If you decide to have sex, you should do so in a responsible manner. This includes protecting yourself against possible pregnancy and against any STD infection.

TAKE NOTE

If you have been a victim of sexual abuse you can receive guidance and help by contacting Lifeline at 0800 150 150. The Lifeline website for victims of sexual abuse can be found at http://www.lifeline.co.za/need-support/rape/.

TEACHER'S NOTE

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

ACTIVITY: Write a letter

TEACHER'S NOTE

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

So often we make promises to other people and work very hard to keep them, but when we make promises to ourselves we often neglect to honour these.

Write a letter to yourself in which you explain what you want to do with regards to sexual activity. Do you want to engage in sex or do you want to wait until you are older? Explain why you made this decision.

Then add to your letter what you promise yourself that you will do to protect yourself from contracting an STD or from a pregnancy before you are ready to be a parent. Explain how you see yourself practising responsible choices regarding sex.

Put your letter in a safe place at home where you can often see it to remind yourself of your promise to yourself. Remember this is a private letter and you can choose whether you want to show it to anyone else or not.

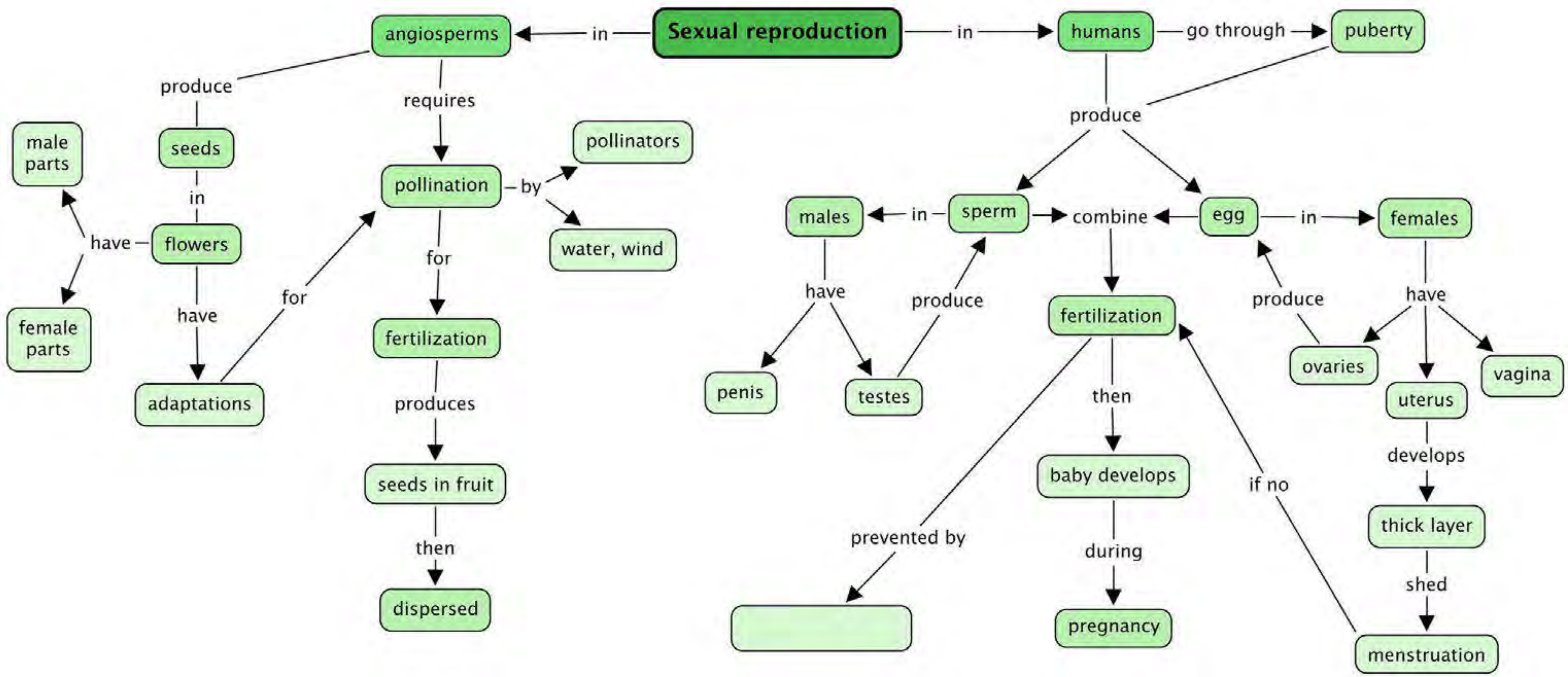
SUMMARY:

Key Concepts

- Sexual reproduction occurs when a sperm and an egg from two people combine to make offspring which look similar but not identical to the parents.
- In angiosperm plants, seeds are produced in the flowers.
- The male structures of flowers are the anthers and filaments, making up the stamens.
- The female structures of a flower are the stigma, style and ovary, forming the pistil.
- Pollination occurs when pollen is transferred from the anther of one flower to the stigma of another flower of the same species.
- Pollination is assisted by animals (pollinators), the wind and/ or water.
- Pollinators play an important role in the production of crops for humans.
- The pollen grows a pollen tube down the style to deliver the pollen nucleus to the ovules in the ovary.
- The fertilised ovules become seeds and the ovary may swell to form a fruit.
- Seeds are dispersed in various ways by animals, the wind, water and explosive force.
- In humans the main purpose of reproduction is for the sperm and egg to fuse and develop into a baby during pregnancy.
- Puberty is the stage in the human life cycle when sexual organs mature for reproduction.
- During puberty, boys and girls experience physical and emotional changes.
- The male reproductive organs include the penis and testes that produce sperm.
- The female reproductive organs include the vagina, uterus, oviducts and the ovaries.
- The ovaries produce one mature egg each month during ovulation which is then transported to the oviduct.
- If sexual intercourse takes place, the sperm travel to the egg and one will fuse with it in the process of fertilisation.
- The fertilised egg then moves to the uterus, is embedded in the lining of the uterus and grows for approximately 9 months before the baby is born.
- If fertilisation does not take place the egg moves to the uterus from where it is discarded in the vagina. The uterus lining is broken up and discarded through the vagina during menstruation.
- Pregnancy and STDs can be prevented mostly by wearing a male condom.

Concept Map

Study the concept map below. Does it make sense to you? Are you starting to see what concept maps do? To complete the concept map below, fill in the blank spot. Look at the concept it is linked to in order to find the answer: 'In humans, fertilisation is prevented by ....'



Sexual reproduction
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angiosperms
produce
seeds
in
flowers
have
male parts
female parts
have
adaptations
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by
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seeds in fruit
then
dispersed
in
humans
go through
puberty
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sperm
egg
in
males
have
penis
testes
produce
combine
fertilization
then
baby develops
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ovaries
produce
uterus
vagina
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thick layer
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menstruation
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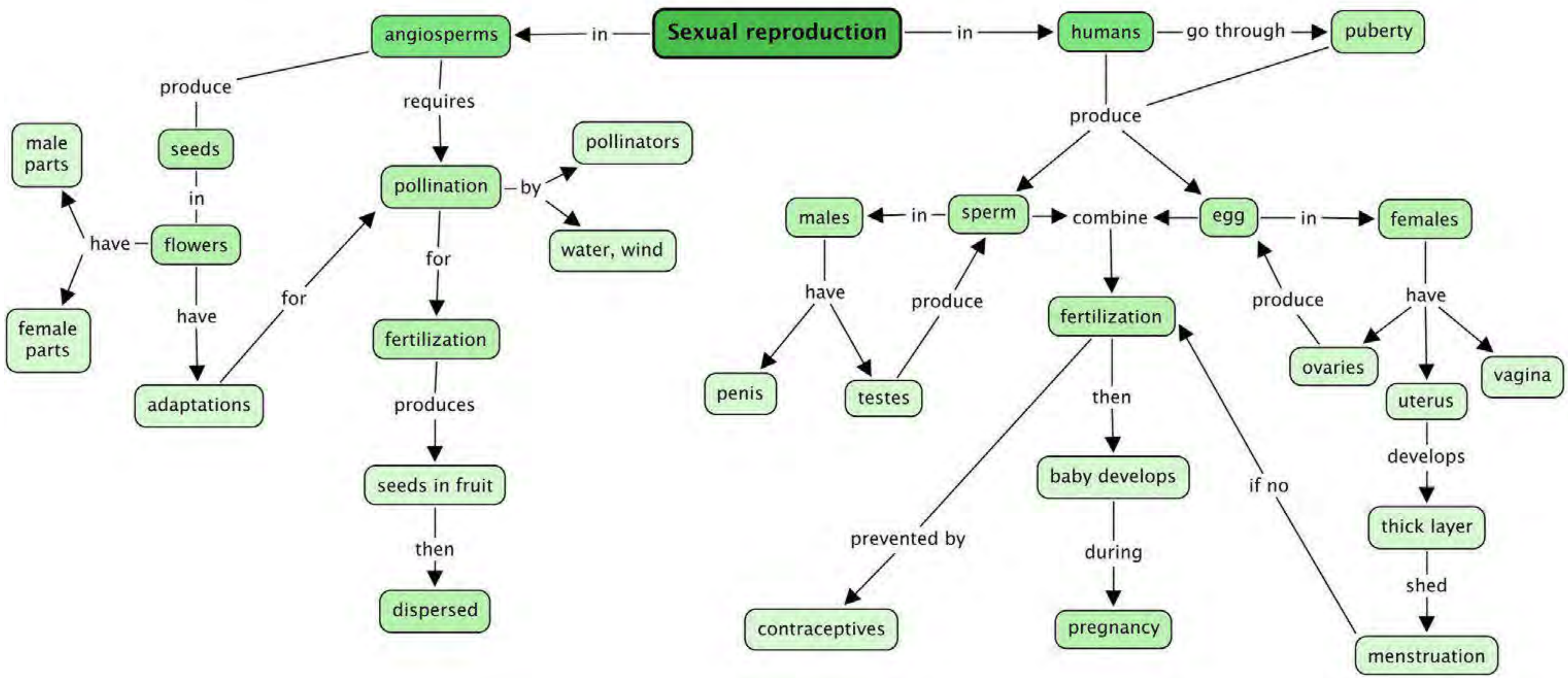
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humans
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sperm
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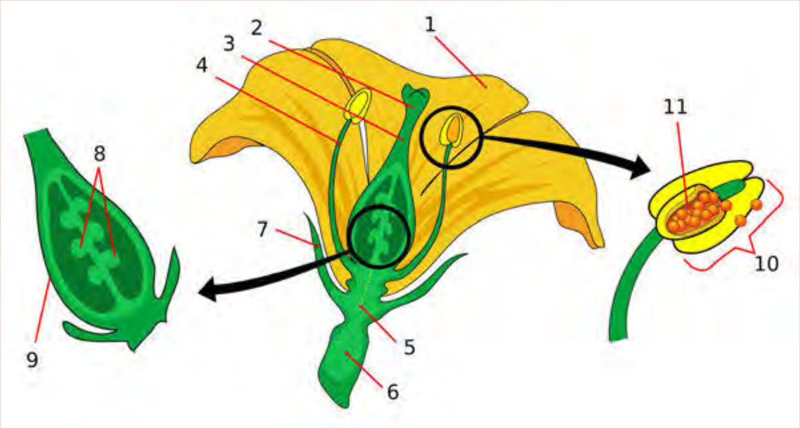
pregnancy
prevented by
contraceptives
in
females
have
ovaries
produce
uterus
vagina
develops
thick layer
shed
menstruation
if no

REVISION:

1. Study the following diagram of a flower and the reproductive parts. Provide labels for numbers 1-12. [12 marks]



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

2. Describe the function of the following structures: [5 marks]

Structure	***Function***
petal	*bright coloured structure that attracts pollinators*
ovules	*the part of the ovary of the flower that contains the female sex cell and that becomes the seed after fertilisation*
pollen grains	*fine powdery substance that contains the male sex cells that are transported to the stigma, and burrow down the style to the ovules where fertilisation takes place*
filament	*stalk-like structure of the stamen that holds and supports the anther*
receptacle	*tope part of the flower stalk to which all the other flower parts attach*

3. Look at the following image of a bat busy drinking nectar from the flower. How is this flower adapted for pollination by the bat? [3 marks]

A bat drinking nectar.

Some of the points that learners could note are: The flower is brightly coloured and probably gives off a sweet smelling smell to attract the bat. The flower has nectar for the bat to drink so that the bat comes to the flower. The flower is also probably open at night as the bat is nocturnal. The flower has a similar shape to the bat's head so that the bat can fit easily into the flower to reach the nectar. But the flower is still big enough with the nectar at the bottom so that the bat has to stick its whole head in and therefore brush against the pollen. The stamens are long and have feathery ends which brush against the bat as it sticks its head into the flower. This *makes sure that pollen is brushed off onto the bat as it sticks its head in and the pollen can then be transferred to another flower when the bat visits that flower.*

4. Look at the following image of the seed. How do you think this seed is dispersed? How is this seed adapted for this kind of dispersal? [3 marks]

A seed.

This seed is dispersed by wind. Learners may point out some of the following adaptations: This seed is large, but it is very light as the 'wings' are very thin, so that it can travel on the wind to be dispersed. The seed has 'wings' which help it move through the air like a helicopter. This helps it to move to a spot away from the parent tree so that it can grow somewhere else and not compete with the parent tree for space, water, etc. This also helps it to be lifted up by a draft of air, otherwise if it was just the small central brown seed without the wings, it would just fall directly down from the tree/plant.

5. A Gr. 7 learner was trying to explain the process of the human reproduction cycle, but they muddled up the order of the cycle. Write numbers 1 - 6 to place their sentences below into the correct order. [3 marks]

______ The sperm arrive in the oviduct.

______ During sexual intercourse, the sperm is propelled from the penis.

______ One sperm enters the outer cover of the egg to fertilise it.

______ The fertilised egg is implanted in the uterine lining.

______ The sperm travel from the vagina, through the uterus to the oviduct.

______ The egg is released from the ovaries and travels along the oviduct.

4 The sperm arrive in the oviduct.
2 or 1 During sexual intercourse, the sperm is propelled from the penis.
5 One sperm enters the outer cover of the egg to fertilise it.
6The fertilised egg is implanted in the uterine lining.
3 The sperm travel from the vagina, through the uterus to the oviduct.
1 or 2 The egg is released from the ovaries and travels along the oviduct.

6. Explain the difference between ovulation and menstruation. [2 marks]
Ovulation: when the ovary releases a ripe egg cell into the fallopian tube. Menstruation: when the blood-rich lining of the uterus and unfertilised egg cell is discarded through the vagina.
7. Once an egg is fertilised, where is it implanted or embedded? [1 mark]
In the blood-rich lining of the uterus.
8. The reproductive organs are structured in a very specific way - to make fertilisation and pregnancy possible. Explain the function of each of these

structures in the male and female bodies. [12 marks]

Reproductive organs	***Their function***
Ovaries	*Produces female sex hormones and stores, matures and releases ripe egg cells.*
Oviducts	*Transports the ripened egg cell from the ovary to the uterus; fertilisation takes place in the fallopian tubes (oviducts) so sperm swims from the uterus into the fallopian tube (oviduct).*
Uterus	*Once a month the lining of the uterus grows blood-rich and thick to allow the fertilised egg to implant in it and to grow an umbilical cord and placenta; uterus also undergoes strong contractions during childbirth.*
Vagina	*Muscular, elastic tube that can expand to hold the erect penis; sperm swim from the penis in the vagina to the uterus; it also allows the blood-thick lining of the uterus to be expelled once a month during menstruation; during childbirth it is the birth canal through which the baby travels and leaves the mother's body.*
Penis	*Can become erect (stiff and hard) to be placed into the vagina; ejaculates sperm in a liquid called semen; urine is also passed via the urethra.*
Testes	*Produce the male hormone; produces sperm that travel through different tubes to the penis from where it is ejaculated.*

9. During puberty the penis and testes develop and mature to fulfil their function in reproduction. Explain what changes occur and why these changes are necessary. [2 marks]
The penis grows longer and slightly wider; it begins to ejaculate preparing for reproduction. The testes mature and start to produce sperm which can fertilise an egg.
10. Explain what changes occur inside the ovaries of a girl during puberty and why these changes are important for reproduction. [2 marks]
During puberty, the ovaries are stimulated to start maturing and releasing the eggs on a monthly basis. The fertilisation of a mature egg by a sperm cell is needed for pregnancy to occur.
11. A Gr. 7 learner was asked to define the terms puberty, menstruation, fertilisation, pregnancy and conception. First **evaluate** how well they defined each of these terms and then **correct or improve** their definitions in each case. [10 marks]

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

Total [55 marks]

4 Variation

TEACHER'S NOTE

Chapter overview

1 week

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

4.1 Variation within a species (1.5 hours)

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

4.2 Inheritance in humans (1.5 hours)

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

KEY QUESTIONS:

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

4.1 Variation within a species

In the last chapters we looked at how to classify organisms on Earth. Do you remember what the classification levels are? What is the smallest group in the classification system?

TEACHER'S NOTE

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

A species is a group of organisms that can interbreed with each other to produce fertile offspring. In this section you will learn why the ability to create a fertile offspring is the single most defining characteristic of a species.

Wherever organisms in a species live, they need to survive in those conditions. We say they are adapted to their environment. Those individuals of a species, which have characteristics that make them more successful at surviving, will reproduce more and pass on their characteristics to their offspring. However, environments change over periods of time. This means that the species needs to constantly change over time to better survive the conditions of their changing habitat. If the organisms do not adapt to their environment, they may not survive, and the species will die out. But how do species adapt? Does it happen quickly or over a long time?

What does variation mean when we use it in Natural Sciences? Let's take a look at some animals with which we are all familiar to find out what variation means.

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

Do you have a dog, or have you seen some dogs in your neighbourhood? Think of those dogs, and use the following image to answer the questions.

QUESTIONS:

1. What kingdom of animals do dogs belong to?
   The animal kingdom.

2. What phylum do dogs belong to? Why do you say so? Give a reason for your answer.
   Dogs are from the phylum Chordata as they are vertebrates, having a backbone and internal bony skeleton.
3. What class do dogs belong to? Give three reasons why you would classify dogs in this class.
   Dogs are mammals as they are endothermic (warm-blooded), they have fur, they have mammary glands, they give birth to live young.
4. Look at the dogs in the above picture and write down some common characteristics of the animals.
   Some common characteristics include: four legs, fur, tail, sharp teeth, snout (elongated nose), pointy ears, paws with claws, a snout.
5. Do you think these dogs are part of the same species? How would you know? Discuss this with your class and teacher.
   Yes, they are. All the different types of domestic dogs can reproduce with each other to create offspring. The ability to reproduce and have fertile offspring is the definition of a species.
6. Although these dogs share many characteristics, there are many differences between them. What are some of these differences?
   Some differences include fur colour, fur length, body shape, body size, length of legs, length of tails, length of snout, shape of ears, etc.

7. Another example of variation is horses. Horses all belong to the same species as they can mate and produce offspring which are fertile. This means their offspring are able to reproduce. But there are many

Horses and ponies are from the same species. But what about donkeys?

If a horse and a donkey mate, they are able to produce offspring, but the offspring are infertile. They are called mules or hinnies. Do you think donkeys and horses are the same species? Give a reason for your answer.

A donkey

Horses and donkeys are not the same species as they are not able to produce fertile offspring which can reproduce.

TEACHER'S NOTE

Both belong to the family Equidae and the genus Equus, but they are different species. The domestic horse is from the species *Equus caballus* and the domestic donkey is from the species *Equus asinus*. This question was included to reinforce the concept of a species being organisms which can reproduce to produce fertile offspring.

All living organisms that reproduce sexually produce offspring that are different from the parent organisms. Remember that we learnt about sexual reproduction in angiosperms and humans in the last chapter. This allows the new organisms to be different to other organisms within the same species. We call this difference **variation**. As we saw in the last activity, all dogs on Earth are actually the same species, as well as horses, but there are huge differences between all the individuals. We say there is variation.

Three kittens from the same litter but they all look different!

Even animals from the same litter or children from the same parents have differences. Take a look at the kittens in the box below. They are all from the same litter so they share the same parents, but they all look different.

All humans on Earth are from the same species, and yet there is huge variation among us. Look at the following photos of people from around the world.

A Tibetan girl.

A Swedish man.

A schoolgirl in Congo.

An Indian lady.

A Cambodian boy.

A Dutch girl.

A Masai warrior in Kenya.

A Chinese soldier.

An English boy.

An Iranian woman.

An Ethiopian man.

A Peruvian woman.

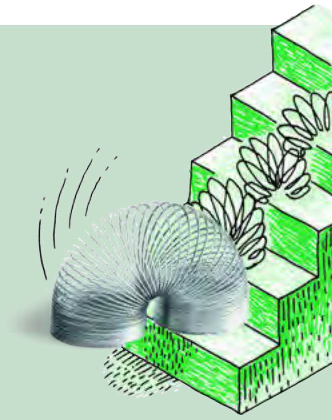
Humans are all one species. Do you remember what the species name is for humans?

TEACHER'S NOTE

Homo sapiens.

South Africa is an amazing example of diversity amongst our people. Just have a look at your class and how much variation there is between all of you in one class. Some learners may be tall and others may be shorter, some have dark hair, some have blonde or brown hair, and there is a range of skin colours in South Africa. Since you are all from the same species this is another example of variation. Let's have a look at how your class varies in height.

ACTIVITY: The height of learners in your class



TEACHER'S NOTE

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

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

MATERIALS:

- 2 m measuring tape
- pencil, table drawn on scrap paper and clipboard to work on

INSTRUCTIONS:

1. Attach a measuring tape or similar apparatus to a wall in your class.
2. Learners who are having their length measured must be barefoot and must place their heels against the wall, standing up straight against the wall.
3. Learners who are taking the measurement must stand on a chair and place a ruler or pencil horizontally on the person's head (and flatten the hair) when taking the measurement.
4. Another learner should record the name and height of each learner.

TEACHER'S NOTE

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

5. Use this method to record the height of each learner in the class.
6. Draw a table to record the measurements.
7. Represent these results on a bar graph in the space provided.

Use the following space to record the heights of learners in your class in a table.

TEACHER'S NOTE

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

Now use this information to draw a graph to represent the information. You will need to draw a bar graph. Think about what must go along the horizontal x-axis and what must go along the vertical y-axis. Remember, the x-axis is for the independent variables and the y-axis is the dependent variable. Give your graph a heading.

TAKE NOTE

Do you remember how to calculate an average? You need to add up all the individual measurements, then divide by the number of learners you have measured.

TEACHER'S NOTE

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

Learner-dependent answer

TEACHER'S NOTE

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

QUESTIONS:

1. Who is the tallest and who is the shortest in your class?
   Class-dependent answer.
2. What is the average height of all the learners in your class? Use the following space to show your working for this calculation.
   Learner-dependent answer.

TAKE NOTE

3. What is the average height of the boys and what is the average height of the girls? Use the space to show your working.
   Learner-dependent answer.
4. As a homework activity, measure the heights of some of the adult members in your family. Record these heights in the following space to discuss with your class the next day.
   Learner-dependent answer.
5. Discuss these results with your class.
   a) Do the shorter people in your class also have shorter family members and do the taller people in your class also have taller family members?
   b) Is there a correlation (relationship) between the heights of learners in your class and the adults in their family?
   c) What other similarities are there between family members?
   d) Write down some notes from your class discussion below.

TEACHER'S NOTE

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

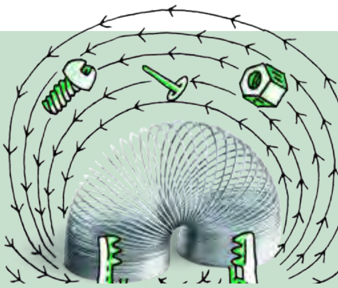
We have now seen that there is huge variation between all the people on Earth, and even in your class. But, there are also lots of similarities, especially between family members, such as height and skin colour. These characteristics (or traits) are passed down from one generation to the next in a family. We say they are inherited traits. Let's look at this a bit more.

4.2 Inheritance in humans

We say that certain traits are passed down from generation to generation over many years, from parent organisms to their offspring. This is called **inheritance**.

There are some traits which are very easy to see how they are inherited, such as skin colour or height. Did you know that some people are able to wink with one eye but not with both? Or that others can only see some colours but not all the colours - this is called colour blindness. Let's find out a bit more about some of these inherited traits.

ACTIVITY: What is your inheritance?



1. Think about your most recent family event or family photo. Is there something that you all have in common? It can be something about your

physical appearance, or your behaviour or something that you can each do. Discuss any inherited traits or characteristics that get passed down from generation to generation in your family.
Learner-dependent answer.

2. One of the very interesting inherited traits is the ability to roll your tongue.

Can you roll your tongue?

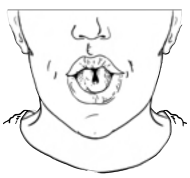
Can you roll your tongue? Can your family members roll their tongues?
Learner-dependent answer.

3. There are many other traits and abilities that are inherited from our parents, that they inherited from their parents, which they inherited from their parents and so on. Below is a table detailing some of these traits.
4. Count how many people in your class can do each or have each of these traits or characteristics.
5. Record the number of learners in your class who have each characteristic.
6. Calculate the percentage of learners that have this characteristic.

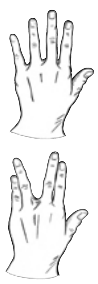
TEACHER'S NOTE

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

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

Characteristic	Illustration	Number of learners with the characteristic	Percentage of learners with the characteristic
Tongue rolling			

Thumb shape	 	Hitchhiker thumb: Straight thumb:	
Dominant hand	 	Right-handed: Left-handed:	
Attachment of earlobe	 	Attached earlobe: Unattached earlobe:	
Dimples			
Second toe length		Longer second toe:	

Vulcan sign			

TAKE NOTE

We can use the word **inheritance** in different ways. When someone dies they may leave an inheritance of money, a home, car or other physical belongings to their children or other people. In Science, inheritance is how parents pass on traits or characteristics to their

When you have collected all the data and have worked out the percentage of learners that have a certain trait, draw a bar graph in the space provided. Remember to label your graph and to give it a heading.

TEACHER'S NOTE

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

How does variation in a species help it to survive?

Natural selection

VISIT

Watch a video that explains how natural selection works bit.ly/17zOR9R .

Afterwards, experiment with natural selection by controlling the environment and causing changes in rabbits. (simulation) bit.ly/15zeea9

TEACHER'S NOTE

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

Have you ever heard the saying: "survival of the fittest or strongest"? This refers to the way in which the organisms are able to survive in their environments because they have adapted the best or they have certain characteristics which allow them to survive better than others.

Survival refers to the characteristics that allow the members of a species to thrive and reproduce successfully so their advantageous characteristics are passed on successfully. Thus over generations the entire species can survive as the majority of its members happen to have inherited the advantageous characteristics.

For example, imagine some impala in one group in a game reserve started to develop a characteristic, which was passed down from the parents to the offspring, allowing them to run faster for longer. The impala in this group can then run faster than the impala in another group. Over time, the faster impala will be able to escape the predators such as cheetahs and lions more often and so they will live long enough to reproduce and raise their offspring successfully. They will therefore pass on the swift running characteristic. The slower impala will get caught more often and so they will not survive to produce offspring. The slower impala are slowly removed over time. The characteristic making some of the impala faster allows those impala to survive and pass this trait on to their offspring. This is the principle of **natural selection**.

TEACHER'S NOTE

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

Let's look at a famous and interesting example of how variation in the peppered moth allowed for natural selection.

ACTIVITY: Natural selection in the peppered moth

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Read the following information about the peppered moth.
2. Answer the questions that follow.

The peppered moth's story of evasion

The peppered moth has been studied in a lot of detail over the past 200 years as it has a very interesting evolution over a short time period. Originally, most of the peppered moths were a light, speckled colour, as you can see in the top moth in the image.

This colouring allowed the moths to be camouflaged when they rested upon the light-coloured trees and lichens in their habitat. However, not all the peppered moths were this light colour. There was some variation and there were a few which were a much darker, grey colour. They could not camouflage themselves as well as the light coloured one. The darker coloured moth is shown below the lighter coloured moth.

The light and dark variation in the peppered moth.

During the Industrial Revolution in England, there was a huge increase in the number of factories. These factories mainly burnt coal as an energy source, which increased the amount of pollution and soot in the air. The pollution caused the lichen on the trees to die off. The soot coated the trees in the peppered moths' habitat. These trees now did not have any lichen and they were a dark grey colour because of the soot covering them.

The light coloured moths were therefore not camouflaged anymore and could be seen easily by predators when they rested on the trees. As a result, more of the light-coloured moths were eaten by birds and didn't have a chance to mate and lay eggs. Therefore the number of light-coloured moths decreased. In comparison, the few moths that were a dark grey colour were now at an advantage as they were now the same colour as the soot covered trees and could hide. These darker-coloured moths could therefore go on to have more offspring. Over time, this resulted in more and more of the moths being dark-coloured.

VISIT

Play the evolution game and hunt for peppered moths!

bit.ly/178YdKJ

QUESTIONS:

1. When the moths land on the trees and they are camouflaged, what are they hiding from?
   The camouflage helps them to hide from predators such as birds which eat them.
2. Why do you think there were only originally a few of the dark coloured moths, and there were lots of light-coloured moths?
   The light-coloured moths were originally dominant. The dark ones were a variation which started to develop. But, originally, they could be easily seen on the light-coloured trees covered in lichen and so the birds could see them more easily than the light ones and so ate them. This kept the number of dark moths down.
3. Why do you think the dark grey moths started to increase over time after the Industrial Revolution?
   After the industrial revolution, the dark moths were now better camouflaged on the dark, soot-covered trees. The birds could not see them as easily, and the light moths were clearly visible, so the birds started to eat the light coloured moths more than the dark coloured moths. The dark moths were able to survive and reproduce more, thereby passing on their dark trait to their offspring. This increased the numbers.
4. Since the Industrial Revolution, the numbers of light-coloured moths have started to increase again due to improved environmental standards. Why do you think this is?
   We are now more environmentally aware, and use more electrical machines and fewer coal-powered machine. As a result, there is less pollution and

soot in the air. This means these habitats are more protected, so the trees are not covered in soot and lichen is able to grow. Therefore, the light moths are once again better camouflaged on the trees and so avoid predation, whilst the dark grey moths are now clearly visible again.

We have now looked at how variation within a species helps it to adapt to its changing environment and therefore survive. But, these changes do not happen quickly. Although small changes can happen within a few generations, big changes take a very, very long to happen over thousands of years.

VISIT
10 reasons to love science (video) bit.ly/1bf3K5r

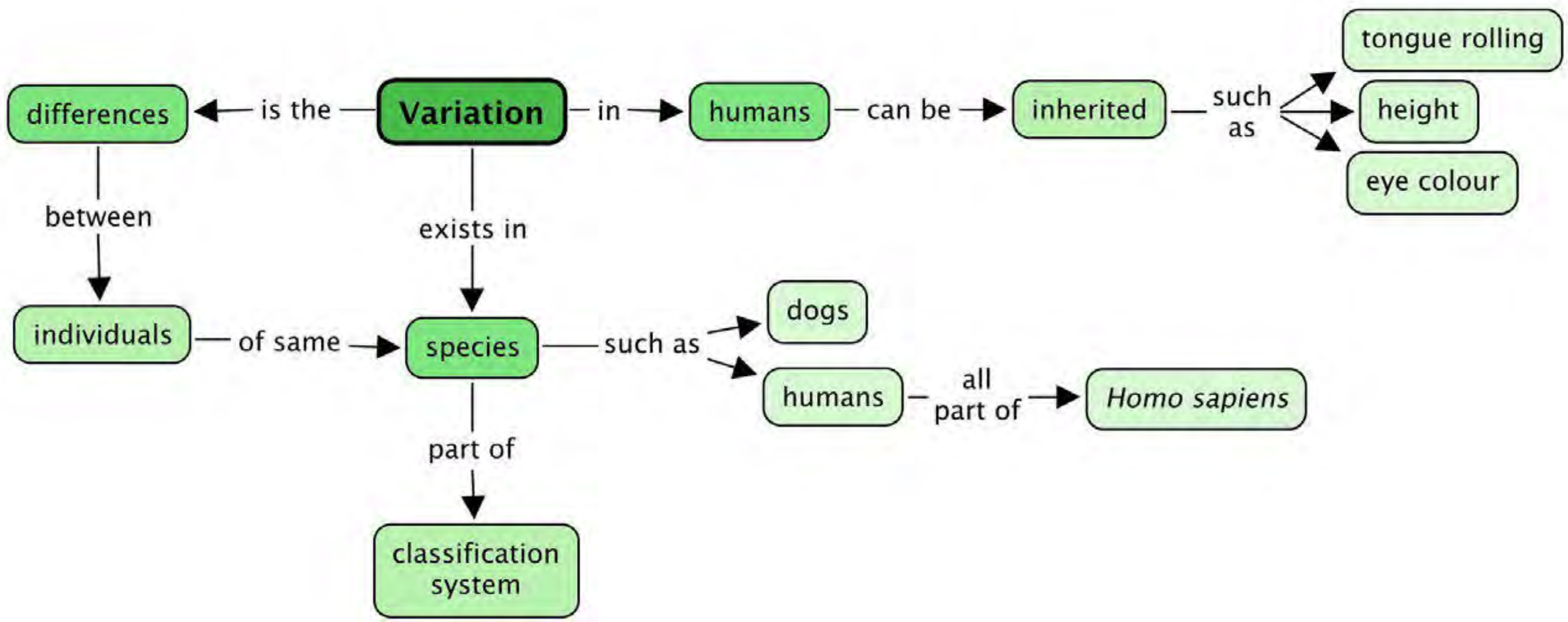
SUMMARY:

Key Concepts

- A species is a category within the classification system.
- Living organisms of the same type belong to the same species.
- Organisms from the same species can reproduce sexually and produce offspring that are fertile and can reproduce.
- People belong to the species *Homo sapiens*.
- Variation is the difference between individuals from the same species.
- This variation can be inherited from one generation to the next.
- The individuals that are better suited (adapted) to their environment will survive to reproduce. This is called natural selection.
- Small changes can take place in a species over shorter periods, like from one generation to the next.
- Over very long periods these small changes can accumulate so that big changes occur over time.

Concept Map

This was a short section and so we have a smaller concept map than in the previous sections.

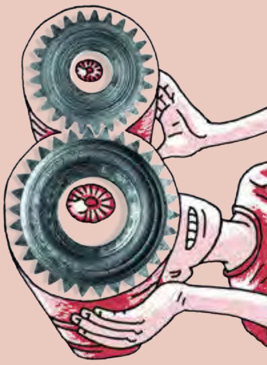

Variation
is the
differences
between
individuals
of same
species
exists in
in
humans
can be
inherited
such as
tongue rolling
height
eye colour
such as
dogs
humans
all part of
Homo sapiens
part of
classification system

REVISION:

1. Are dobermans, terriers and bulldogs from the same species? Give a reason for your answer. [2 marks]
   All these dogs belong to the same species because if they breed, the offspring are fertile and can breed again.
2. A new breed of cat has been developed, called the munchkin cat. Breeders specifically tried to breed a cat with very short front legs. Explain how you think they achieved this. [2 marks]

   People observed some cats that were born with shorter than average front legs and then mated these cats with other cats with shorter front legs until over time they had cats with increasingly shorter legs.
3. Predict whether you think munchkin cats would be able to hunt as well as other cats with normal length front legs. [2 marks]
   They would probably not be able to jump, catch and claw their prey or be as fast as other cats, so they would probably not be as good at hunting as other cats.
4. Do you think it is correct for humans to breed animals in this way? Explain your answer. [2 marks]
   Learners are required to give a value judgement. Some might agree that it is the right of humans, but others might feel that humans are being cruel and that it is wrong.
5. Explain in your own words what you understand by the term "inherited characteristics". [2 marks]
   This means that the characteristics (traits) are passed down from the parents to the offspring from one generation to the next.
6. Why do you think it takes a long time for a species to adapt and change to its changing environment? [2 marks]
   A species takes a long time to adapt as the individuals which have the trait which gives them an advantage are usually in the minority when the trait first starts to emerge. These individuals need to reproduce to pass on their trait. This takes over many generations. Only after many generations will the trait start to be dominant in the species as more and more individuals are born with the advantageous trait. Species which reproduce quickly and have short generation times (short life spans), such as moths, will evolve over a quicker time period than species which have long life spans and reproduce less, such as humans.



TEACHER'S NOTE

This is an extension question.

Total [12 marks]

GLOSSARY

abiotic: non-living elements of the environment such as soil, water and air

adapt / adapted: to change the way that something looks or the way something is done based on the surroundings / environment

amphibian: any of a class of vertebrate animals that live on land and in water at different times in its life-cycle, are ectothermic and have a naked skin, and that the larvae hatch in water and has gills, which later transforms into the adult that breathes with lungs

angiosperm: a plant that has flowers and produces seeds that are enclosed in a fruit

antenna (antennae): one of two long thin parts on the head of some arthropods (like insects and crustaceans) used for touch, smell and taste

anther: the part of the male sex organ of a plant that contains the pollen

aquatic: being in or near water

arthropod: any of a large group of animals with a hard body, no backbone and legs that are divided into sections

asexual reproduction: reproduction of plants and fungi that doesn't require male and female sex cells to fuse in order to make a new organism

atmosphere: the layers of gas that surround the Earth

biosphere: the parts of the Earth's surface, water and atmosphere in which life can exist (and where plants, animals and organisms can live)

bulb: a type of underground stem with one or more buds that are covered by leaves or scales - like onions and tulips

cartilage: strong, flexible tissue similar to bone

cell: the smallest structural unit or building block of life that can sustain the seven life processes

cellular respiration: the process in living organisms by which oxygen is used to release energy from food and carbon dioxide is given off as a by-product

characteristic: a typical feature or quality that makes one thing different from another

class: the major taxonomic rank below phylum and above order that includes groups of vertebrate animals such as fishes, amphibians, reptiles, birds and mammals, and the invertebrate groups such as insects and arachnids

classify: a systematic grouping of objects, items or organisms based on characteristics, relationships and processes

component: one of the parts that something is made of

conception:	moment of fertilisation when the male sperm and the female egg cell fuse and a new individual is formed
cotyledon:	the seed leaf that is involved in the storage or absorption of food reserves
depend / dependent:	to need something or somebody to do their part in providing a shelter, food, air, etc. for an organism's survival
dependent variable:	the variable of interest that is measured to get the results
dicotyledon:	a plant that has a seed with two cotyledons, nodes and internodes on its stem, a tap root and generally leaves on small stalks called petioles; the leaves have a net-type leaf vein
disperse:	spread over a wide area
diversity:	the number and variety of species present in an area and the location of their different habitats
ectothermic:	relating to animals that have a blood temperature that changes if the temperature of their surroundings change
ejaculate:	when a male releases sperm from the penis
embryo sac:	structure within the ovule that contains the egg cell; contains the newly developing plant and endosperm after fertilisation
endothermic:	relating to animals that have a blood temperature that does not change if the temperature of their surroundings change
environment:	the external surroundings, conditions, resources, stimuli, etc. in which an organisms lives and interacts
exoskeleton:	the hard outer covering that protects the body of certain arthropods
fair test:	an experiment where only one independent variable is changed each time the experiment is repeated
fallopian tube (oviduct):	a tube lying close to each ovary that receives the mature ova (egg) and transports it to the uterus
favourable:	good, suitable or acceptable
fertilisation:	the process when a male sex cell fuses with a female sex cell to make a new, unique individual with half the genetic material from the male and half from the female parent organisms
filament:	the stalk-like structure of the stamen that holds and supports the anther
fuse:	to join or blend to form a single entity
genetic information (DNA):	the inherited information coded into the cell that determines what type of cell it is and what it needs to do
gill:	the organ in fish and other water-breathing animals that allows them to breathe underwater

gravity:	the force that attracts a body towards the centre of the Earth or towards any other physical body having mass
habitat:	the natural place where a plant or animal lives
herbaceous:	a plant that has a non-woody stem and which normally dies at the end of the growing season
hormone:	chemical messengers that travel in the bloodstream to tissues and organs to affect many different reactions in the body.
hydrosphere:	the water on the Earth's surface, including the oceans, seas, lakes, rivers and dams
hypothesis / hypotheses:	a statement that is an educated guess about the outcome of the experiment; an idea that is suggested as the possible explanation for something that has not yet been proved to be true or correct
independent variable:	those variables that will be changed one at a time to see what effect they will cause in the dependent variable; variables that are under the control of the investigator
inheritance:	something that is passed on genetically from one generation to another
invertebrate:	an animal without a line of bones (backbone) going down its back
jointed (segmented) limbs:	separate parts of the leg is covered in a hard exoskeleton with clear joints between them
kingdom:	refers to five major divisions of living organisms; plants, animals, fungi, protists and bacteria that is in turn composed of smaller groups called phyla
larva / larvae:	a stage in the development of insects and other animals where it has come out of the egg and is mainly concerned with consuming food
leaf vein:	little tubes that branch throughout a leaf carrying water and dissolved substances
lithosphere:	the crust or outer part of the Earth
mammary gland:	milk producing glands in female mammals
marine:	of or relating to the sea
mate:	come together for breeding, copulating
matter:	the physical substances from which all things are made, such as rocks, soil, air, water, plants and animals
maturing:	to become physically mature and fully developed
menstruation:	a recurring monthly event where the lining of the uterus breaks down and is discharged as menstrual blood
microorganism:	an organism that is too small to see without a microscope
monocotyledon:	a plant that has a seed with one cotyledon, adventitious, generally shallow roots and leaves that forms sheaths around the stem; the leaves have a parallel leaf vein

natural selection:	a process in which organisms with more suitable features survive and reproduce more successfully in a particular environment, resulting in more offspring that carry the same traits
order:	a taxonomic rank below class and above family that classifies organisms based on specific characteristics, such as diet and tooth structure, such as herbivores, carnivores and primates
organic:	produced by or formed from living organisms
organism:	an individual living thing that can react to stimuli, reproduce, grow, etc, such as a bacterium, protist, fungus, plant or animal
ovary:	the female reproductive organ in which the female sex hormones oestrogen and progesterone as well as female sex cells (ova) are produced and stored; in a flower it is the thickened part at the base of the flower that contains the ovules
ovule:	the part of the ovary of the flower that contains the female sex cell and that becomes the seed after fertilisation
ovulating:	when a mature egg (ova) is ready and gets released (and is in the right place) for fertilisation to take place
peduncle:	the stalk or stem of a flower
penis:	the male sex organ for the transfer of sperm cells to the female
petal(s):	each of the modified leaf sections of a flower that are typically coloured to attract animals
photosynthesis:	the process by which green plants (and some bacteria) use energy from light to turn carbon dioxide and water into food and oxygen
phyla:	a taxonomic rank in biological classification that is below kingdom and above class, that divides organisms according to major body similarities, such as chordates, molluscs and arthropods
pistil (carpel):	the female organs of a flower containing the stigma, style and ovary
pollen:	a fine powdery substance that is often yellow and contains the male sex cells
pollen tube:	a hollow tube that develops from a pollen grain and grows into the stigma and down the style to deliver the male sex cells to the ovary of the flower
pollination:	the transference of pollen from the anther of one flower to the stigma of another flower of the same species
pollinator(s):	an agent that carries pollen from one flower to another (bees, butterflies, birds or the wind for instance)
puberty:	the period between childhood and adulthood when the sex organs mature causing changes in the body that prepare the body to be able to reproduce
receptacle:	the place where a flower is attached to the peduncle (stalk or stem)

requirement:	something that you need or must have
respire:	to take oxygen into the body and release carbon dioxide; to breathe
rhizome:	a horizontal stem underground that has both roots and shoots
roots:	the part of a plant that is (mostly) underground and responsible for anchoring the plant, and for absorbing water and minerals from the soil
scientific method:	a set way of doing / conducting a scientific investigation allowing you to gain new knowledge by collecting measurable evidence based on observation, measurement and experiment based on the formulation, testing and changing of the hypotheses
scrotum:	the external sac of skin that encloses the testes in males
seeds:	the reproductive organ formed in gymnosperms and angiosperms from which a new plant can grow; it is usually covered by a protective coat and also contains food reserves for the young plant
sepal(s):	small green leaves that protect the developing bud
sexual intercourse:	when the male sperm is introduced into a woman's body
sexual reproduction:	the process of producing new individuals of a species by fusing the genes of two individuals
shoot:	a young branch that sprouts from the main stem of a plant
sperm:	the male sex cell produced by the testes
spore:	the reproductive cell of mosses and ferns (and other organisms) that under the right conditions can develop into a new individual fern or moss
stamen:	the male reproductive organ of a flower containing the filament and anther
stem:	the long thin part of a plant that rises from the ground and from which smaller branches can grow; it supports the leaves, flowers and fruit
stigma:	the sticky tip of a flower pistil where the pollen is deposited during pollination
style:	the stalk-like slender part of the pistil joining the stigma and the ovary, and holding the stigma in a favourable position to receive pollen; the pollen tube grows through the style to deliver the male sex cells to the ovules
sustain:	to keep things alive or healthy
symbiotic:	a type of relationship between organisms in which one or both organisms benefit
tap root:	the main root of a plant that grows deep into the soil of a plant that has a single, dominant main stem
testes:	sperm producing glands of the male body
umbilical cord:	the cord- or tube-like structure that connects the foetus from its abdomen with the placenta of the mother; it transports nourishment and oxygen to the foetus and removes waste

uterus:	the hollow muscular organ in the pelvic area of female mammals in which the fertilised egg implants and develops (also known as the womb)
vagina:	an elastic muscular tube or canal that connects the neck of the uterus (cervix) with the external sexual opening
variables:	any factor that can affect the outcome of the investigation and can be measured, controlled or varied in some way
variation:	differences between living organisms of the same species
vertebrate:	an animal that has a backbone (spine) that holds the nerve or spinal column


concentrated
hydrochloric acid
Spirit
Vinegar
STINK
BOMBS
10.33
A
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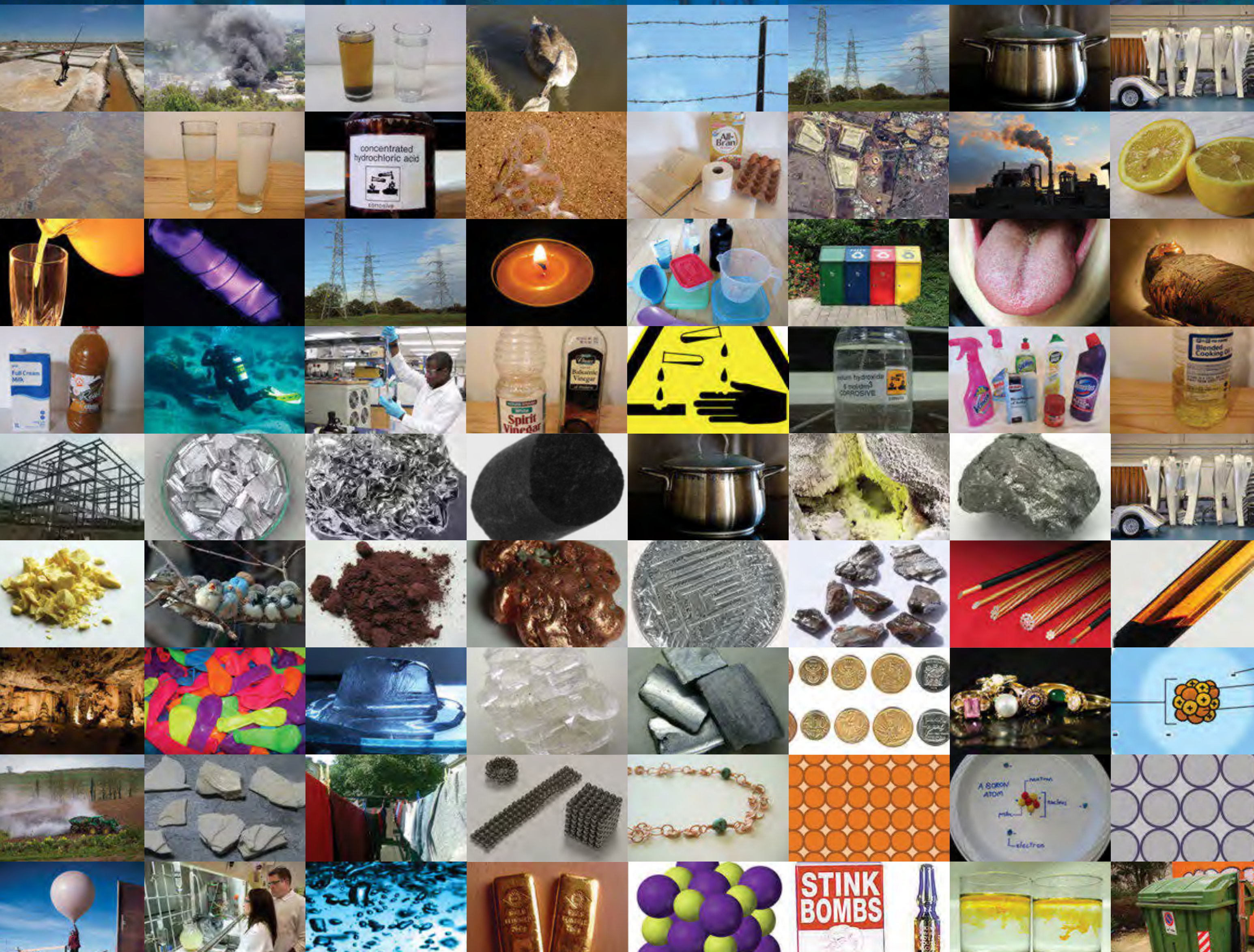
MATTER AND MATERIALS



1 Properties of materials

TEACHER'S NOTE

Chapter overview

2 weeks.

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

1.1 Physical properties of materials (5 hours)

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

1.2 Impact on the environment (1 hour)

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

KEY QUESTIONS:

- Which properties are important when choosing a material for a particular use?
- How can we measure the strength of a material?
- What does it mean when a liquid boils?
- How can we explain the term 'boiling point'?
- How can we explain the term 'melting point'?
- Why should we always think about the impact on the environment when we manufacture or use a particular material?

We learnt in Gr. 5 that the properties of a material determine what it can be used for. Can you remember what *properties* are?

1.1 Physical properties of materials

What are properties and why are they important?

You may remember that properties are distinctive characteristics that describe an object or material. For instance, we can describe a metal by saying that it is strong and **durable**. A metal is is also **malleable**. This **property**, malleability, means that a metal can be formed into sheets which can be used for a variety of different purposes. For example, metal sheets can be used as roof panels for a house, or to press body panels for a car.

TEACHER'S NOTE

Here you could also remind learners of a property they learnt about in Term 2 of Gr. 5. **ductile**: the property of a material that allows it to be drawn out into a wire

The walls and roof of this house are made of sheets of corrugated metal.

Can you see some parts of a car hanging up inside a car factory? These are made of sheets of metal.

What other properties of metals do you remember? Discuss this as a class.

TEACHER'S NOTE

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

Let's do a warm-up activity to get us thinking about materials and their properties.

ACTIVITY: Thinking about materials and their properties

INSTRUCTIONS:

1. Complete the following table by adding the names of different materials that have the properties listed.

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

QUESTIONS:

1. What does it mean when a material is flexible?
   Flexible means supple and bendy; able to flex and bend.
2. Suggest three possible uses of flexible materials?
   Flexible materials can be used to make clothing that needs to bend and fold; tubing or a pipe that needs to bend; coverings for electrical wiring that need to bend around corners; soles of shoes that need to flex when walking, etc.
3. Suggest three possible uses of a material that is a good conductor of electricity.
   Transmission cables for electricity, electrical wiring, electronic components for computers and other electronic equipment, electrical fencing (to protect property), etc.
4. Suggest three possible uses of a material that is a good conductor of heat.

   Good conductors of heat can be used for making pots and pans, heating elements, etc.

5. Which of the above properties would be important if you were choosing a material for making cookware (cooking pots)?

A metal pot.

Materials for cookware would need to be strong, rigid, and able to conduct heat.

6. Which of the above properties would be important if you were choosing a material for making the wires used for distribution of electricity (shown in the adjacent photo)?

These electrical wires carried by pylons are made of metal.

These electrical wires need to be strong, flexible and able to conduct electricity.

7. Which of the above properties would be important if you were choosing a material to make a barbed wire fence?

A barbed wire fence.

The material used to make barbed wire fences needs to be strong, but also ductile so that it can be made into long thin wires, and also flexible so that the wires can be bent.

VISIT

An interesting video on a new type of 'concrete canvas' with varying properties. bit.ly/147izAO

We can think of certain properties of materials in terms of advantages and disadvantages. Do you know what those are? Let's find out.

TEACHER'S NOTE

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

Advantages versus disadvantages

We have seen that strength and durability are desirable properties in some materials. We want things to be strong and to last long. Let's think of an example.

Why would plastic shopping bags need to be strong?

A black, plastic shopping bag.

TEACHER'S NOTE

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

Why would plastic shopping bags need to be durable?

TEACHER'S NOTE

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

We call the desirable properties of materials advantages. Disadvantages are unfavourable features, as can be seen in the images of plastic in the environment.

A goose about to eat a plastic bag in a river.

These plastic rings from soft drink packaging are very dangerous in the wild as they can entangle an animal's neck.

TEACHER'S NOTE

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

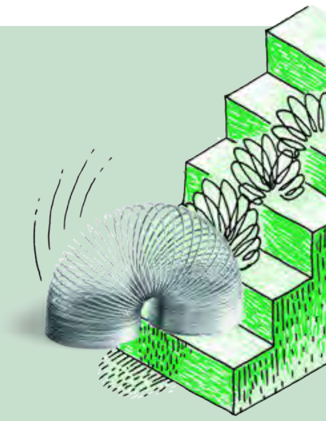
VISIT

A Hawaiian student looks at plastic objects found in the stomachs of albatrosses.

bit.ly/13PxkJj

The following activity has another example of advantages versus disadvantages.

ACTIVITY: Advantages versus disadvantages



TEACHER'S NOTE

This is an optional activity.

Can you imagine a car made of solid gold? A car like this would be very valuable!

INSTRUCTIONS:

1. Look at the image of a gold car then answer the questions that follow.
2. Discuss some of the questions with your classmates before writing down your answers.

QUESTIONS:

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

We always have to weigh up the advantages against the disadvantages when we choose materials for a particular job.

How would you test how strong a material is? Let's imagine you have different types of paper. How would you test which paper is the strongest? Discuss this as a class and write some notes on the lines provided.

TEACHER'S NOTE

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

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

The strength of paper is important because we use paper for many different things.

All these objects are made from different types of paper with different properties that suit the function of the object.

In the next activity we are going to investigate the tearing strength of different types of paper.

INVESTIGATION: Which type of paper is the strongest?

TEACHER'S NOTE

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

AIM: To compare the tearing strengths of different types of paper.

TEACHER'S NOTE

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

HYPOTHESIS:

When you write a hypothesis, you must state what you think will happen in your investigation.

TEACHER'S NOTE

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

MATERIALS AND APPARATUS:

- strips of different types of paper (20cm x 5cm)
- hole puncher
- strong paper clips
- yoghurt tub
- marbles
- string
- hand lens (optional)

TEACHER'S NOTE

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

METHOD:

TEACHER'S NOTE

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

1. Punch a hole at both ends of each paper strip. This is so that you can test the paper twice on each side. Make sure that the holes are in the middle, and also at the same distance from the end of each strip. This will make it a fair test.
2. Form the paper clip into an S-shape and hang it from the hole in the paper.
3. Make a handle for the yoghurt tub, using the string.
4. Hang the yoghurt tub from the paper clip and hold it in your hand.
5. Add marbles one-by-one to the yoghurt tub until the paper tears. Count the number of marbles in the tub. (Tip: Place the marbles very gently into the yoghurt tub or the shock of dropping them in might tear the paper).

6. Repeat steps 1 - 5 using the other end of the strip and count the marbles again. Take the average of the number of marbles.
7. Repeat this using the other strips of paper, doing each twice and taking the averages.
8. If each marble has a mass of 5 grams, work out the mass in grams that was needed to tear each strip of paper and write the number in the final column of your table.
9. If you have time, you can also test different kinds of materials, such as a plastic shopping bag, aluminium foil or plastic wrap.

Tip: To calculate the **average** of a set of numbers, you add all the numbers together and then divide by how many numbers there were in the set.

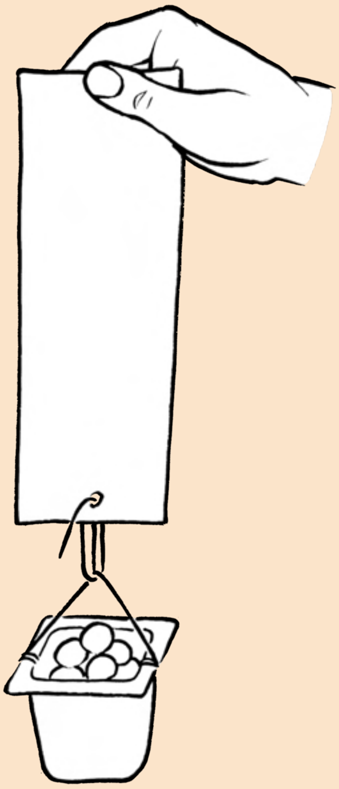
In this investigation, you will add the number of marbles together for each time you tested the paper strength (this was twice for each strip of paper) and then divide by 2 to calculate the average number of marbles that each piece of paper can hold before it tears.

For example, if you had 5 marbles in the first attempt, and 3 marbles in the second attempt, the average will be calculated as follows:

5 + 3 = 8 marbles

8 ÷ 2 = 4 marbles on average

Therefore, the paper type could hold an average of 4 marbles.



RESULTS AND OBSERVATIONS:

Record your results in the table.

Type of paper	Number of marbles (Trial 1)	Number of marbles (Trial 2)	Average number of marbles	Mass of the marbles

Now answer the following questions:

1. Look carefully at the surface of one of the paper strips. Now look carefully at the torn edge. Can you see anything special? Describe what you think the paper is made of.
   Learners should notice that the paper appears to be made of a layer of fibers. The fibers cling to each other because they have tiny branches on them, that become entangled to give the paper extra strength.
2. Which paper is the strongest?
   Learner-dependent answer based on the evidence from the investigation.

3. Which paper is the weakest?
   Learner-dependent answer based on the evidence from the investigation.
4. Arrange the different types of paper *in order of increasing tearing strength*. (That means from weakest to strongest.)
   Learner-dependent answer

ANALYSIS AND EVALUATION:

Let's now analyse and think about the results of the investigation.

1. What do you think causes one paper to be stronger than another?
   More than one factor play a role here, but generally paper that is thicker tends to be stronger. This is because the layer of fibres is thicker, so more fibres to cling to each other. Papers in which the fibres are longer and more tightly packed are also stronger, and coating the paper with a super thin layer of plastic also adds additional strength. Learners could be encouraged to look for signs of these treatments.
2. How would you modify the investigation to test the strength of different types of plastic?
   Plastics are generally stronger than paper, so for a start, the testing method should allow for greater weights to be hung from the plastic strips. This is a good opportunity to introduce the notion of fair testing: As many variables as possible should be kept the same: length of the plastic strips, method of fastening the weight to the plastic strips, etc.
3. What did you do to ensure fair testing?
   - *We used paper strips of the same length and width.*
   - *We punched identical holes in all the different paper strips.*
   - *We punched the hole in exactly the same place on all the strips.*
   - *We used the same method to hang the marbles from the paper strip for all the different types of paper.*
   - *We repeated each measurement (by testing both sides of the paper strip).*
4. How would you modify the investigation to test the flexibility of different types of materials?
   Learner-dependent answer. One suggestion might be to cut strips of the same size of the materials to be tested, and lay them across the edge of a table, hang a weight on the overhanging edge and find a way to measure the amount of flexing that occurs. Learners could discuss ways of ensuring the test is fair.
5. Why did you repeat the experiment for the same type of paper?
   It is important to repeat experiments to be sure you get the same/similar answers every time. Repeating an experiment and calculating an average value helps to eliminate errors, or results that arise by chance (or luck). We say it makes the answer more reliable.

CONCLUSION:

What can you conclude from this investigation?

TEACHER'S NOTE

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

Strength, **flexibility** (the ability to flex or bend), electrical conductivity and heat conductivity are important properties of materials that we learnt about in Gr. 5 and have revised again here.

Can you think of materials that are both strong and flexible? Most people will immediately think of plastics! Most plastics can easily be melted and **moulded** into different shapes for different purposes. Why do you think plastics can be 'melted and moulded' with ease?

TEACHER'S NOTE

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

All of these items are made of plastic in different shapes, sizes and colours.

We are going to learn about two new properties of materials, namely boiling point and melting point.

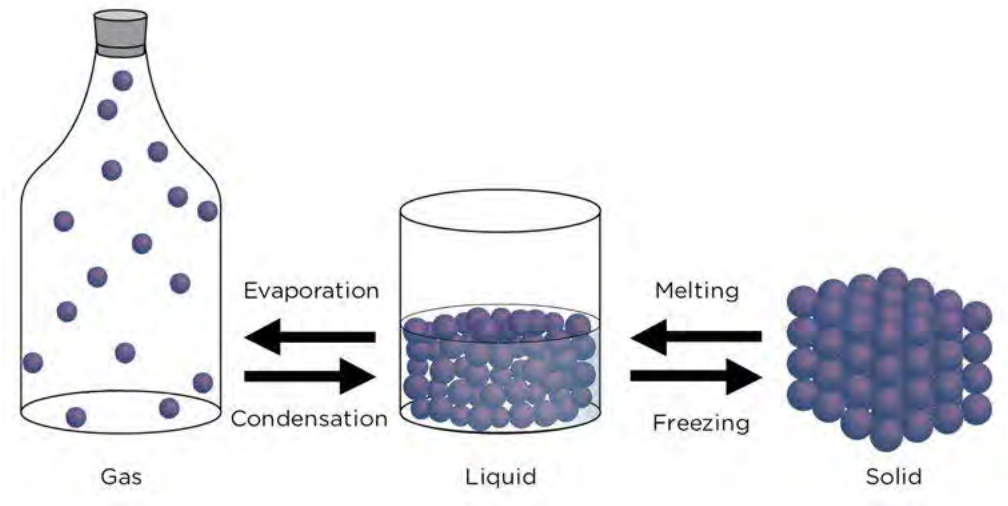
First, let's check if everyone knows that there is a difference between the words heat and temperature. The two words, heat and temperature, are connected but they do not mean the same thing:

- **Heat** is the transfer of energy from one object to another. This happens because of the difference in temperature between the two objects. The transfer of energy will be from the hotter object to the cooler object until they are the same temperature. You cannot measure heat directly, but you can detect its effect on a substance. Changes in heat can usually be detected as changes in temperature.
- **Temperature** is used to describe how hot or cold something is. Temperature can be measured directly with a thermometer.

Adding heat energy usually results in a temperature rise, so people often confuse heat and temperature. But they are not the same thing! We will look more at heating as a transfer of energy next term in Energy and Change.

Boiling and melting points

Do you remember learning about the state changes in previous grades? We will be focusing on boiling and melting in this section. Have a look at the following diagram to refresh your memories about the different changes of state between solids, liquids and gases.



1. Melting is when a solid changes into a liquid. Look at this photo of a candle burning. What is happening to the wax around the flame?
   The wax is melting.

2. Discuss with your partner why you think this is happening to the wax. Write your answer below.

A burning candle.

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

As you can see in the previous diagram, a liquid can change into a gas by evaporation. For example if you leave a saucer of water out in the sun, the water will evaporate. Evaporation can take place at any temperature. But, in boiling, the liquid needs to be heated to reach its **boiling point**. Bubbles of water vapour then form in the liquid and rise up.

TEACHER'S NOTE

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

Can you think of at least three different ways to boil water? Discuss this with your class and write your answer down.

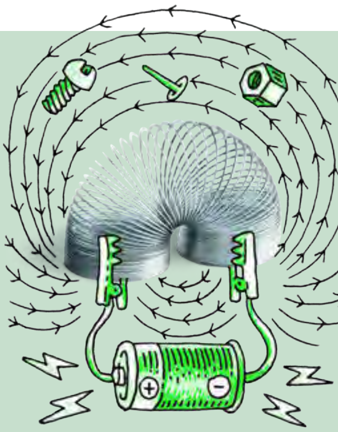
TEACHER'S NOTE

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

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

What would happen if you tried to put the kettle into the microwave or on the stove? We will soon find out!

ACTIVITY: Boiling and melting



TEACHER'S NOTE

This is an optional activity.

Look carefully at the picture. It looks as if something has gone wrong here!

QUESTIONS:

1. Write a short story to explain what you think happened to the kettle in the picture.
   Just a few sentences are required here. The learners should note that someone placed the plastic kettle on the stove. When the person tried to heat the water, the kettle melted as a result of contact with the flame/heat. The kettle is meant to be plugged in to heat the water.
2. Why do you think the person made the mistake of heating the kettle on the stove?
   Learners can come up with their own reasons here. Perhaps the person was used to heating water on the stove in a metal kettle. Perhaps the person did not know that the plastic would melt. Perhaps the person was just absent-minded and made a mistake.
3. Do you think plastic is a good choice of material for making a whole cooking pot? Why do you say so?
   No. Plastic is not a good choice because it melts when it is heated above a certain temperature.

4. Why does a plastic kettle not melt when we boil water in it?
The water boils at a temperature that is lower than the temperature needed to melt the plastic of the kettle.
5. Sometimes, just the handles of the cooking pot are made from plastic or wood. Why do you think this is so?
This is because wood and plastic are not good conductors of heat, unlike metal, and so you can pick up the pot easily.

TEACHER'S NOTE

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

At what temperature does water boil? We are going to do an investigation to find out! Since we have to make temperature measurements in the investigation, we are going to first check if everyone knows how temperature is measured.

TEACHER'S NOTE

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

Have you ever been so sick that you had a fever? Have you ever had your temperature taken?

Perhaps you have had your temperature taken with a **thermometer**. A thermometer can be used to find out how hot or cold something is. A thermometer is an instrument for measuring temperature.

TAKE NOTE

The mercury inside these kinds of thermometers is toxic and dangerous so they must be handled with care.

This is a thermometer used to take your temperature when you have a fever.

TEACHER'S NOTE

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

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

Activity: How does a thermometer work?

The common glass thermometer that you see in the image is called a bulb thermometer. All bulb thermometers consist of a fairly large bulb, connected to a long thin tube. The thermometer usually contains some type of brightly coloured liquid. Liquids take up less space when they are cold and more space when they are warm; we say they contract when they are cooled and expand when they are warmed.

QUESTIONS:

1. What do you think will happen to the liquid level in the thermometer when the liquid inside expands?

The liquid level will rise when the liquid expands.

2. What do you think will happen to the liquid level in the thermometer when it is put into the refrigerator? Say *why* this would happen.

The inside of the refrigerator is cold. This will make the liquid inside the thermometer contract. The liquid level will drop.

Let's now investigate boiling and melting.

INVESTIGATION: What is the boiling point of water?

TEACHER'S NOTE

The investigation in the learners books includes only that of investigating boiling point of water, as suggested in CAPS. However, if you would also like to look at melting point of ice, this second part has been included in the teachers guide later.

AIM: To observe boiling and to determine the boiling point of water.

TEACHER'S NOTE

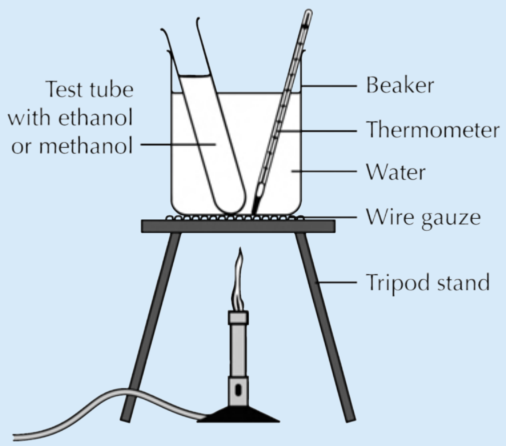
CAPS suggests that this investigation could be performed on `other liquids' such as orange juice, apple juice and cola. One issue to be aware of is that the suggested beverages are all solutions of substances*in water*. Their boiling points will be slightly higher than that of pure water, but this is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

Here are some suggestions for extensions for this investigation:

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

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

Warning: Take care when working with these substances, especially methanol, since it is dangerous. Wear gloves if possible, and avoid inhaling the fumes. Furthermore, ethanol and methanol are both extremely flammable and care should be taken when heating them. A safe way of heating ethanol or methanol to its boiling point is shown in the following diagram. The test tube containing the ethanol or methanol should be suspended in a beaker of tap water, and slowly heated. The principle of thermal equilibrium means that the water and ethanol/methanol will be at the same temperature, so the temperature of the water can be substituted for the temperature of the ethanol/methanol.



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

HYPOTHESIS:

What is your hypothesis for this investigation?

TEACHER'S NOTE

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

MATERIALS AND APPARATUS:

- glass beakers x 2 (or small pot)
- Bunsen burner (or stove plate)
- tripod with gauze
- tap water
- thermometer
- funnel
- ice blocks

TEACHER'S NOTE

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

Before you start, discuss the following questions in your group:

1. Discuss what you know about gases, liquids and solids; the three states of matter. Write down your ideas from your discussion.
   - *The particles in solids are tightly packed into fixed positions, so solids retain their shape. They cannot be compressed.*
   - *The particles in liquids are also close to each other, but they are not in fixed positions and can move around, that means liquids can fill the container they are in. They are not really compressible either.*
   - *The particles of gases are really far apart, they are not ordered in any way, they can move anywhere they want. Gases are compressible as a result.*

   Learners should be encouraged to think about the different states of matter in terms of the particle model which was first introduced in Gr 6 and is built upon more next year in Gr 8.
2. What needs to happen to water to make it freeze?
   In order for water to freeze, it needs to be cooled down.
3. What needs to happen to water to make it boil?
   In order for water to boil it needs to be heated.
4. How do we measure temperature?
   We measure temperature with a thermometer.
5. Can you remember the boiling point and freezing/melting point of water? If you can, write them in the space below.
   It is not important that learners remember these temperatures, as they will be determining them experimentally shortly. This question has been added to allow you to gauge how many learners know them.
6. Let's make some predictions. Read the two statements below, and indicate whether you AGREE, DISAGREE or are NOT SURE, by drawing a cross in the matching column:
   Learner-dependent answers.

TEACHER'S NOTE

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

Statement	AGREE	DISAGREE	NOT SURE
Water can get hotter than 100°C.			
Water always freezes at 0°C.			

VISIT

This video shows you how to use a laboratory thermometer.

bit.ly/16ww1kU

Safety precautions

- Your teacher will demonstrate how to handle the Bunsen burner safely.
- Remember that boiling water can cause painful burns.
- The thermometer is made of very thin glass. Hold it gently, and do not use it to stir the water. Be careful not to drop it or bump it against the bottom or sides of the beaker.

TEACHER'S NOTE

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

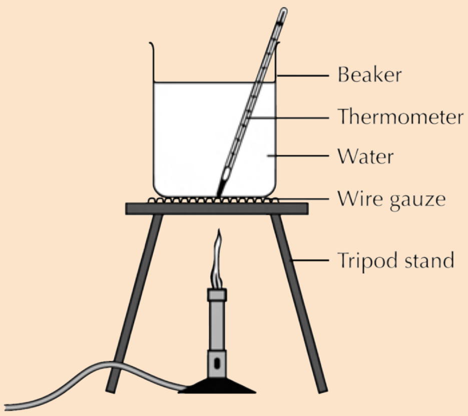
It might be best to try this experiment in advance to determine how frequently water temperature should be measured. Time intervals would depend on the volume of water. CAPS suggests intervals of 3 minutes, but shorter intervals will provide more data points to plot on the graph.

TAKE NOTE

Perhaps you measured the boiling point of the water as slightly less than 100°C. This does not mean that your measurements were incorrect. The boiling point of water depends on the atmospheric pressure. At sea level (close to the ocean) water boils at 100°C. Water boils at a lower temperature at higher **altitudes** (for example, on a mountain) because the air pressure is less.

METHOD:

1. Set up your apparatus as shown in the image. Remember that when you want to take the temperature, the thermometer must not be touching the sides.
2. Take a measurement of the water temperature before you start heating the water. This will be your measurement at time 0.



3. Light the burner and heat the water.
4. Measure the temperature of the water at regular intervals. Record the temperature in the table provided.
5. After a while you will notice that the temperature of the water becomes **constant** (this is when the temperature stops going up). Continue to take the temperature three more times (once every three minutes) after this happens. What do you notice about the water?

TEACHER'S NOTE

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

RESULTS AND OBSERVATIONS:

Record your results in the table.

Elapsed time (minutes)	Temperature of the water (°C)
0	

We are now going to draw a graph of the results recorded in the table. Here are some guidelines for drawing the graph:

1. The title of your graph should be: **Determining the boiling point of water**.
2. The independent variable should be 'Time'. Label the axis, and use minutes as units. Remember that the **independent variable** should always be drawn on the horizontal axis of your graph, or the x-axis.

VISIT

Water can boil at room temperature, inside a vacuum bit.ly/16ww3cp

TEACHER'S NOTE

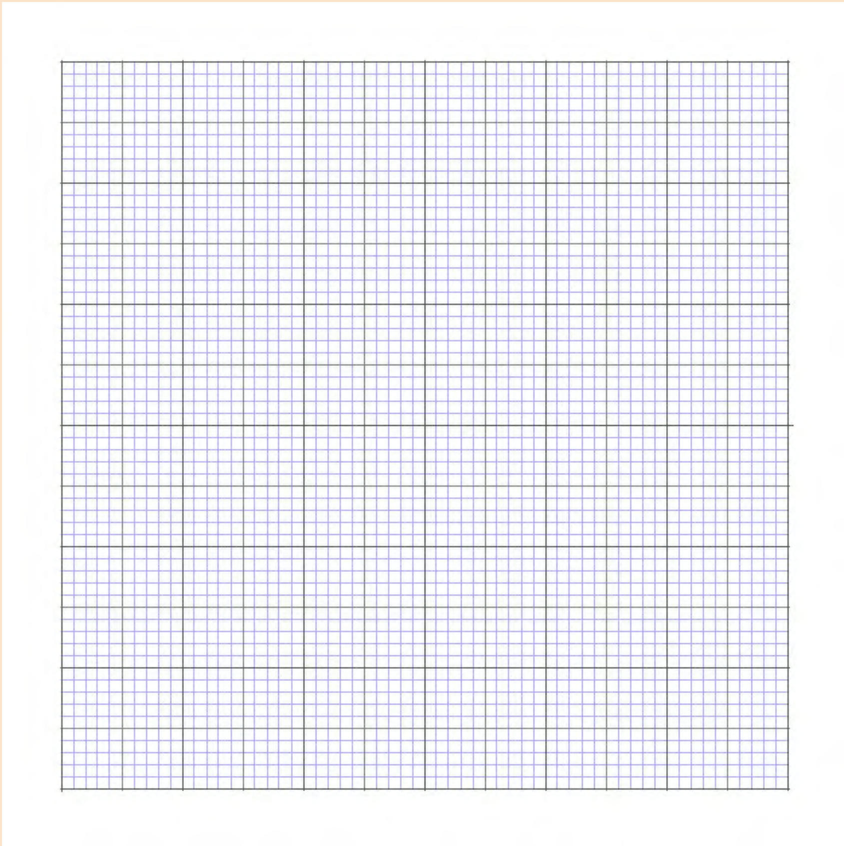
Learners should be reminded that the independent variable is the one that was `manipulated'; in this case the total amount of energy added to the water increased with time. Since we have no real measure of the energy added to the water, but since we do know that the energy was added at a constant rate,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

3. The dependent variable should be 'Temperature'. Label the axis, and use degrees Celsius (°C) as units. The **dependent variable** should always be drawn on the vertical axis of your graph; this is the y-axis.

TEACHER'S NOTE

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

4. Plot the data on a line graph using the graph paper - each data point must be marked with a small, neat cross.

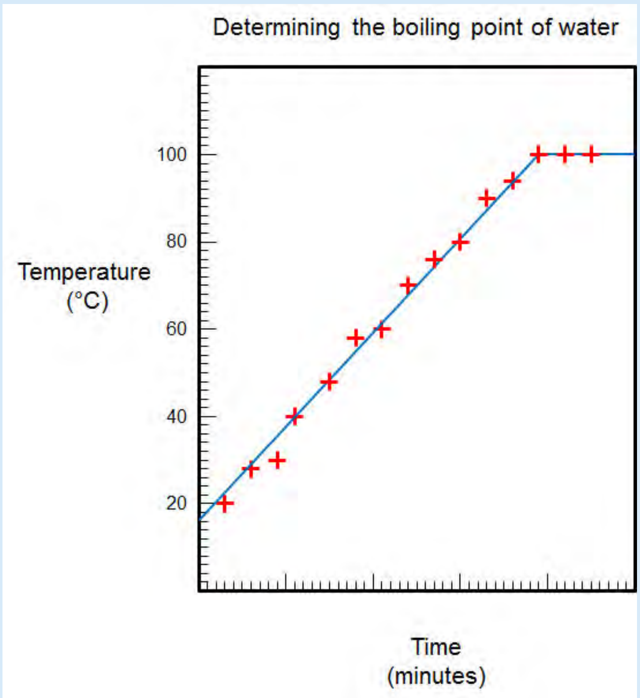


TAKE NOTE

The boiling point of water also depends on the purity of the water. Water which contains impurities (such as salt or sugar) boils at a higher temperature than pure water. This is why orange juice or apple juice will boil at temperatures slightly above 100°C.

TEACHER'S NOTE

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



TAKE NOTE

Different thermometers from different batches might also give slightly different readings. This is because they might have been calibrated differently.

ANALYSIS:

1. What did you see when the water started to boil?
   I saw bubbles in the water.
2. What do you think happened to the water when it boiled?
   Some of the liquid water turned into gas, that is why there were bubbles.
3. Describe the shape of your graph. Is it a straight line?
   The first part of the graph has a positive slope, then the graph becomes a horizontal line.
4. How did the temperature of the water change over time?
   The temperature of the water increased gradually, then it became constant.
5. How does the shape of the graph show the way the temperature changed over time?
   The left part of the graph where the slope is positive, shows that the temperature of the water increased. The right part of the graph where the graph is horizontal, shows that the temperature of the water did not change over time, but stayed constant.
6. What happened to the temperature of the water when it started to boil?
   The temperature did not go up anymore, it stayed constant.
7. How long did it take for the water to start boiling?
   Learner-dependent answer.
8. At what temperature did the water boil?
   Learner-dependent answer.
   The boiling temperature depends on the elevation above sea level and the air pressure at the time of measurement. Water boils at 100°C at sea level and at temperatures slightly below that at elevated altitudes.
9. What do we call the temperature at which the water boils? Indicate this temperature on your graph.
   The temperature at which water boils is called the boiling point of water.

TEACHER'S NOTE

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

10. Suppose we used a Bunsen burner with a bigger flame.
    a) Do you think the water would boil at a temperature that is higher, lower or the same as the boiling point you just measured? Why do you say so?
    The water will boil at the same temperature. The bigger flame gives more energy to the water but does not affect the boiling point.
    b) Do you think the time required for the water to boil would be longer, shorter or the same? Why do you say so?
    The water will boil in a shorter time. The bigger flame gives more energy to the water per time unit. That means less time will be needed to heat the water.

CONCLUSION:

Write a conclusion for this investigation. When writing a conclusion, you must go back to look at your initial aim.

TEACHER'S NOTE

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

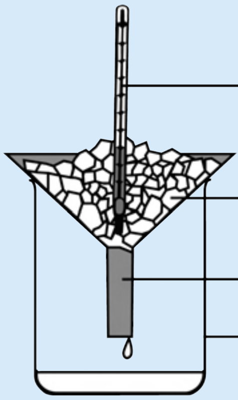
TEACHER'S NOTE

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

Part 2: Measuring the melting point

METHOD:

1. Set up your apparatus as shown in the following picture.



   Note: It is better to use crushed ice rather than larger blocks of ice, because it gives better contact between the thermometer bulb and the ice.
2. Leave the thermometer in the ice for a few minutes. Read the measurement on the thermometer. What do you notice about the ice?
   Note: Learners should notice that, even though the ice is starting to melt, the temperature remains constant.
3. Wait 3 minutes and measure the temperature again. Is the ice getting warmer or does the temperature remain constant?
   Note: The temperature remains constant.
4. Do step 3 one more time.
5. Take some of the ice pieces and drop them into the beaker. Swirl the ice with a small amount of water for about 20 seconds and then measure the temperature of the ice-water-mixture in the beaker. Is it different from the original temperature of the ice?
   Note: The temperature of the ice-water-mixture should be the same as the original temperature of the ice.
6. Place the beaker in a warm spot (you could even heat it carefully over the Bunsen burner). Measure the temperature of the ice-water-mixture every three minutes. What do you notice about the temperature when all the ice has melted?
   Note: Once all the ice has melted, the temperature of the water begins to rise.

7. Once all the ice has melted, continue to measure the temperature every 3 minutes, 3 more times.
8. Record your measurements in a table in the space provided.

RESULTS AND OBSERVATIONS:

Use the space provided to draw your own table to record your results. Have a look at the table that you filled in for part 1 to give you some hints.

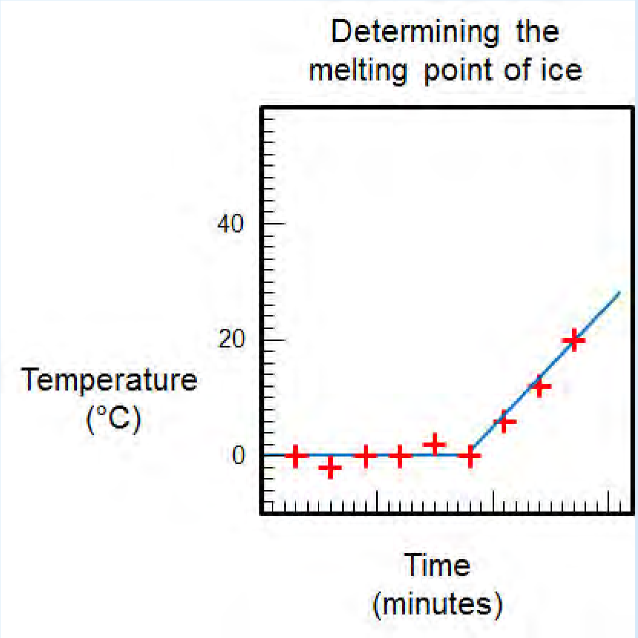
Now draw a graph of your experimental data. Here are some guidelines for drawing the graph:

1. The title of your graph should be: **Determining the melting point of ice**.
2. Which is the independent variable?
   The independent variable is Time.
3. Which is the dependent variable?
   The dependent variable is Temperature.

Note: See explanation given for variables within the first part of the investigation.

4. Plot the data on your graph, and draw a smooth line through the data points.

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



Beware that temperatures below 0°C may be recorded, so learners' graphs may not be identical.

ANALYSIS:

1. What did it look like when the ice started to melt?
   The ice became wet where it melted.
2. Describe the shape of your graph. Is it a straight line?
   The first part of the graph is a horizontal line, then the graph goes up (the line has a positive slope).
3. How did the temperature of the ice (and water) change over time?
   At first, the temperature of the ice-water-mixture stayed constant, then after all the ice had melted, the temperature of the water started to go up.
4. How does the shape of the graph show the way the temperature changed over time?
   The horizontal part of the graph represents the stage when the temperature stayed constant. The right side of the graph, where the slope is positive, shows that the temperature was going up.
5. What happened to the temperature of the water when all the ice had melted?
   Once all the ice was melted the temperature of the water started to go up.
6. How long did it take for all the ice to melt?
   Learner-dependent answer.
7. At what temperature did the ice melt?
   The ice melted at 0°C.
8. What do we call the temperature at which the ice melts? Indicate this temperature on your graph.
   The temperature at which ice melts is called the melting point of ice.
9. At what temperature do you think water will freeze?
   Water freezes at 0°C.

Note: The purpose of this question is to make learners realise that melting and freezing are the reverse of each other. The phase transition between water and ice (liquid and solid water) always occurs at 0°C (in pure water).

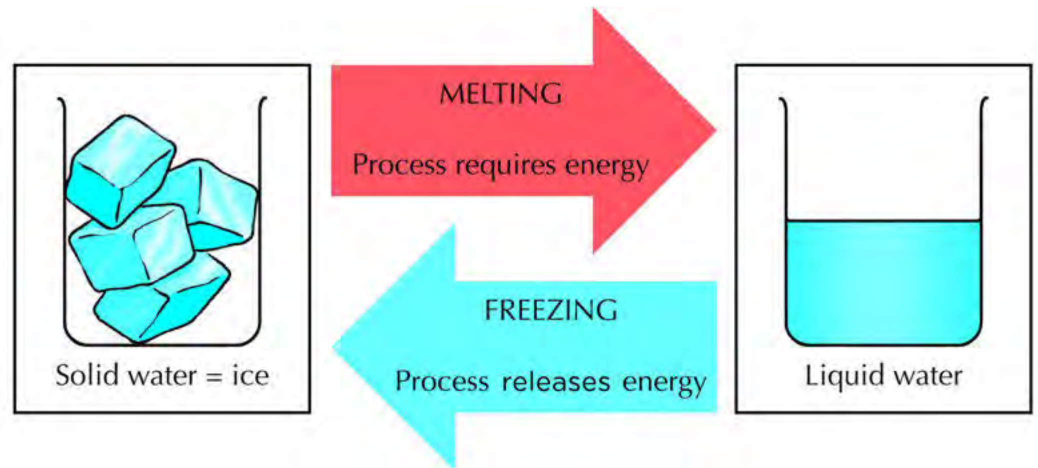
10. Suppose we used a Bunsen burner to melt the ice.
    a) Do you think the ice would melt at a temperature that is higher, lower or the same as the melting point you just measured? Why do you say so?
    The ice would melt at the same temperature because the melting point stays the same.
    b) Do you think the time required for the ice to melt would be longer, shorter or the same? Why do you say so?
    The ice would melt in a shorter time, because the burner gives it more energy in a shorter time.

Note: Once again, this has been included to bring learners to the realisation that a fixed amount of energy will be needed to melt a fixed amount of ice. Heating the ice with a burner simply delivers the energy at a faster rate, so melting occurs sooner. Melting occurs at the melting point which is 0°C. The melting point is not affected.

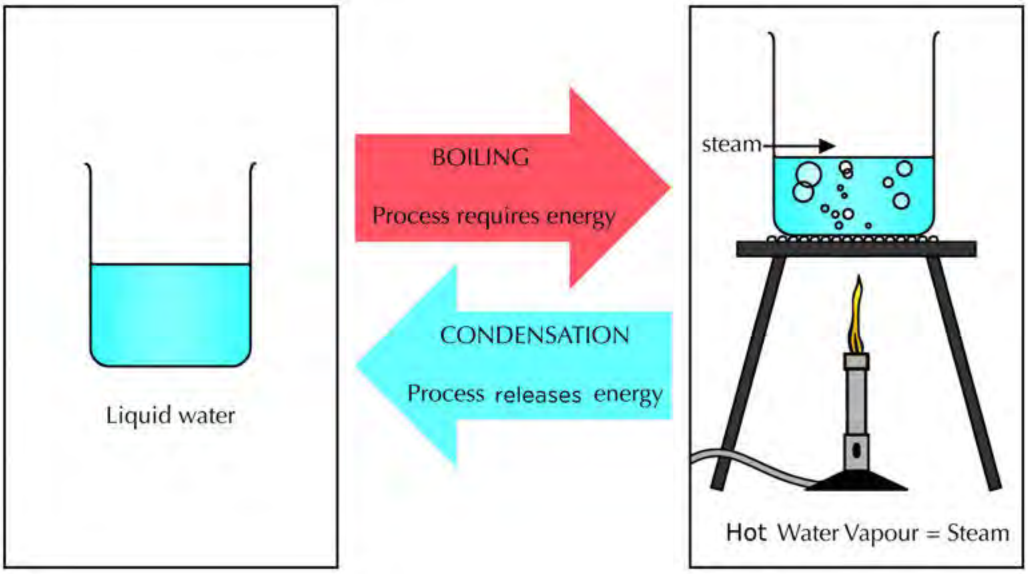
TAKE NOTE

Ice melts at 0°C. Water freezes at 0°C. Coincidence, or not?

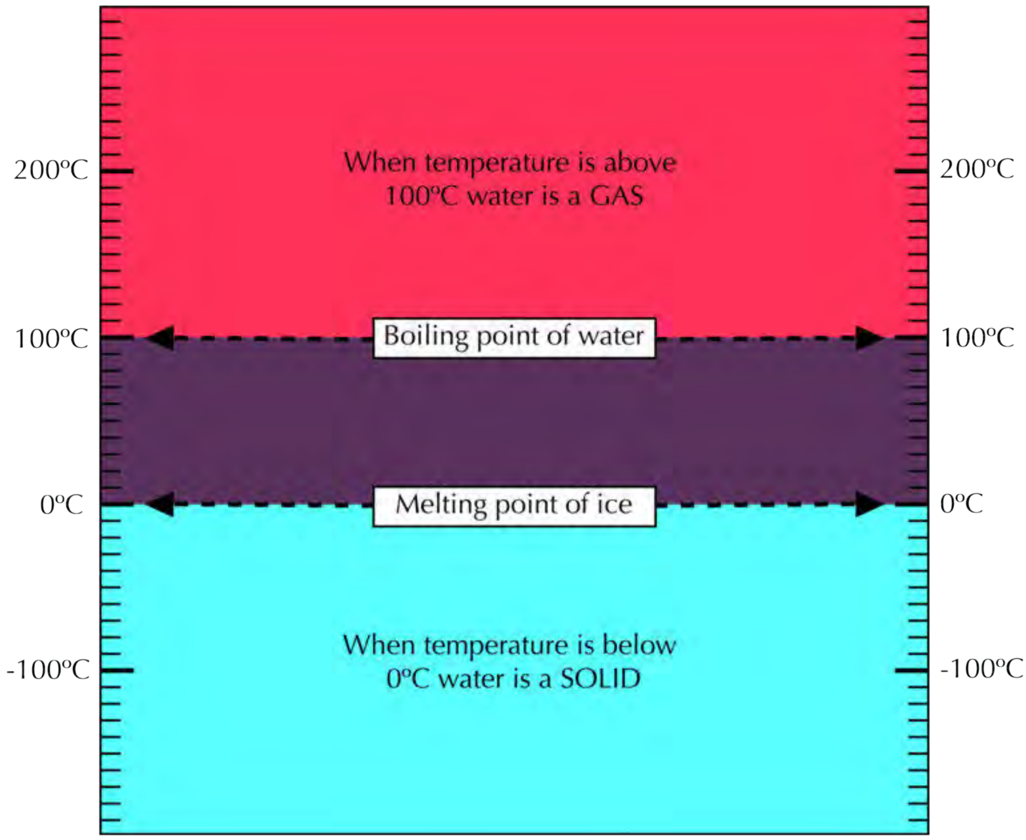
We will learn more about changes of state in Gr. 8 Matter and Materials. In order to melt ice, we need to add energy to it to raise the temperature to **melting point**. However, if we want to freeze water, we need to remove (take out) energy from it until the temperature decreases to freezing point.



Does boiling have a reverse process? Boiling is when liquid water changes to water vapour or steam. The reverse process, when steam turns back to water, is called condensation. In order to boil water, we need to add energy to it. But if we want to condense the water vapour, we need to cool it down (take energy out of it).



The following diagram summarises what we have learnt so far.



TEACHER'S NOTE

In words, the summary of the diagram is:

- Boiling occurs when a liquid turns to a gas at boiling point.

- Water boils at a temperature of 100°C when the air pressure equals 1 atmosphere. This is called the normal boiling point of water.
- When water is heated, its temperature will rise until the water starts to boil. While the water is boiling the temperature will remain constant.
- Melting occurs when a solid turns to a liquid.
- Ice (the solid form of water) melts at a temperature of 0°C. This is called the melting point of ice. This is also called the freezing point of water.
- When ice is heated, its temperature will remain constant until all the ice has melted. Only then will the temperature of the water (that was ice before it melted) rise above 0°C.

Ask your learners what 'room temperature' is and if they can find room temperature on the diagram? Get them to mark where it is on the diagram. Room temperature is 25°C. Once they have located where this is on the diagram, ask them what state water will be at 25°C? Water is a liquid at 25°C.

Do all liquids boil at 100°C? No, of course not! Not all substances melt at 0°C either.

Can you think of a few substances that are solids at low temperatures, but have low melting points? (Think of things that melt easily when it is hot outside. Ice cream is an example.)

TEACHER'S NOTE

Discuss this in class and get your learners' input. Some examples are: Ice cream, butter, and chocolate.

In the next activity we are going to explore the boiling and melting points of a few substances other than water.

ACTIVITY: Boiling and melting points of other substances

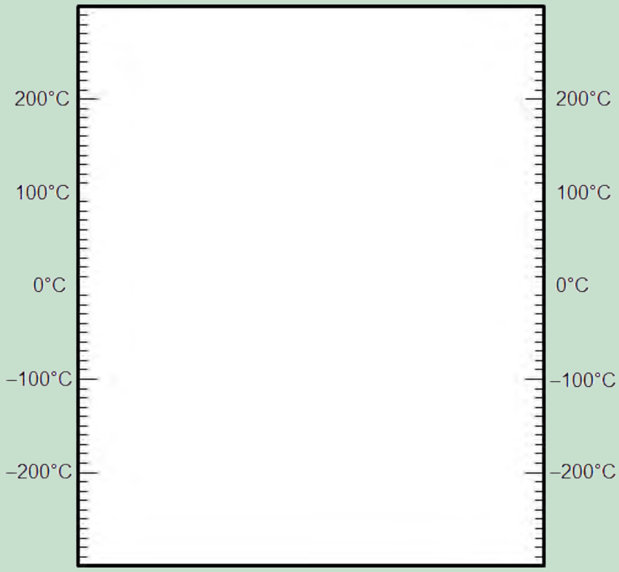
TEACHER'S NOTE

This is an **optional** activity.

INSTRUCTIONS:

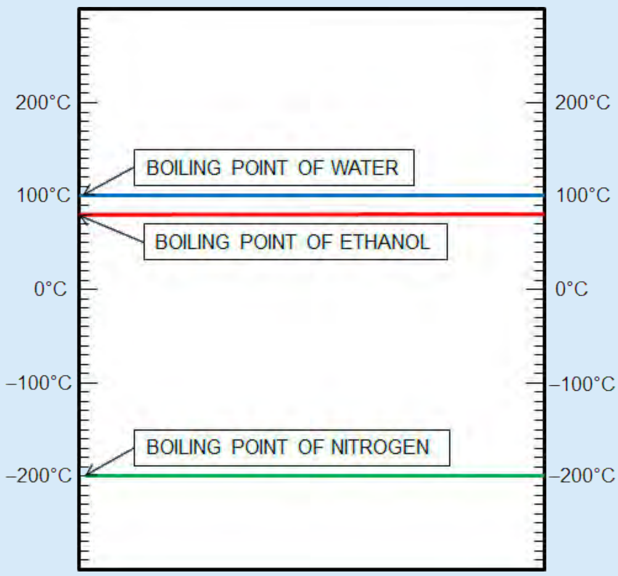
1. Place the boiling and melting points of the substances listed below on the blank template provided and then answer the questions.
2. The boiling point of nitrogen is - 200°C. Draw a green line at this temperature on the diagram and label it 'Boiling point of nitrogen'.
3. The boiling point of ethanol is 78°C. Draw a red line at this temperature on the diagram and label it 'Boiling point of ethanol'.
4. Now draw a blue line at the boiling point of water and also label this line.

5. What is room temperature? Draw a black line at this temperature and label it.



TEACHER'S NOTE

Learners' diagram should look like this:



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

VISIT

Play an interactive game based on the melting points of solids. bit.ly/16ww5RR

QUESTIONS:

1. What state would nitrogen be in at room temperature? Why do you say so?
   Nitrogen would be a gas at room temperature, because room temperature is higher than the boiling point of nitrogen.

2. Suppose you mix some water and some ethanol. They are mixed but they have not changed into something else. The mixture is at room temperature to begin with. Now suppose you start heating the mixture. What temperature would be reached first: 78°C or 100°C?
   78°C
3. What do you think will happen when the mixture reaches a temperature of 78°C? Do you think the ethanol will start to boil?
   Learners may be unsure, but you could say that the ethanol is still ethanol, it has not been changed in the process of mixing, so it will most certainly start to boil at 78°C.
4. Will the water boil at the same time?
   No. Water only starts to boil at 100°C.

TEACHER'S NOTE

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

So far we have seen that materials have different properties such as their strength, their flexibility and their melting and boiling points. These properties determine how these different materials are used.

We also briefly mentioned how some materials can conduct heat better than others. This is called heat conductivity. Think of some objects which you want to be able to conduct heat well and what material they should be made of. Write some of your ideas down.

TEACHER'S NOTE

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

Why do you think you put a jersey on when you are cold? What can we say about the wool that the jersey is made from in terms of heat conductivity?

TEACHER'S NOTE

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

We will learn more about heat transfer later in the year. Another property of materials is how well they can conduct electricity. This is called electrical conductivity. We will look more at how different materials can be used as electrical insulators (meaning they do not conduct electricity well), later in the year.

1.2 Impact on the environment

Earlier, we saw how some of the properties of materials may be advantages under certain circumstances, but can become disadvantages under a different set of circumstances, such as plastics and other materials which, if they end up in nature, can have serious consequences and cause harm to other animals. Every process used to produce materials for our benefit has an **impact** on the environment. Some processes have a small impact and others have a large impact.

We have already seen how the use of materials, such as plastics and paper, has a negative impact on our environment, but what about their production?

ACTIVITY: Environmental impact of material production

VISIT
What is fracking? (An article) bit.ly/16BKP3A

INSTRUCTIONS:

1. Look at the pictures and answer the questions that follow about the production of different materials in South Africa.
2. You will need to do some extra research for this activity. Some information about each of the processes has been provided, but you will need to research them in more detail and answer the questions that follow.

Mining:

Mining in South Africa has been one of the main reasons for our development. South Africa is still one of the top gold mining countries in the world. We also mine and produce other metals such as chromium, platinum, as well as coal and iron ore. Although this is hugely beneficial for the economy, it has devastating effects on the environment.

1. This huge hole is actually a diamond mine about 40 km outside of Pretoria. What effects do you think this has had on the environment?

The Premier Diamond Mine outside of Pretoria.

The local habitats are affected by the digging of the hole, the roads that are built and the other infrastructure put in place. Diamond mines require huge amounts of diesel which produce greenhouse gases which build up in the atmosphere.

2. In this photograph, the 2010 World Cup Soccer Stadium can be seen in the centre. In the top left are huge areas called slag piles. These are huge piles of crushed rock left over from decades of gold mining. What impact do you think this has on this area?

An aerial view of the Soccer City Stadium and surrounding area.

Note: *Learners may battle with this question so you can ask them if they think anything can grow or live on these dumps again?*
As can be seen, these slag piles do not have anything growing on them as they are not green, and they have been there for decades, so they are reducing the possibilities for habitats and natural vegetation to grow back. The rock can contain toxic chemicals (such as cyanide) which seep into the ground and contaminate soil and water.

3. Coal mining in South Africa also has a major impact on the environment. Not only the mining, but the use of coal in power stations has negative impacts. What are some of these?
Huge amounts of land are destroyed when mining coal. Coal mining also requires large amounts of water, which reduces the water for surrounding areas. Water runoff can also contaminate water supplies. There is air pollution in coal mining and in the use of coal in power stations. when coal is burning, greenhouse gases are released which contribute to acid rain formation and the greenhouse effect. It also contaminates the air for other organisms.

VISIT
An article on fracking in South Africa. bit.ly/13lJ1Yw

VISIT
Video on the environmental impact of coal mining in South Africa. bit.ly/14n2Hyz

Paper making:

Can you imagine your world without paper? Probably not! We use it every day of our lives. South Africa has a big paper-making industry. Although paper is important in our lives today, the production has negative impacts on the environment.

VISIT
For a list of the 10 most serious environmental concerns of the 21st century, visit the website. Each of the environmental issues is accompanied by a short video. bit.ly/147jh0V

A tree plantation for paper.

A paper-making factory.

1. Huge areas of land are used to plant the trees that are then harvested to

make pulp and then paper. What impact do you think this has on the environment? Hint: Also think about what you learnt about in Life and Living about biodiversity.
Plantations take up a lot of space and therefore natural, indigenous vegetation has to be cleared (deforestation). This destroys habitats for other organisms. These trees also use a lot of water and prevent anything from growing underneath them. They reduce the biodiversity in the area.

2. Look at the photo of the paper-making factory. What effects does this have on the environment?
There is a huge amount of air pollution from paper-making factories, which contributes to a build up in greenhouse gases. Paper mills use huge amounts of water, and the waste water contains many chemicals and substances which damage the environment.

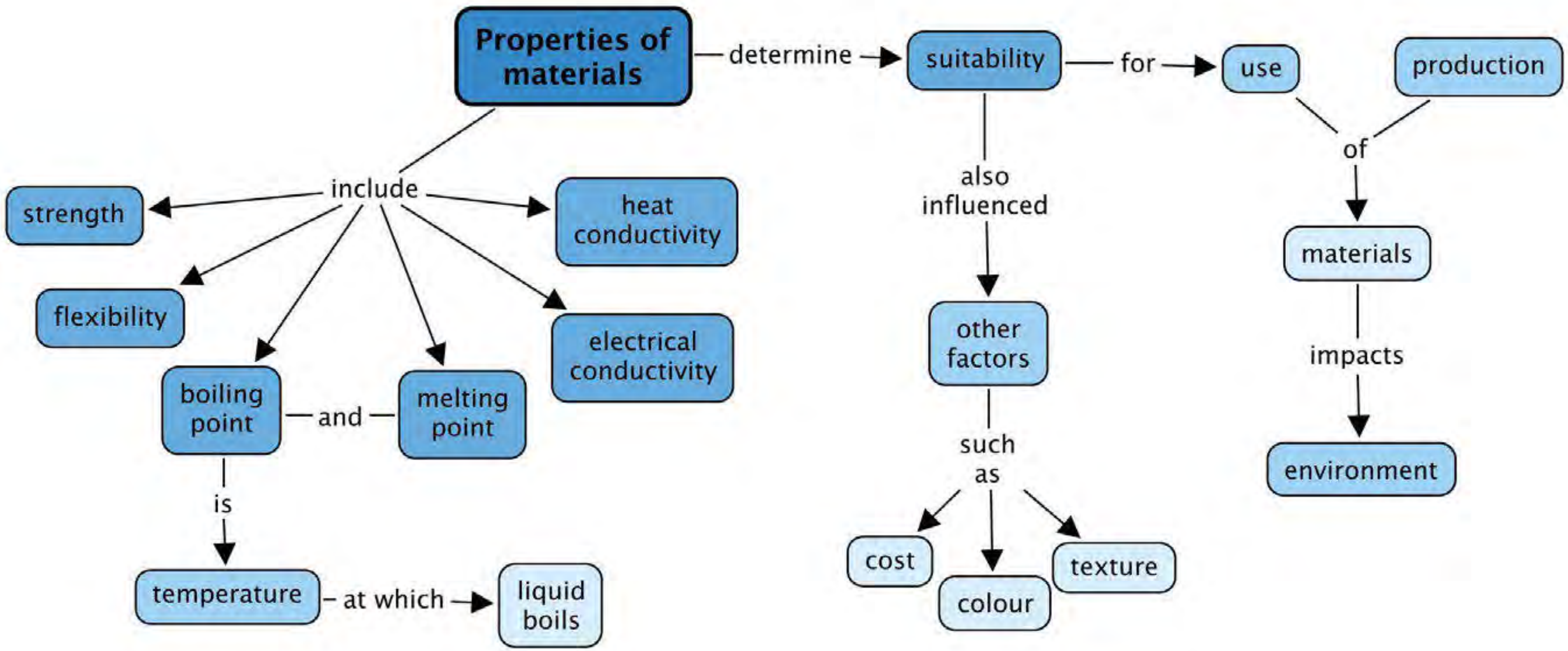
SUMMARY:

Key Concepts

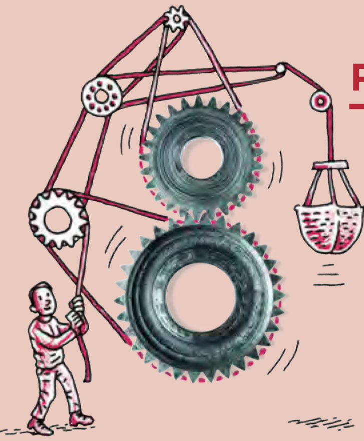
- The properties of a material determine the purposes for which it can be used.
- Some of the properties of materials include strength, flexibility, heat and electrical conductivity and they have specific boiling and melting points.
- Boiling point is the temperature at which a liquid boils.
- Melting point is the temperature at which a solid melts.
- The suitability of a material for a certain use is also influenced by other factors such as its cost, its colour and its texture.
- The ways we use materials and the processes we use to produce them always have an impact on the environment.

Concept Map

Below is a concept map for what we have learnt about the properties of materials. We discussed several properties of materials in this chapter. Can you see how we can summarise a lot of information onto one page?



Properties of materials
determine
suitability
for
use
production
of
materials
impacts
environment
also influenced
other factors
such as
cost
colour
texture
include
strength
flexibility
boiling point
and
melting point
heat conductivity
electrical conductivity
is
temperature
at which
liquid boils

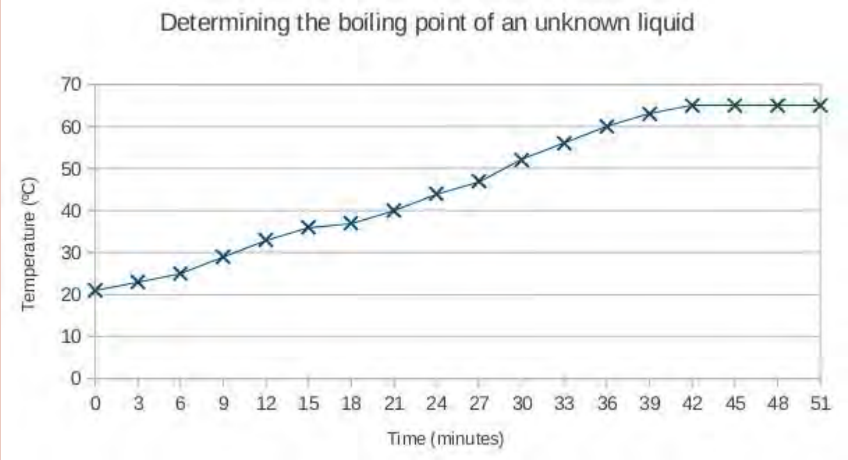


REVISION:

1. Below are a number of short sentences. In each case, you must complete the sentence by filling in the missing words. Write the whole sentences out on the lines provided. Fill in the missing word. [8 x 1 mark each = 8 marks]
   a) The set of characteristics that describe a material are called the _______________ of that material.
   The set of characteristics that describe a material are called the properties of that material.
   b) Materials that can be hammered into thin sheets are called _____________. (Metals have this property.)
   Materials that can be hammered into thin sheets are called malleable.
   c) Materials that can be bent are called _____________. (Some plastics have this property.)
   Materials that can be bent are called flexible.
   d) The boiling point of a material is the _______________ at which the liquid state of that material turns into a gas.
   The boiling point of a material is the temperature at which the liquid state of that material turns into a gas.
   e) When we want to measure temperature we use a _________.
   When we want to measure temperature we use a thermometer.
   f) The boiling point of water at sea level is _____________.
   The boiling point of water is 100 °C.
   g) A material that conducts heat well is said to have a high _______________.
   A material that conducts heat well is said to have a high heat conductivity.
   h) If you want to create a circuit for a bulb, the material that you use in the circuit to connect the battery to the bulb must have a high _______________.
   If you want to create a circuit for a bulb, the material that you use in the circuit to connect the battery to the bulb must have a high electrical conductivity.
2. State whether each of the following statements is TRUE or FALSE. If you think a statement is FALSE, you have to write a TRUE statement in its place. [4 x 2 marks each = 8 marks]
   a) All liquids boil at 100°C.
   FALSE: There are a few alternative true statements possible:
   - *Not all liquids boil at 100°C.*
   - *Water boils at 100°C.*
   - *Each liquid has its own unique boiling point.*

   b) Water always boils at 100°C.
   FALSE: At sea level, water boils at 100°C. (At higher altitudes water boils at temperatures slightly below 100°C.)
   c) Any given material will melt and freeze at the same temperature.
   TRUE
   d) When water is boiled over a bigger flame, it will boil at a higher temperature.
   FALSE: Two alternative TRUE statements are possible:
   - *When water is boiled over a bigger flame, it will boil at the same temperature, namely 100°C (at lower altitude/at sea level).*
   - *When water is boiled over a bigger flame, it will boil more quickly (sooner).*

3. A scientist wants to determine the boiling point of an unknown liquid. She places the unknown liquid in a beaker and carefully heats it on a hot plate. The scientist measures the temperature of the liquid at regular time intervals (every 3 minutes). Afterwards, she draws the the following graph:



a) At what temperature does the unknown liquid boil? Show this temperature on the graph. [2 marks]
The unknown liquid boils at 65°C. (Learner must indicate this temperature on the graph.)

b) How long does it take for the unknown liquid to start boiling? [1 mark]
The unknown liquid starts to boil after approximately 40 minutes.

c) The scientist suspects that the unknown liquid is one of the substances on the following list. Use the list to identify the unknown liquid. Say *why* you think it is this substance. [2 marks]

Substance	**Boiling point (°C)**
Acetone	56
Methanol	65
Ethanol	78
Isopropanol	83
Water	100

The unknown liquid is methanol. The boiling point of methanol is the same as that of the unknown liquid, namely 65°C.

d) What was the temperature of the unknown liquid at the start of the experiment? [1 mark]
21°C

Total [22 marks]

2 Separating mixtures

TEACHER'S NOTE

Chapter overview

2 weeks

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

2.1 Mixtures (1 hour)

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

2.2 Methods of physical separation (4 hours)

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

2.3 Sorting and recycling materials (1 hour)

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

KEY QUESTIONS:

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

2.1 Mixtures

TEACHER'S NOTE

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

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

What does it mean to *mix* something? Can you mime an explanation (that means you have to explain without saying a single word!)

TEACHER'S NOTE

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

Is it possible to mix water? Discuss this with your class.

TEACHER'S NOTE

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

One substance alone cannot be a mixture. A **mixture** is made up of two or more different substances.

A mixture can contain solids, liquids and/or gases. The components in a mixture are not chemically joined; they are just mixed. That means we do not need to use chemical reactions to separate them. Mixtures can be separated using physical methods alone and that is what this chapter is all about: how to separate mixtures.

There are many different kinds of mixtures. Before we learn how to separate them, it is worth looking at all the different kinds of mixtures briefly.

Different kinds of mixtures

TEACHER'S NOTE

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

A mixture of a solid and a solid

Soil is a mixture of different components.

Can you think of an example of a mixture of a solid and a solid? Soil is an example of a mixture of solids. What are the substances found in soil?

TEACHER'S NOTE

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

A mixture of a solid and a liquid

What happens when clay or sand is mixed with water? Would you be able to see through a mixture of clay and water?

Can you see the difference between an opaque suspension of sand and clay in water (on the left) and a clear solution of sugar in water on the right?

The mixture of clay or sand with water is muddy. The small clay particles become suspended in the water. This kind of mixture is called a **suspension**. Suspensions are **opaque**; that means they are cloudy and we cannot see through them very well.

What happens when sugar is mixed with water? Does the mixture become muddy? Why not? The sugar dissolves in the water and the mixture is called a **solution**. Solutions are **clear**; that means we can see through them.

TEACHER'S NOTE

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

A mixture of a solid and a gas

The black smoke from a burning building.

Have you ever seen smoke from a fire? What is the smoke made of? Do you think it is a mixture?

TEACHER'S NOTE

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

A mixture of a liquid and a liquid

Milk is not a single substance, but actually a mixture of two liquids! The one liquid component in milk is water, and the other is fatty oil. The reason milk is opaque is that tiny droplets of the oil is suspended in the water. Can you remember what a mixture is called when a solid is suspended in liquid?

TEACHER'S NOTE

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

When some liquids are suspended in liquid, we call the mixture an **emulsion**. Like suspensions, emulsions tend to be opaque.

A clear, transparent solution on the left and an opaque emulsion on the right

Are all liquid-liquid mixtures emulsions? (One way to recognise an emulsion is that it is opaque). Are all liquid-liquid mixtures opaque? Can you think of a liquid-liquid mixture that is not an emulsion? Discuss this with your class and give an answer below.

TEACHER'S NOTE

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

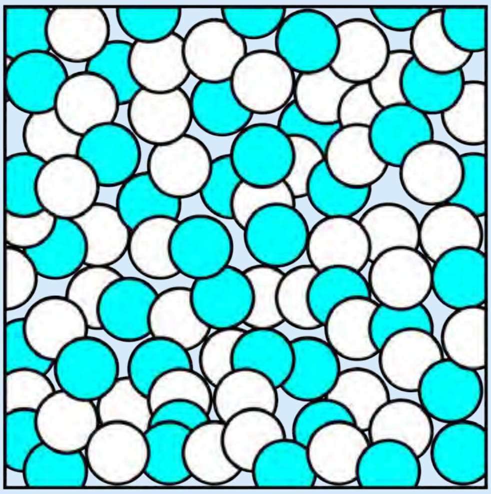
A better example of a liquid-liquid solution is vinegar, which is a mixture of ethanoic acid (acetic acid) - a liquid at room temperature - and water. This example might be a sensible inclusion since it would serve as early introduction to households acids that will feature prominently in the next chapter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

A mixture of vinegar and water is clear, and that is a clue that the mixture is a **solution**.

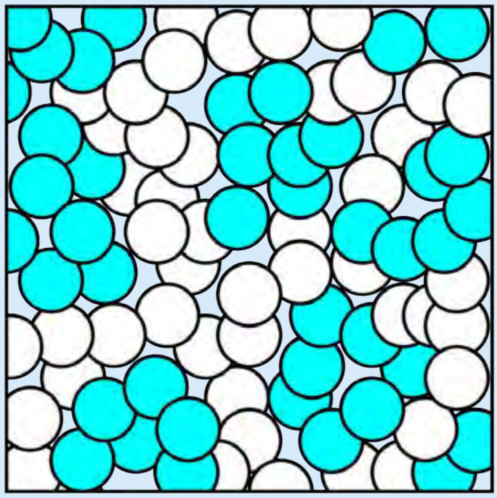
Solutions are special kinds of mixtures in which the particles are *so well mixed* that they are not separated from each other. We cannot make out separate substances anymore - everything looks the same when we look with the naked eye.

TEACHER'S NOTE

The particle model of matter will only be dealt with in detail in Gr. 8, but the following kinds of visual representations may aid understanding of abstract concepts. You can draw these on the board with different colours. Learners were exposed to similar images in Gr. 6. However, it is not critical at this stage and you do not need to go into detail. Solutions look glassy/translucent, and the solid particles cannot be seen. The substances cannot be separated by filtration (dealt with later in this chapter).



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



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

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

A mixture of a gas and a gas

We learnt in Gr. 6 Matter and Materials that the particles of gases are far apart. This means that gases can mix very easily, because it is easy for their particles to move in amongst each other. The air we breathe is not a single gas but actually a mixture of gases! Do you know what the two most **abundant** components are?

TEACHER'S NOTE

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

VISIT

An artists, Berndnaut Smilde, uses a fog machine to make small clouds inside a room which only last a few seconds. A wonderful example of science as art!
bit.ly/16wwIA6

A mixture of a liquid and a gas

Do you remember that we discussed boiling in the previous chapter (Properties of Materials)? What happens to a liquid when it boils?

TEACHER'S NOTE

The liquid turns to a gas.

Can you see the water vapour in the picture of a boiling kettle? Point to it with your finger. Discuss this with your teacher and classmates and when you have agreed on an answer, draw an arrow onto the picture to indicate the water vapour.

Can we see most gases? Why do you think so?

TEACHER'S NOTE

A suggestions is to do a demonstration of this in class if you can get a kettle and plug it in to show learners the colourless steam at the spout of the kettle. Learners may point to the cloud in front of the kettle. This is not actually water vapour, which would be invisible to the human eye. The cloud forms when the water vapour cools down sufficiently to condense into micro-droplets that are visible to the human eye.

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

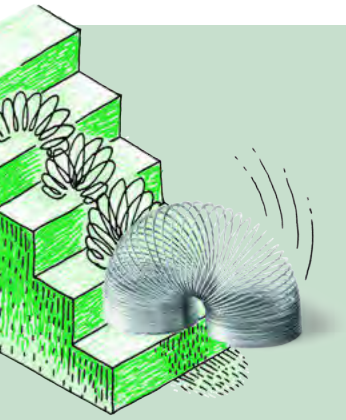
The image below indicates where the arrow should be drawn:

TEACHER'S NOTE

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

Clouds and fog or mist are all examples of tiny water droplets suspended in air.

We have learnt that mixtures can be made of substances in the same state or in different states. The following activity will help us apply our new knowledge about mixtures to more examples.



ACTIVITY: Types of mixtures

INSTRUCTIONS:

1. Look at the list of mixtures. Discuss in your group, or with your partner, what each mixture consists of.
2. Identify the type of substances (solid, liquid or gas) that are mixed in each of the examples on the list.
3. Write the name of each example in the appropriate block on the diagram.

Mixtures:

- air
- smoke
- hair oil (emulsion of oil and water)
- clear fruit juice (eg. apple juice)
- cloudy apple juice
- salty water
- **alloys** such as brass (used for coins) and stainless steel (used for rust-resistant metal items)
- foam plastic (like the material used for making mattresses and pillows)
- spray deodorant
- air freshener (aerosol type)
- paint
- dust cloud
- soil

For instance, sugar dissolved in water would go in the middle block of the bottom row, to show that it is a solid (sugar) mixed with a liquid (water).

	gas	liquid	solid
gas			
liquid			
solid		Sugar dissolved in water	

TEACHER'S NOTE

Gas-gas mixtures: Air

Gas-liquid mixtures: spray deodorant and air freshener

Gas-solid mixtures: smoke, dust cloud and foam plastic

Liquid-liquid mixtures: Clear fruit juice, hair oil

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

Solid-solid mixtures: Alloys, soil

Why do we make mixtures? Mixtures have many uses: perhaps we are mixing ingredients to bake a cake, or mixing metals to make a really strong alloy.

A cake is a mixture of ingredients, including flour, eggs and milk.

Many things around us occur naturally as mixtures: salty sea water, moist air, soil, compost, rocks (mixture of minerals) to name a few. Many mixtures are man made, for instance; Coca Cola, paint, salad dressing and so forth.

TEACHER'S NOTE

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

Mixtures are very useful. However, sometimes we need to separate mixtures into their components. Remember that the substances in a mixture have not combined chemically. They have not turned into new substances, but are still the same substances as before - they have just been physically combined. That is why we can use physical methods to separate them again.

2.2 Methods of physical separation

Now that we know about the different kinds of mixtures that are possible, we are going to learn about some ways of separating them.

TEACHER'S NOTE

As an introduction to this you can ask learners about why they think we would want to separate mixtures. For example, imagine that our drinking water comes from a well in the ground and it is muddy. Muddy water is not good to drink. We would want separate the water from the solid material (sand or clay) before using it! Once separated, we would keep the water to drink and throw the sand away. Ask learners if they can think of a way to separate the water from the sand? *Learners may suggest filtration (filtering) as a method for separating the sand and water.*

How do we separate mixtures?

Suppose you were given a basket of apples and oranges. How would you sort them? You would probably pick out all the oranges from the apples by hand. The same method may not be suitable for all mixtures. You would probably not consider sorting sugar and sand **grains** by hand. Why not?

TEACHER'S NOTE

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

Let us look at some of the most commonly used methods of physical separation.

Hand sorting

A mixture of different coloured beads.

How would you separate the mixture of beads in the adjacent picture into the different colours?

VISIT

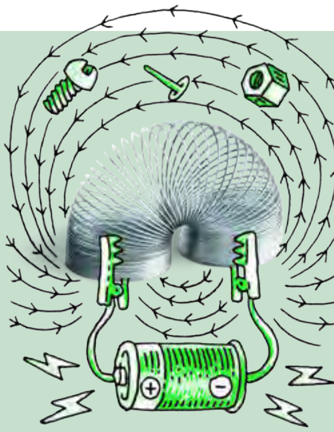
Sometimes people create machines to perform tasks for them, like this Skittles sorting machine.
bit.ly/1cx5078

TEACHER'S NOTE

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

TEACHER'S NOTE

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



ACTIVITY: Thinking about hand sorting

1. Would hand sorting also be a practical way to sort out the mixture of rice and lentil beans in the picture below?

A mixture of rice and lentils

Yes, as long as there are not too many of them to sort.

2. Would hand sorting be a practical way to sort the pebbles out of a large pile of sand?
Probably not. It would take way too long!
3. Besides what we discussed in the chapter, think of at least three other examples of mixtures that could be hand sorted.
Learner-dependent answer. Suggestions may include:
   - *Sorting thorns from wool*
   - *Sorting lego blocks into different sizes or colours*
   - *Sorting stones from a packet of dried lentils or beans*
   - *Sorting mail*
   - *Sorting fruit or eggs according to size or grade*
4. When is hand sorting a good method for separating the components in a mixture?
When the 'particles' in the mixture are relatively large and when there are not too many of them to sort.

Sieving

Can you think of a practical way to sort stones or pebbles from sand? Do you think picking the pebbles out by hand would work?

TEACHER'S NOTE

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

How would you separate the pebbles from the sand in this pile?

When we have large quantities of materials to sort and the different particles have different sizes, we can **sieve** the mixture. The smaller particles will fall through the openings in the sieve, while the larger particles stay behind.

Filtration

Muddy water is poured through a funnel lined with filter paper to remove the small sand and clay particles.

When the particles in a mixture are too small to be caught by a sieve and when the components of the mixture are in different states, we can separate them by **filtration** using a filter.

What type of mixture is the muddy water in the glass an example of?

TEACHER'S NOTE

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

TAKE NOTE

The clear liquid that has passed through the filter paper is called the **filtrate** and the particles that are left behind on the filter paper is called the **residue**

TEACHER'S NOTE

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

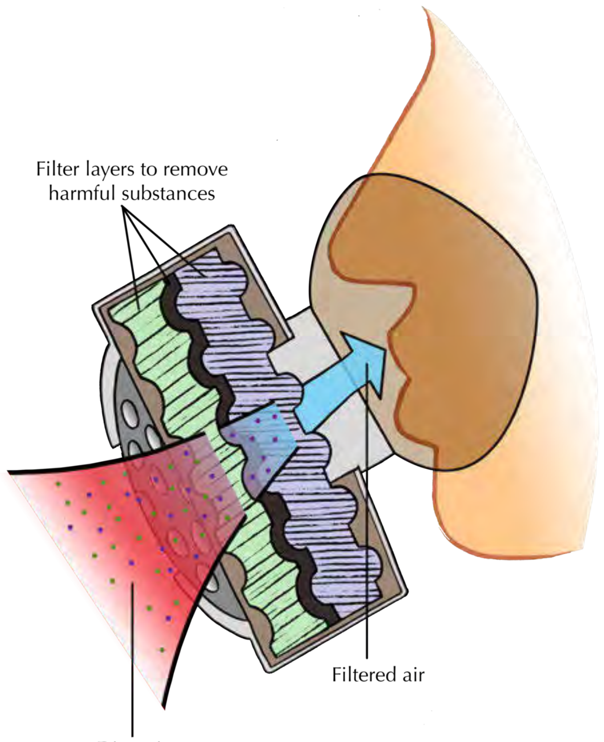
A firefighter wears a mask to filter out the smoke.

Have you ever noticed how, when people have to work in dusty or smoky environments, they wear dust masks or smoke masks? Why do you think that is necessary?

TEACHER'S NOTE

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

The following diagram shows how a gas mask works. Layers of very fine filters trap harmful substances and dust or smoke particles, so that only clean air is let through.



A smoke mask consists of filter layers which clean the dirty air before it is breathed into the body.

ACTIVITY: Thinking about sieving and filtering

1. Besides what we discussed in the chapter, think of at least three other mixtures that could be sieved, and write them in the space below.
   Learner-dependent answer. Suggestions may include:
   Sieving flour to remove lumps, husks and other large bits
   Pouring tea through a sieve to catch the tea leaves (this is a crude way of filtering)
   Rinsing sand or soil from spinach leaves before we cook them
   Filtering leaves out of a swimming pool (we call it filtering, but what we are actually doing is sieving the leaves out of the water)
2. When is sieving a good method for separating the components in a mixture?
   When the components of the mixture have different sizes and there are many of them to sort.
3. Nowadays most people use tea bags to make tea, but there was a time when people brewed tea from leaves and then poured the tea through a sieve into the cup. Why do you think they did this?

Tea leaves and bits have collected in the sieve after pouring the tea into the cup.

To remove the tea leaves from the tea before drinking it.

4. Sometimes the particles that we want to remove from a mixture are so small that they will pass easily through a sieve (think of the example of the muddy water from before). Can you think of a way to overcome this?
   Learners may realise that they need to make the openings in the sieve smaller if they want to catch smaller particles.
5. Besides what we discussed in the chapter, think of at least three other mixtures that could be filtered, and list them below.
   Learner-dependent answer. Suggestions may include:
   Filtering coffee grounds through a coffee filter or in a plunger
   The vacuum cleaner has a filter for trapping dust particles inside the machine and letting clean air through. That is how it removes dust particles from the carpet and furniture.
   Air conditioners contain filters to filter out dust before the air from outside enters a building.
6. When is filtering a good method for separating the components in a mixture?
   When the 'particles' in the mixture are very small, and in different states.

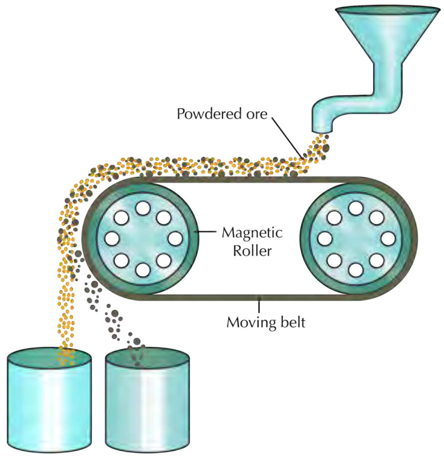
Can you remember the activity from Gr. 6 when Tom used magnetism to separate different kinds of metals at his uncle's junk yard? The **magnetic** properties of the metals allowed them to be separated in this way.

Magnetic separation

TEACHER'S NOTE

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

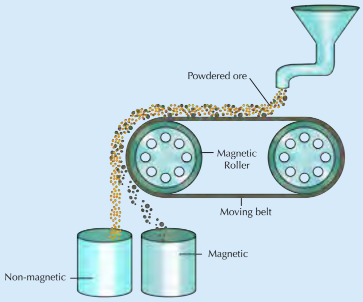
The following diagram shows how magnetic separation can be used to separate a mixture of components. In the example, mineral ore that contains two compounds (one magnetic, and the other non-magnetic) is being separated. The ore grains are fed onto a revolving belt. The roller on the end of the belt is magnetic. This means that all the magnetic grains in the ore will stick to the belt when it goes around the roller, while the non-magnetic grains will fall off the end. As soon as the magnetic grains move past the magnetic roller, they will also fall down.



In the above diagram, what colour are the non-magnetic grains and into which container do they fall? Label this on the diagram. What colour are the magnetic grains and which container do they fall into?

TEACHER'S NOTE

The non-magnetic grains are yellow-orange and fall into the container on the left. the magnetic grains are grey-brown and fall into the container on the right. The diagram should be labelled as follows:



ACTIVITY: Thinking about magnetic separation

1. Besides what we discussed in the chapter, can you think of two other mixtures that could be separated magnetically? Write them in the space provided.
   Learner-dependent answer. Suggestions may include:
   Removing iron filings (magnetic) from sand or sugar (non-magnetic).
   Separating aluminium cans (non-magnetic) from steel cans (magnetic).
2. When is magnetic separation suitable for separating the components in a mixture?

When the components in the mixture have different magnetic properties, in other words when one or more components in the mixture is magnetic and the others are non-magnetic.

How can we separate the components in a solution? Let's find out.

Separating solutions

The substances in a solution are mixed on the level of individual particles. In a sugar and water solution, the sugar particles and the water particles are mixed so well that we could not distinguish them with the naked eye. You might think that mixtures that are so 'well-mixed' are impossible to separate! But as we shall soon see, this is not true.

Separation by evaporation

TEACHER'S NOTE

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

Do you know where most of the salt that we use in South Africa comes from? South Africa gets it salt from inland salt pans, coastal salt pans and seawater. A salt pan is a shallow dam in the ground where salt water **evaporates** to leave a layer of dry salt.

An aerial view of salt pans.

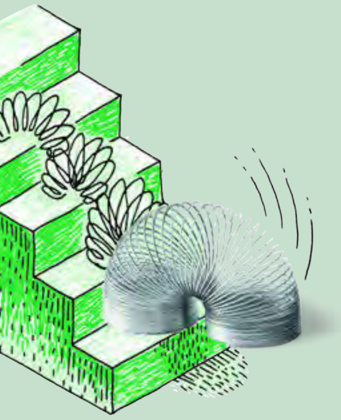
Salt pans in India. A man is busy collecting the dried salt to be packaged and sold.

When sea water is allowed to stand in shallow pans, the water gets heated by sunlight and slowly turns into water vapour, through evaporation. Once the water has evaporated completely, the solid salt is left behind.

Do you think this is a good method for separating salt from water? Do you think it would work for a sugar and water solution?

TEACHER'S NOTE

Yes, it would.



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

TEACHER'S NOTE

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

QUESTIONS:

1. Do you think separation by evaporation would be a good method to separate a salt-water-solution if you wanted to keep both the salt and the water? Why do you say so?
   Evaporation by itself is not a good method of separation if you want to keep both the salt and the water. Once the water evaporates, it is lost.
2. Can you think of a way to modify the method so that the water that evaporates is not lost? Perhaps the following diagram will help you to formulate a plan. Write an explanation below.

In the picture, the salt-water solution is heated in a kettle, and a metal plate (with some ice inside to keep its outer surface cold) is held in the water *vapour that is escaping from the spout of the kettle. The water vapour cools when it touches the cold metal plate and condenses. It then runs off the plate and into the collection beaker. The salt is left behind in the kettle once all the water has evaporated. But, you still have the water in the beaker.*

3. What is happening in the kettle?
   Salt water is boiling.
4. Can you say what change in state is happening inside the kettle? What is the process called?
   Liquid water is changing to water vapour. The process is evaporation.
5. What change of state is occurring on the cold surface of the metal plate? What is the process called? (Hint: the change of state from gas to liquid was covered in the previous chapter, under *Physical properties of materials*.)
   Water vapour is changing to liquid water. The process is called condensation.
6. Does the salt evaporate with the water? How would you find out?
   No. You can taste that the water is salty before evaporation, and not salty after condensation. If you boil the water until all of it has evaporated, you can see salt crystals form.
7. What can you tell about the purity of the water after it has evaporated and condensed?
   It does not taste salty after evaporation/condensation so we assume that it is pure, but it may have other things in it which we can't taste.

TEACHER'S NOTE

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

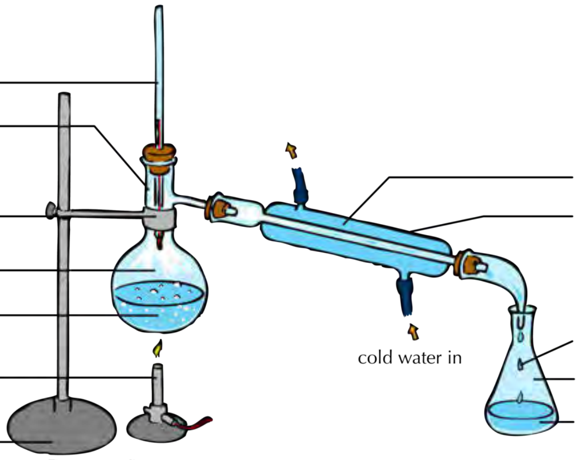
The water that is lost through evaporation can be **condensed** on a cold surface. The cold metal plate will do the job, but it would be difficult to recover all the condensed water, because it will be dripping off the surface of the plate in many different places. Scientists have a solution for that problem: they use a special technique to separate mixtures like these without losing any of the components. The technique is called **distillation**.

Distillation

TEACHER'S NOTE

If you have the equipment to set up this distillation process, then you can demonstrate it in class. Otherwise there are alternative materials and equipment that you can use. For example, if you do not have a Liebig condenser, you can use a piece of copper pipe. Here are two links which explain how to build your own distillation equipment: http://www.instructables.com/id/Build-a-Lab-Quality-Distillation-Apparatus and http://nukegingrich.files.wordpress.com/2009/06/diy-still.pdf. Another suggestion is to get learners to also do the research to see how to make their own distillation apparatus, specifically looking at materials which are easy and cheaper to come by. You do not have to have laboratory equipment to demonstrate many science experiments - many can just be done by thinking of the materials which you use in everyday life and making a plan! This also makes science more accessible to everyone.

Distillation is the separation of one substance from another by evaporation followed by condensation. The apparatus used in this technique is called a **still**.



Experimental setup for distillation

VISIT
Find out more about the distillation of crude oil in this video bit.ly/14n3a3J

Suppose we want to separate the water and salt in seawater. We would place the seawater in the round flask on the left of the picture (in the distillation flask). We would then boil the seawater to produce water vapour, or steam. The salt would not evaporate with the water, because only the water evaporates. The water vapour rises through the top of the flask and passes into the Liebig condenser.

Two Liebig condensers which are used in the distillation process

VISIT
A video describing how a solar still can desalinate (take salt out of) water.
bit.ly/14zWJwW

The Liebig condenser consists of a glass tube within a larger glass tube. The condenser is designed in such a way that cold water can flow through the space between the tubes. This cools the surface of the inner tube. The water vapour condenses against this cold surface and flows into the receiving flask. Since the salt has not evaporated, it stays behind in the distillation flask.

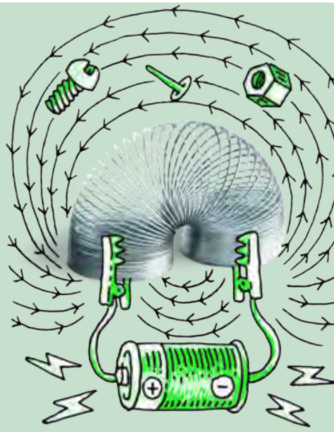
TEACHER'S NOTE

The solar still video is short but provides an interesting topic for discussions: applications of separating methods; inventions; advantages and disadvantages; you could even discuss open-source projects and sharing information. The

Italian inventor of the Eliodomestico solar still designed it with developing countries in mind. It is relatively cheap, easy to assemble, and requires no electricity. It is described as an eco-distiller that runs on solar power. All you need to do is pour in 5 litres of salty or impure water, tighten the cap, and leave it out in the sun. By the end of a day it can provide bacteria-free, salt-free water that is suitable for drinking. It is also an open-source project which means that anybody can use the design and replicate, modify or upgrade it, but not sell it for profit.

Distillation is also the best way to separate two liquids that have different boiling points, like water and ethanol for example. Let us have a look.

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



TEACHER'S NOTE

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

QUESTIONS:

1. Can you remember the temperature at which water boils? Write it down below.
   100°C
2. What is this temperature called?
   The boiling point of water.
3. Ethanol boils at a temperature lower than the boiling point of water, namely 78°C. Suppose you mix some water and some ethanol. The mixture is at room temperature to begin with. Now suppose you start heating the mixture. What temperature would be reached first: 78°C or 100°C?
   78°C
4. What do you think will happen when the mixture reaches a temperature of 78°C? Do you think the ethanol will start to boil?
   Learners could be reminded that the ethanol is still ethanol, it has not been changed in the process of mixing, so it will most certainly start to boil at 78°C.
5. Will the water boil at the same time?
   No. Water only starts to boil at 100°C. As long as the temperature is below 100°C, the water will not boil.

TEACHER'S NOTE

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

We can use the same distillation method that we used for separating seawater, to separate the two liquids. The principle is exactly the same, except that we will distill the mixture more than once. Here is how it works:

The mixture of the two liquids is placed in the distillation flask and heated to the lowest boiling point. In the case of an ethanol/water mixture, that temperature would be the boiling point of ethanol, namely 78°C. All of the liquid with that boiling point will evaporate, condense in the Liebig condenser, and pass into the receiving flask. The liquid with the higher boiling point will remain in the distillation flask. Suppose it contains a third substance that we want to separate. How would you do this?

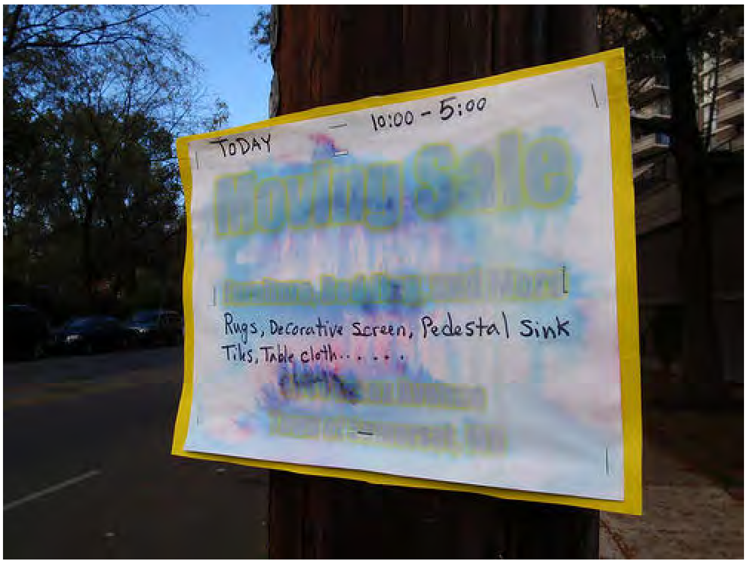
TEACHER'S NOTE

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

TEACHER'S NOTE

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

There is one more separation technique for us to explore. Have you noticed how ink on paper will sometimes 'run' when it gets wet?



Can you see how the ink on this sign has run after being wet, probably by the rain?

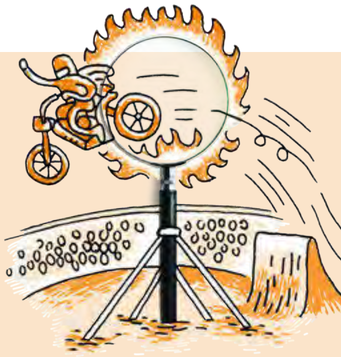
Most inks are a mixture of different pigments, blended to give them just the right colour. A **pigment** is a chemical that gives colour to materials. When a mixture contains colourful compounds, it is often possible to separate the different components using a separating method called chromatography. Let's have a look at this next.

TAKE NOTE

Chromatography comes from from the Greek words *chroma* (meaning 'colour') and *graph* (meaning 'to write').

Chromatography

Chromatography is a method for separating coloured substances into individual pigments. We are going to explore this in the next investigation.



INVESTIGATION: Is black ink really black?

AIM: To separate the pigment components in ink using different liquids.

TEACHER'S NOTE

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

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

HYPOTHESIS:

What do you propose the answer to our investigative question is? This is your hypothesis.

TEACHER'S NOTE

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

MATERIALS AND APPARATUS:

- absorbent paper cut into strips approximately 3 cm wide and 12 cm long

TEACHER'S NOTE

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

TAKE NOTE

A **solvent** is a substance that dissolves a **solute**, resulting in a solution. A solvent is usually a liquid, but can also be a solid or a gas.

- clear drinking glass or beaker
- assorted black pens and markers
- tap water
- pencil
- paper clip or clothes peg
- filter paper
- dropper
- variety of liquid solvents (ammonia, surgical spirits, methylated spirits, and nail polish remover)

TEACHER'S NOTE

Possible hazards:

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

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

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

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

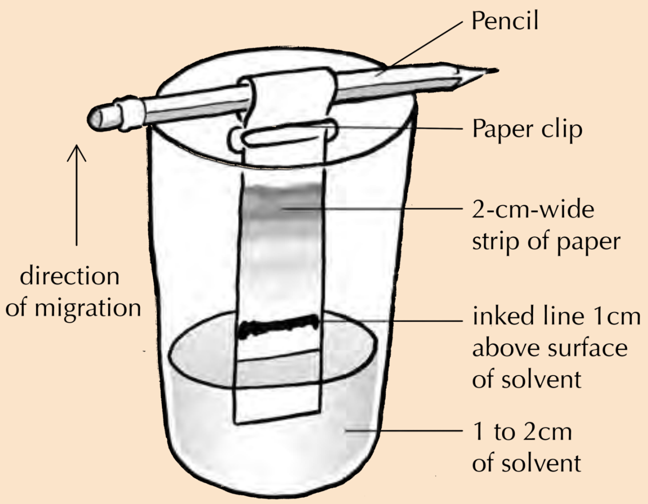
Careful laboratory practice will not only ensure your own safety, it will also set a good example to learners.

METHOD:

To make a strip chromatogram

1. Use a black pen or marker to draw a line across one end of the paper strip, 2 cm from the end.
2. Pour tap water into the beaker to a depth of approximately 1 cm.
3. Wrap the unmarked end of the paper strip around the pencil and secure it in place with a paper clip.
4. Before putting it into the glass, adjust the strip of paper so that the height of the inked line is approximately 1 cm above the surface of the liquid by holding it against the outside of the beaker.
5. Lower the strip into the glass and rest the pencil across the top of the glass as shown in the diagram. The end of the strip should be in the water, but the inked line should be above the surface of the water.
6. Allow the liquid to soak up into the paper, rising through the inked line.

VISIT
Pen colour science.
bit.ly/13Py29D



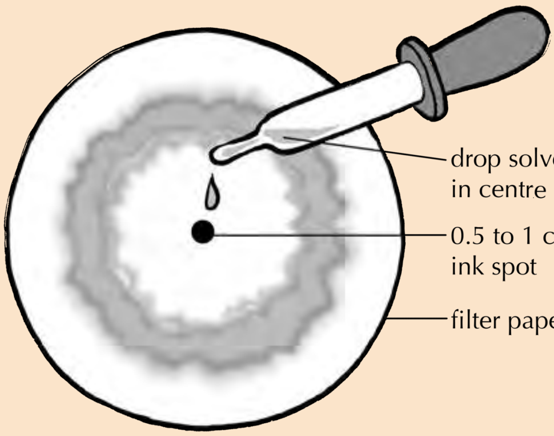
7. When the migrating pigments approach the top of the strip, near the paper clip, remove the paper strip and allow it to dry on a flat, non-porous surface.
8. Make a similar strip chromatogram for each of the black pens you have collected.
9. Compare the chromatograms. Are they the same or are they different?
10. When you have finished comparing your chromatogram with those of the rest of the class, you can either stick your chromatogram in the following space, or draw a picture of it in the space.

TEACHER'S NOTE

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

To make a circular chromatogram

1. Lay a large round piece of filter paper on a smooth non-absorbent surface, like the surface of your desk, for instance.
2. Use one of the coloured pens to make a 0.5 to 1 cm ink spot in the centre of the disk.
3. Lay the paper disk flat over the top of a beaker.
4. Place a drop of water in the centre of the ink spot.
5. Add another drop of water every minute or so to make the chromatogram spread toward the edges of the paper disk.



6. Repeat the experiment with one of the other solvents (ammonia, alcohol or nail polish remover).

OBSERVATIONS:

1. Do the two chromatograms look the same or different? If they look different, and you have used the same pen, why do you think that is?
   Learner-dependent answer
2. Which colour pigments were you able to observe?
   Learner-dependent answer
3. Draw pictures of your chromatograms in the space on the following page.
   Learner-dependent answer

CONCLUSION:

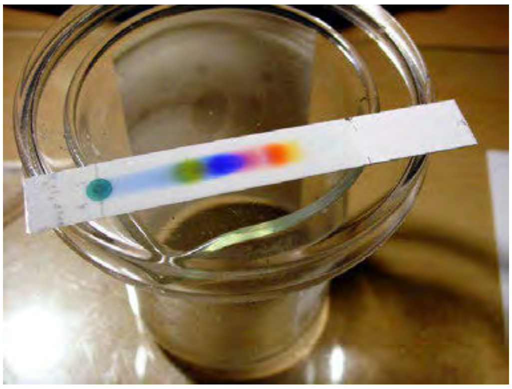
1. What can you conclude about the pigments that make up black ink?
   Learners should note that black ink is actually made up of a number of different coloured pigments.

A closer look at how this works:

In paper chromatography, liquid is drawn through the paper fibers. But, why do the pigments in the ink separate into bands of different colours?

The pigments in the ink are carried along by the liquid, but because they are different compounds, they get carried upward at different speeds. This causes them to appear as bands of different colours on the chromatogram.

Look at the picture of the chromatogram on the following page.



An example of a strip chromatogram

1. Which colour pigment is moving up the paper at the fastest speed? Why do you say so?
   The yellow pigment is moving the fastest because it has travelled the longest distance.
2. Which colour pigment is moving up the paper at the slowest speed?
   The green pigment is moving the slowest because it has travelled the shortest distance.

Why are the different pigments carried at different speeds?

Pigments migrate at different speeds because of differences in their properties: large pigment particles tend to move more slowly. Furthermore, particles that dissolve well in the liquid will tend to stay in the liquid and be carried to the top quickly, while particles that bind well to the paper will tend to move more slowly.

VISIT
Is black really black? (video)
bit.ly/1cMhHJC

Now that we have learnt about some of the different ways in which mixtures can be separated, we are going to apply what we know to separate a mixture made of many components.

ACTIVITY: Separating a complex mixture

TEACHER'S NOTE

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

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

Imagine you are a member of a team of scientists working together in a laboratory. Your team has been given an important job. You have been given a beaker that contains a mixture of substances to separate.

The mixture contains the following components:

- sand
- iron filings
- salt
- ethanol
- water

Your job is to design a procedure for separating the mixture into its individual components. How would you do that? Your procedure should be summarised in the form of a flow chart.

Before you start, imagine what the mixture would look like. Draw a picture of the a clear container and the different contents in the mixture in the space.

TEACHER'S NOTE

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

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

To help you design your procedure, here are a few guiding questions and a template for your flow chart:

1. What is the physical state (solid, liquid or gas) of each of the components in the mixture? Fill these into the table.

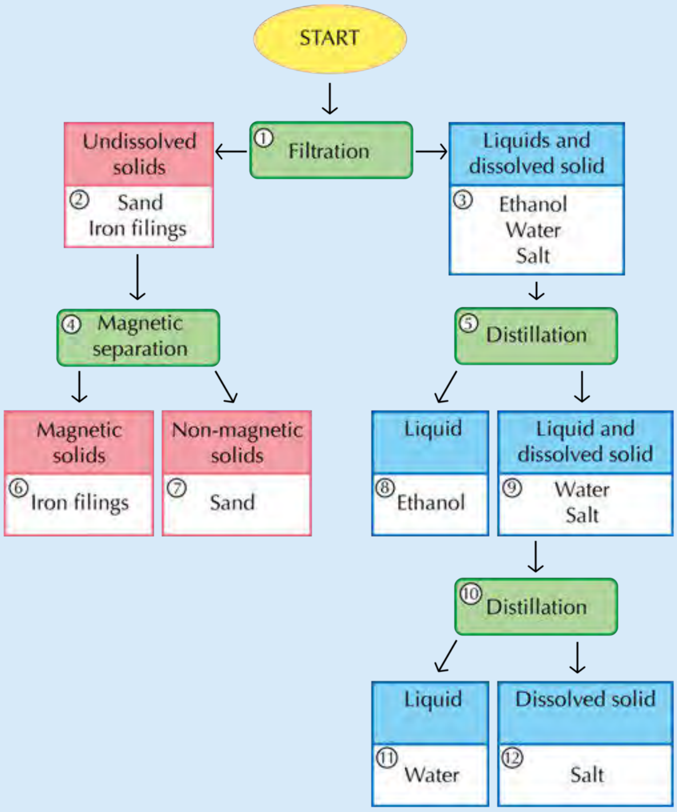
Component (substance)	***State (solid liquid or gas)***	***Dissolved or undissolved?***
Iron	*solid*	*undissolved*
Sand	*solid*	*undissolved*
Salt	*solid*	*dissolved*
Ethanol	*liquid*	*dissolved (in solution with the water and salt)*
Water	*liquid*	*dissolved (in solution with the ethanol and salt)*

2. Name the solids that will not dissolve in the mixture. These are the undissolved solids.
   The sand and iron filings are undissolved.
3. Name the dissolved solids in the mixture.
   Salt is the only dissolved solid.
4. What would be the best method for separating the undissolved solids from the liquids in the mixture? Write the name of this method in the block numbered 1 of the flowchart below.
   Learners should write FILTRATION in block 1.
5. Write the names of the undissolved solids in block 2 of the flowchart.
   Learners should write SAND and IRON FILINGS in block 2.
6. What remains after the undissolved solids have been removed from the mixture? Write the names of these compounds in block 3.
   Learners should write SALT, ETHANOL and WATER in block 3.
7. How could we separate the undissolved solids? (Hint: look at the flow chart for some ideas.) Write the name of this process in block 4.
   Learners should write MAGNETIC SEPARATION in block 4.
8. Write the names of the two undissolved solids in blocks 6 and 7.
   Learners should write IRON FILINGS in block 6 and SAND in block 7.
9. How could we separate the liquids from the dissolved solid? We could evaporate them, but then they would be lost. What other option is available if we want to separate the components in a solution? Write the name of this process in block 5.
   Learners should write DISTILLATION in block 5.
10. Which liquid would be distilled first? (Hint: which liquid has the lowest boiling point?) Write the name of this liquid in block 8.
    Learners should write ETHANOL in block 8.
11. What remains in the solution when the first liquid is removed? Write the names of these components in block 9.
    Learners should write WATER and SALT in block 9.
12. How can we separate the liquid from the dissolved solid? (Hint: this process is the same as the one in block 7.) Write the name of the process in block 10.
    Learners should write DISTILLATION in block 10.
13. Write the names of the final two components in blocks 11 and 12.
    Learners should write WATER in block 11 and SALT in block 12.

VISIT
Summary of separating mixtures in short slideshows
bit.ly/1cMhKVY

TEACHER'S NOTE

Completed flowchart should look as follows:



So far, we have been discussing materials, their properties, how to mix them and how to separate them if they are mixed. The final section of this chapter deals with waste materials and what we can do to reduce their impact on the environment.

2.3 Sorting and recycling materials

Over time, some of our things get old and break and we need to throw them away. When we buy food or other items, the packaging used for wrapping these items is also thrown away. But what does 'away' mean? Does it mean these waste items just disappear? Where do you think our rubbish goes once we 'throw it away'?

TEACHER'S NOTE

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

ACTIVITY: What happens when we throw things away?

INSTRUCTIONS:

1. Work in groups of 3 to 4.
2. In your group, spend 5 minutes discussing the posters and what you think they mean.

QUESTIONS:

TEACHER'S NOTE

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

1. Write a paragraph to explain the messages on the posters. What do you think they mean?
   Learner-dependent answer
2. Do you think it is possible to stop throwing things away altogether?
   Many things can be reused or recycled. Many of the waste that is not recyclable can be turned into compost for the garden. Learners may have interesting opinions about this question, and hopefully it will get them thinking about creative ways of reusing and repurposing waste.
3. Can you suggest ways to reduce the amount of trash that is thrown away in your home?
   Learner-dependent answer. Learners should generate suggestions centred on reusing, recycling and repurposing.

TEACHER'S NOTE

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

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

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

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

How is household waste managed by local authorities?

VISIT
Have you ever heard of the Great Pacific Garbage Patch? Millions of tonnes of plastic waste end up in the ocean, and stay there.
bit.ly/1950eda

In some suburbs, recycling is actively encouraged and special transparent recycling bags are provided for this purpose. Do you have recycling in your community? Is the recyclable waste collected from your home or do you have to drop it off at a container or a depot? Did you know that some people even make money selling recyclable waste that they collect?

Do you know which materials from household waste can be recycled? What are the four main categories?

TEACHER'S NOTE

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

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

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

Have you seen colourful bins similar to these around your school or in shopping areas? They are for recycling.

If you ever need to dispose of objects, like batteries and fluorescent light bulbs that contain harmful substances, be sure to use the correct recycling bin.

TEACHER'S NOTE

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

Activity: Other things we throw away

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

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

Item	Recycling ideas
Garden waste and other organic waste such as vegetable peelings and foods that have spoiled.	• These items can be turned into compost. • Cooked food, spoiled meat or fish and bones should preferably be buried because they can attract flies and other pests. In this way they can decompose underground and provide nutrients to growing plants in the garden.
Old clothes and other textile items; old shoes.	• Clothes, shoes, curtains, and blankets that are still good enough to be used can be donated to shelters for the homeless. • Clothes that are too worn can be turned into cloths for washing the car or the windows. • Old jerseys can be sewn into blankets or other items.

Old and expired medicine	• Medicine that is old or expired should never be repurposed. It should be dropped off at your nearest clinic or pharmacy, where they have methods for destroying it.

Careers in chemistry

TEACHER'S NOTE

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

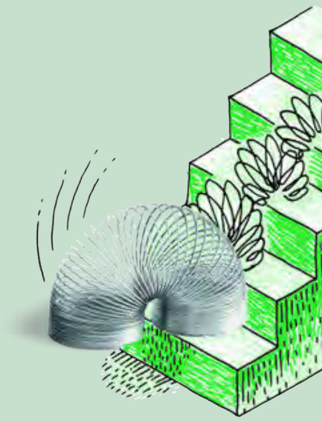
This activity could be turned into a small group project and learners could be required to write a short report on the information they have gathered.

Do you know what chemists do? Let's discover the possibilities of chemistry!

Chemists study various chemical elements and compounds, their properties and how they react with each other. We will learn about elements and compounds in the next chapter. Chemists are also responsible for developing new materials with specific properties; such as new medicines; innovative materials for building buildings and other structures; materials that could be used for making fuels from renewable sources and many others.

If you study chemistry after you have finished school, you can work as a researcher, a laboratory technician, a science teacher and many other important and stimulating jobs! Be curious and discover the possibilities! Science can help us solve problems in the world around us.

ACTIVITY: Careers research task



TEACHER'S NOTE

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

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 one that you find most interesting.
2. Do an internet search to find out the career involves.
3. Write a short description of this career. Find out what level of chemistry you will need for this particular career.
4. 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:

- Chemical education/teaching
- Chemistry researcher
- Environmental chemistry
- Mining industry
- Oil and petroleum industry
- Pharmaceuticals and drug discovery
- Space exploration
- Waste management

VISIT
A useful site to find out more about some chemistry-related careers.
bit.ly/19cXkqe

Your descriptions of the career you are interested in:

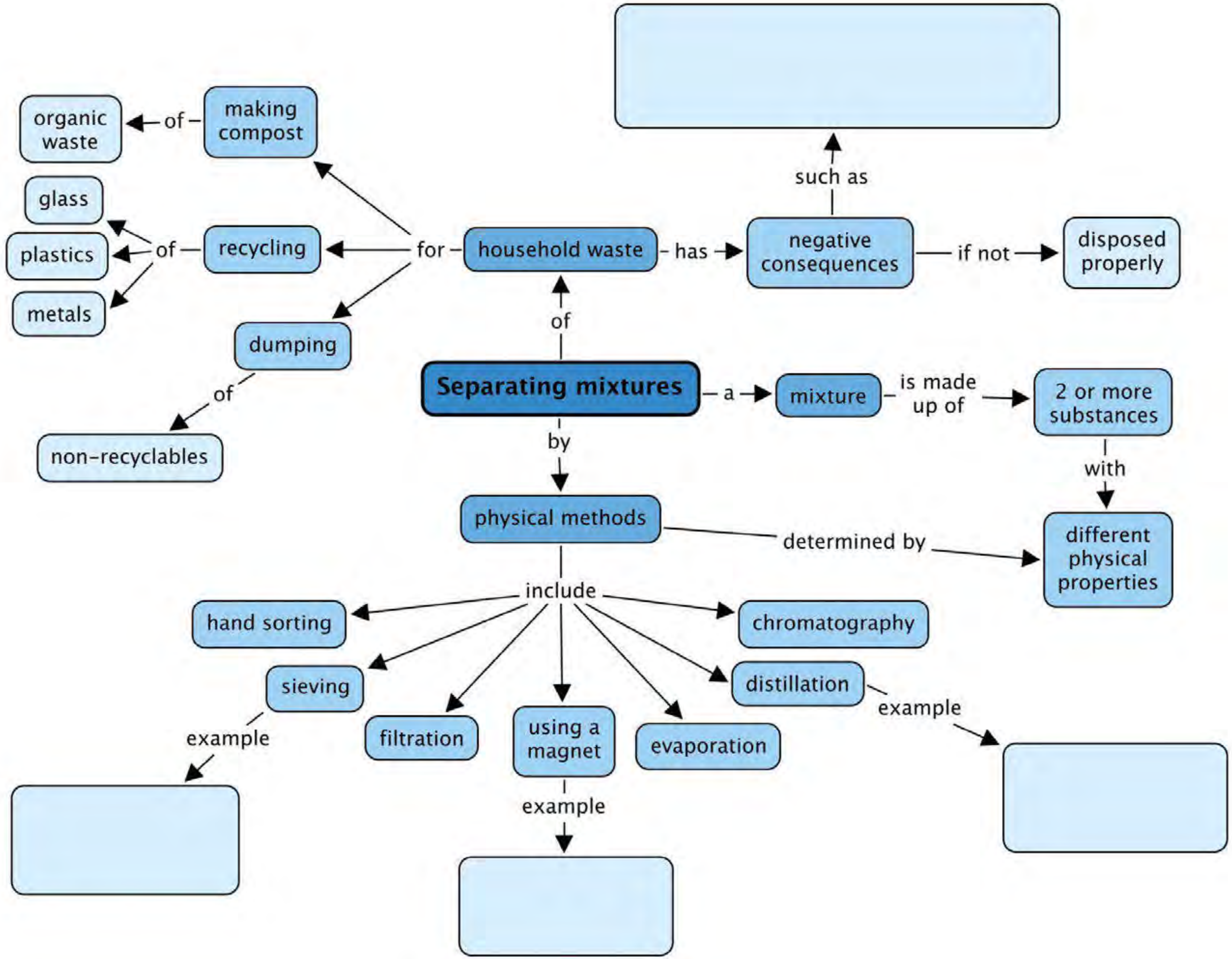
SUMMARY:

Key Concepts

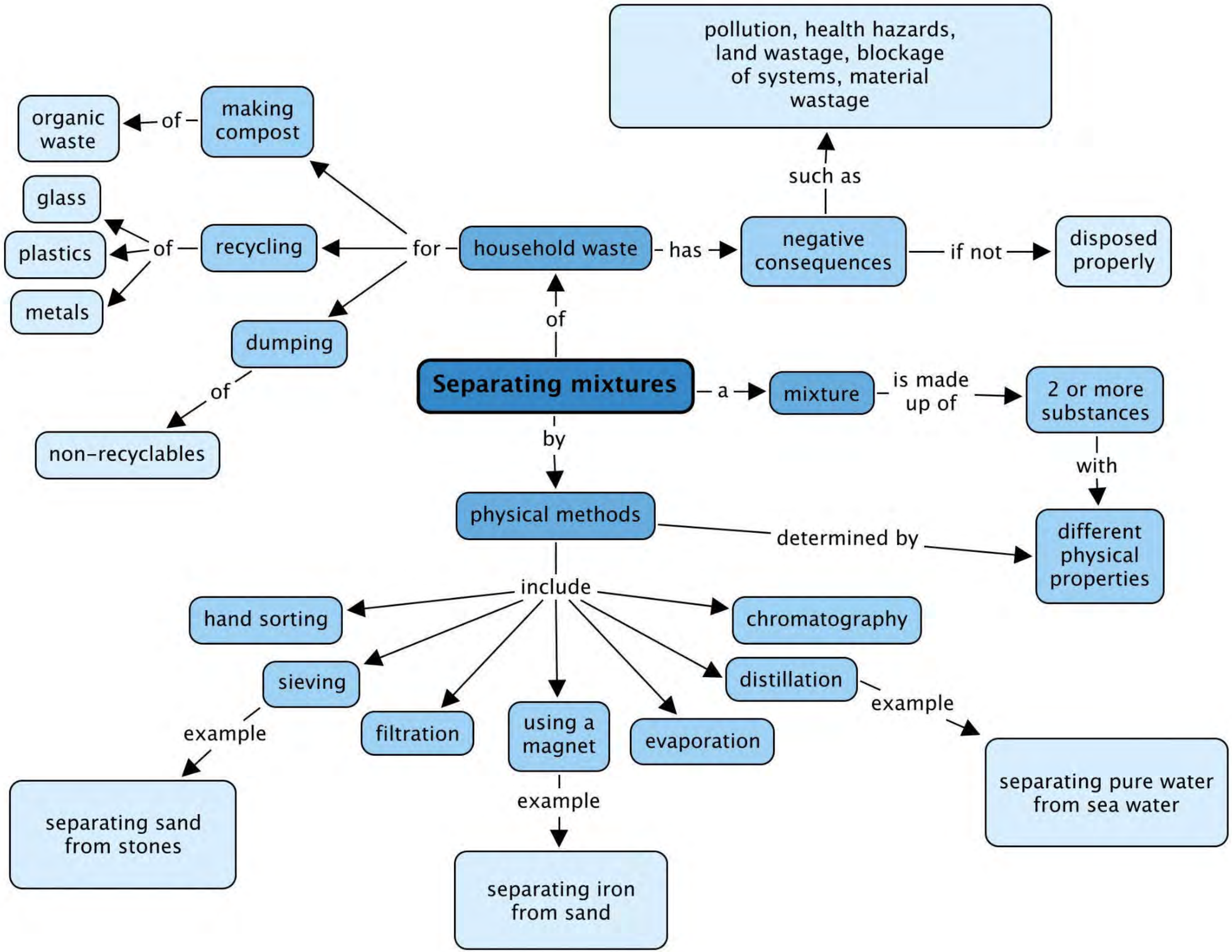
- A mixture consists of two or more components that have different physical properties.
- The components in a mixture are not chemically joined; they do not change their chemical identities and they retain their physical properties as well.
- When we want to separate a mixture, we can use the differences in the physical properties of the components of the mixture to separate the components from each other.
- Hand sorting is a suitable separation method for a mixture that contains a relatively small number of large items.
- Sieving is a suitable separation method when the pieces to be separated are sized differently.
- Filtration is a good method for separating an undissolved solid from a liquid.
- Components with different magnetic properties can be separated using magnetic separation.
- Evaporation is a suitable separation method for removing a liquid from a solid.
- Distillation is a suitable method for separating two liquids with different boiling points.
- Chromatography is a good method for separating coloured pigments from each other.
- Waste disposal should be managed in a responsible way so that the negative impact on the environment is as small as possible.
- Metals, plastics, paper and glass can be recycled.
- Organic waste can be turned into compost.
- Responsible waste disposal is everyone's responsibility, but it is usually managed by the local authorities, who have systems for sorting and recycling waste.
- Poor waste management leads to negative consequences for humans, animals and the environment. Some of these are:
  - pollution of the soil, water resources and the environment;
  - health hazards and the spread of disease;
  - blockage of sewers and drainage systems;
  - land wasted when it is used to dump or bury garbage (landfills); and
  - materials and other resources wasted when they could have been recycled.

Concept Map

We looked at physical methods to separate mixtures and these are shown in the concept map. Give an example of the types of mixtures you could separate using three of these methods. What negative consequences does human waste have on the environment? Fill these in the concept map.



Separating mixtures
of
household waste
for
making compost
of
organic waste
recycling
of
glass
plastics
metals
dumping
of
non-recyclables
has
negative consequences
such as
if not
disposed properly
a
mixture
is made up of
2 or more substances
with
different physical properties
by
physical methods
determined by
include
hand sorting
sieving
example
filtration
using a magnet
example
evaporation
distillation
example
chromatography


Separating mixtures
of
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such as
pollution, health hazards, land wastage, blockage of systems, material wastage
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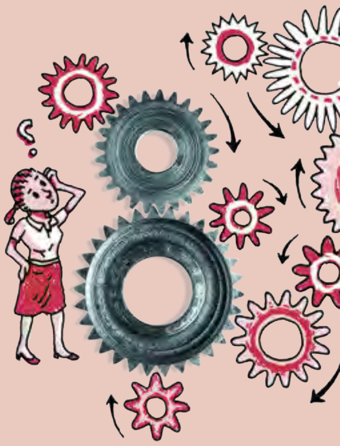
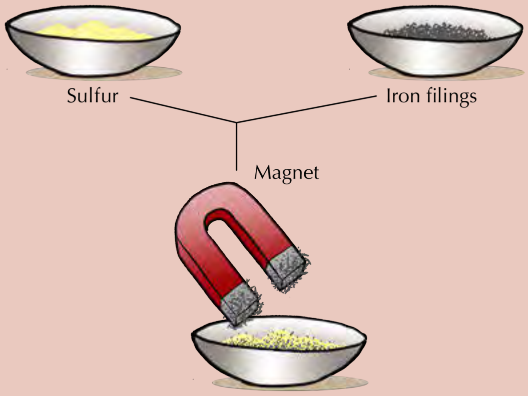
disposed properly
a
mixture
is made up of
2 or more substances
with
different physical properties
by
physical methods
determined by
include
hand sorting
sieving
example
separating sand from stones
filtration
using a magnet
example
separating iron from sand
evaporation
distillation
example
separating pure water from sea water
chromatography

REVISION:



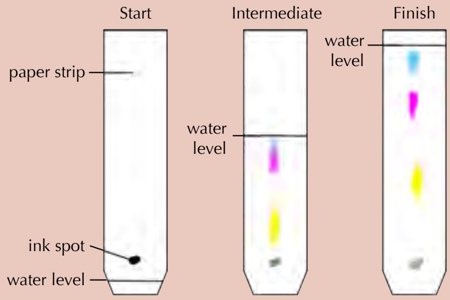
1. Two important words have been left out of the following paragraph. The missing words are **chemical** and **physical**. Rewrite the sentences and fill in the missing words in the paragraph by placing each one in the correct position:
   The components in a mixture have not undergone any __________ changes. They still have the same properties they had before they were mixed. That is why mixtures can be separated using __________ methods. [1 mark]
   The components in a mixture have not undergone any <u>chemical</u> changes. They still have the same properties they had before they were mixed. That is why mixtures can be separated using <u>physical</u> methods.
2. In the diagram below, iron filings and sulfur have been mixed. Write a short paragraph (2 sentences) to explain how the mixture can be separated using magnetic separation. [2 marks]



   Learner's answer should contain the following elements:
   - *Iron filings are attracted to the magnet, but sulfur is not.*
   - *If the magnet is held in the mixture the iron filings will cling to the magnet, but the sulfur will stay behind in the bowl.*
3. A vacuum cleaner creates a suspension of dust in air as it sucks up the dust on the floor. Clean air comes out of the vacuum cleaner. How does the vacuum cleaner separate the dust from the air? [2 marks]
   The vacuum cleaner has a fine filter in it which traps the dust particles. The clean air is able to get through the filter, but the dust is left behind. Some more modern vacuum cleaners also filter the air through water which cleans the air even further. Some very fine dust particles may be able to get through the fine filter, but if the air is passed through water, then even very fine particles are trapped.
4. Write a short paragraph (3 sentences) to explain how salt is produced from seawater. [3 marks]
   Learner's answer should contain the following elements:
   - *Seawater is allowed to stand in shallow pans.*
   - *Sunlight heats the water and it evaporates.*
   - *Solid salt is left behind, that can be dried and put into packages to be sold.*
5. Choose the correct word to complete the sentence from the following list: colours; boiling points, tastes. Write the word below.

Suppose we want to separate two liquids using distillation as separation method. This will only be possible if the two liquids have different... [1 mark]
boiling points

6. The diagram below shows a strip chromatogram that is being prepared from a spot of black ink. The strip on the left shows the chromatogram at the start of the experiment, the strip in the middle shows the chromatogram halfway through the experiment, and the strip on the right shows the chromatogram at the end of the experiment.



   a) How many different pigments does the black ink consist of? Explain your answer. [1 mark]
   b) Which pigment is moving up the paper at the fastest speed? Arrange the pigments in order of increasing speed of movement. [2 marks]
   a) Three different colour bands mean there are (at least) three different pigments in the ink.
   b) The blue pigment moves the fastest. Arranged in order of increasing speed (from slowest to fastest moving pigment): yellow, then pink, then blue.

7. The table on the next page contains a list of mixtures. In the right hand column, next to each mixture, write the **best** method for separating the mixture into its components. [8 marks]

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

8. Name the 4 classes of materials that can be recycled. [4 marks]
   Glass, metal, plastic, paper.
9. Write a sentence to say how you would dispose of each of the following non-recyclable materials: vegetable peels; old running shoes; expired medicine. [3 marks]
   Vegetable peels can be buried in the garden or turned into compost.
   Old running shoes can be donated to someone who needs them, or to a shelter.
   Expired medicine should be taken to the pharmacy.

TOTAL: 27 marks

3 Acids, bases and neutral substances

TEACHER'S NOTE

Chapter overview

2 weeks

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

3.1 Tastes of substances (1 hour)

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

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

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

3.3 Acid-base indicators (3 hours)

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

KEY QUESTIONS:

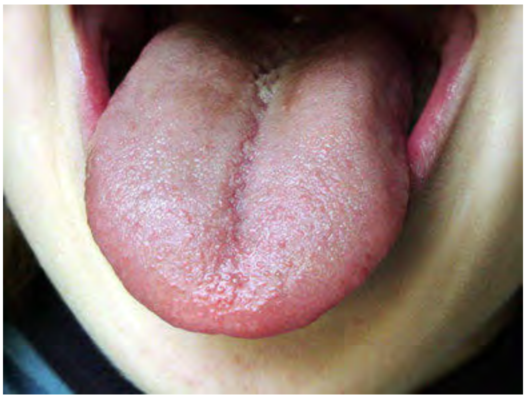
- Which tastes can we sense with our tongues?
- How does our sense of taste ensure our survival?
- What are the unique properties of:
  - acids;
  - bases;
  - neutral substances?
- Which household substances are (or contain):
  - acids;
  - bases;
  - neutral substances?
- How can we tell if something is an acid, a base or a neutral substance?

What do you know about acids? Would you touch an acid? Have you ever tasted an acid? Do you think it is possible to taste an acid without burning your tongue? What do you think it would feel like when an acid burned your tongue?

Before we talk more about acids, let us first examine the human tongue. It is a most fascinating organ, and plays an important role in our sense of taste.

3.1 Tastes of substances

What is your favourite food? What do you like most about your favourite food? You will probably say that you just LOVE the taste of it! The taste of our favourite foods make us feel good. How do we taste our food?



We taste food with tiny structures on our tongues!

Look in the mirror, and stick out your tongue. Look for small, round bumps. These are called **papillae**. Most of them contain **taste buds**. The taste buds are very small structures which have sensitive hairs. The chemicals in the food that you eat dissolve into your saliva in solution. The chemicals then stimulate the tiny hairs within the tastebuds and turn these signals into impulses. These impulses travel to the brain allowing us to experience the sensation of taste.

TEACHER'S NOTE

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

ACTIVITY: Have a look at your own tongue

TEACHER'S NOTE

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

MATERIALS:

- mirror
- pencil
- sugar water
- lemon juice

INSTRUCTIONS:

1. Look in the mirror at your tongue.
2. Stick it out as far you can and try to see the papillae. Are they larger in some areas?

Have you tasted a lemon before?

Close your eyes and imagine biting into a slice of lemon. Can you describe the experience? What does the lemon taste like? Sweet, sour, salty or bitter?

TEACHER'S NOTE

Sour

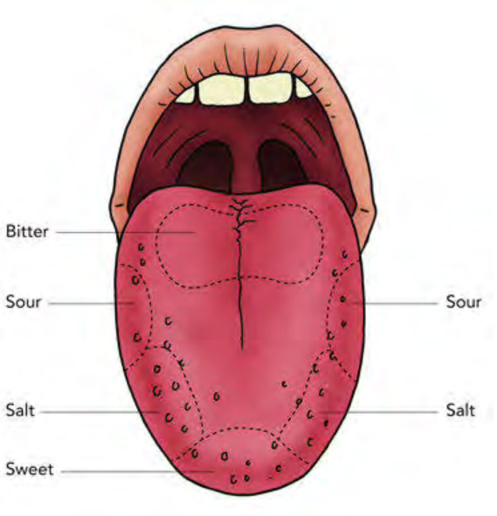
If you have sugar solution and lemon juice available in the class, taste these different substances. See if you can identify *where* on your tongue you taste the two different tastes.

Your tongue can only sense four flavours

You can only sense four different tastes with your tongue. Can you name them?

TEACHER'S NOTE

Sweet, sour, bitter and salt.



The tongue map.

The four main tastes that are most common, are sweet, sour, salt and bitter. These tastes combine to make up the different flavours of our foods.

TAKE NOTE

A flavour is a combination of tastes and smells.

How would you classify the taste of apples? Sweet or sour? Bitter? Perhaps a combination?

Many people really enjoy the sour-salty taste of salt and vinegar chips!

There is a good reason for why we like certain tastes, but not others.

Our sense of taste protects us

Just as we like and seek out foods that taste good, our bodies have also been programmed to avoid food with strong bitter or sour tastes. This helps to protect us against poisons, which often have a strong bitter taste. 'Bitter' is also the basic taste that our tongues are most sensitive to. Spoiled food often tastes sour and it may also have a bad smell. Our instinct will be to avoid it, which will protect us from becoming ill from ingesting the organisms that have spoiled the food.

Sweet almonds, such as these, are edible as they do not contain toxic chemicals, unlike the wild bitter almonds.

Cocoa beans come from cocoa pods. Chocolate is made from cocoa, but cocoa is very bitter. Lots of sugar is added to chocolate to make it sweet.

TAKE NOTE

When we want to say something has the properties of an acid, we use the adjective acidic. When we want to say something has the properties of a base, we use the adjective basic.

Soon the link between the tongue and chemical substances will become clear.

3.2 Properties of acids, bases and neutral substances

In the previous section you had to imagine what it would feel like if an acid burned your tongue. In the next section we are going to learn more about acids. We will learn that they taste sour (and also why it is not a good idea to taste them!).

We will also learn about other substances that have a special relationship with acids. They are called bases. Finally, we will also learn about substances that are neither acids or bases, but neutral substances.

Acids

Do you know the names of any acids? Think about this as a class and make a list of all the acid names you have heard.

TEACHER'S NOTE

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

There are many different acids. You might have already tasted an acid in class. Was it the sugar water or the lemon juice?

TEACHER'S NOTE

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

Do you like sour sweets, such as sour worms? The sour taste comes from fumaric acid. Fumaric acid is a natural acid with a sour taste, that is often added to foods.

The juice of lemons is rich in ascorbic acid (vitamin C) and citric acid, which makes it taste sour.

All acids taste sour. Does this mean that all acids are safe to taste? Definitely NOT! Next, we will learn which acids should not be tasted under any circumstances.

Laboratory acids

Concentrated hydrochloric acid is very corrosive and dangerous.

Some acids are very dangerous and must be handled carefully. These acids are **corrosive**. They can cause serious burns on your skin. Scientists always wear protective clothing when handling these acids. It would be very dangerous to taste them. These acids are most often found and used in laboratories and certain industrial processes. We will refer to them as laboratory acids.

This scientist is handling an acid. Can you see he is wearing protective clothing, gloves and safety glasses?

Look out for this label on bottles which contain corrosive substances, such as strong acids.

TAKE NOTE

The chemical formula of a substance tells us which elements it contains.

Name of the acid	Formula of the acid
hydrochloric acid	HCl
nitric acid	HNO_3
sulfuric acid	H_2SO_4

The above table contains the names and **chemical formulae** of the three most common laboratory acids. Even though you have not learnt how to write chemical formulae yet, we have included them here. You should handle containers with these formulae printed on them with care.

TEACHER'S NOTE

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

There are many other laboratory acids that we have not listed. These are only the most common ones.

Other acids in the foods we eat are not dangerous. In fact, some are even vital for our health and well-being. Let's now have a look at acids that are safe to handle.

Natural and household acids

Not all acids are dangerous. One such acid is called ascorbic acid, or vitamin C. Vitamin C helps our immune system. Which foods contain vitamin C? Have a look at the pictures.

Kiwi fruit.

Strawberries.

Broccoli.

Bell peppers.

We will call the acids that we find in food natural acids. Many of these natural acids are found in the kitchen. For this reason they are also sometimes called household acids.

One very well-known household acid is acetic acid. Vinegar is a mixture of a small amount of acetic acid dissolved in water. So vinegar is a solution of acetic acid in water.

Spirit vinegar and balsamic vinegar.

TEACHER'S NOTE

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

ACTIVITY: True or false?

INSTRUCTIONS:

- Let's briefly revise some of the concepts we have learnt so far.
- Below are some statements. You need to state whether they are true or false. If they are false, explain why.

True or false?

1. We can sense three tastes with our tongues.
   False, we can sense four tastes, namely salty, sweet, sour and bitter.
2. Acids taste sour.
   True
3. If we want to know if something is an acid, we can just taste it.
   False, not all acids are safe to taste, such as laboratory acids.
4. All acids are dangerous.
   False, there are many household acids which are not dangerous, such as acetic acid and acids in foods.
5. Vinegar is a mixture of a small amount of acetic acid dissolved in water.
   True.
6. Laboratory acids must be handled with care and using protective clothing.

   True
7. The following symbol means you can wash your hands using this substance.

False. This symbol means that the substance is corrosive, it is a warning.

8. Formic acid is commonly referred to as Vitamin C.
   False, ascorbic acid is commonly referred to as Vitamin C.
9. Oranges are the food which contain the highest amount of ascorbic acid.
   False, there are many other foods with higher ascorbic acid (Vitamin C), such as strawberries and chillies.

Do you think that it would be possible for acids to lose their strength? There is one class of compounds that can make acids lose their strength. These compounds are called bases.

Bases

Bases can **neutralise** acids and vice versa. What does it mean to neutralise something?

TEACHER'S NOTE

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

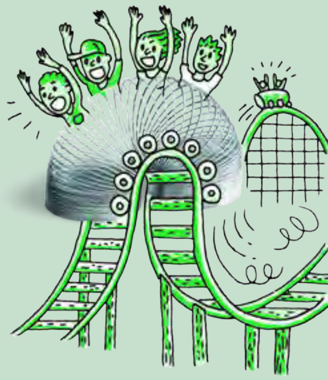
Bases and acids have chemical properties that are the opposite of each other. We can think of bases as the chemical opposite of acids.

As with acids, there are some bases that are extremely dangerous. The same hazard symbol that is used to warn people of the dangers of acids, is also used for these bases. Strong bases react corrosively with other materials and can burn your skin. They must be handled carefully and always while wearing appropriate protective clothing, such as lab coats, gloves and safety glasses.

Sodium hydroxide is a strong base used in laboratories. Do you see the yellow corrosive warning symbol?

Other bases are mild enough to be used as cleaning materials in and around the home. This does not mean that they are completely harmless. It just means that they have been mixed with other substances so that they are not so corrosive.

ACTIVITY: Acids and bases in our homes



TEACHER'S NOTE

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

MATERIALS:

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

INSTRUCTIONS:

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

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

1. All of the products in the picture below contain bases. Which of the products do you recognise? Write their names and what they are used for in the table.

Some household products which are bases.

TEACHER'S NOTE

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

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

2. Next, your teacher will let you come up to feel different substances which are either bases or acids. All of these substances are safe to touch. Take note of how they feel between your fingers and then come back to fill in the table.

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

TAKE NOTE

When an acid and a base are mixed together in the **correct ratio**, they will neutralise each other. This means that the solution made up of the acid and the base becomes something that is neither an acid nor a base, but neutral. In the process, both the acid and the base will lose their unique characteristics.

TEACHER'S NOTE

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

QUESTIONS:

1. What can you conclude about how bases feel?
Bases feel slippery.
2. What can you conclude about how acids feel?
Generally, acids feel rough on the skin.
3. What did your teacher have to do to the dry washing powder before you could feel it in the bowl? Do you know what we call the solution which forms? If so, write it down, otherwise your teacher will help you.
She/he had to add water to make it slippery. A solution of a base and water is called an alkaline solution.
4. Although we have spoken about acids and bases as being chemical opposites, what property do many of them have in common?
Many acids and bases are dangerous to touch or taste - they are corrosive.

TAKE NOTE

Bases that can dissolve in water are called **alkalis**. For this reason, the terms base and alkali are sometimes considered to have the same meaning. (Words that have the same meaning are called synonyms.)

Finally, there is a class of substances that are neither acids nor bases. They are called **neutral** substances. We will explore them next.

Neutral substances

We have learnt that when an acid and a base are mixed (in the right amounts), they will neutralise each other. That means that, together, they will change into something that is neither an acid nor a base. So the acid will lose its properties and so will the base. And the new substance that forms from the two substances will be neither an acid nor a base. We call it a neutral substance.

Some neutral substances are formed when an acid is mixed with a base and a neutralisation reaction occurs. Other substances are neutral to begin with. They are not the product of a neutralisation reaction. The neutral substances that are the most well known are: water, table salt, sugar solution and cooking oil.

Cooking oil is a neutral substance.

TAKE NOTE

To indicate means to show.

We have learnt about three classes of substances: acids, bases and neutral substances. But, we cannot tell whether a substance is an acid, base, or a neutral substance, just by looking at it. We know that acids taste sour, but we have also learnt that it is never a good idea to taste chemicals.

Let's imagine we have an unknown substance. It is colourless and looks just like water. It is also odourless (that means it has no smell). There are no physical signs to show whether it is acidic, basic, or neutral. How can we tell what it is?

3.3 Acid-base indicators

What do the indicators on a car do?

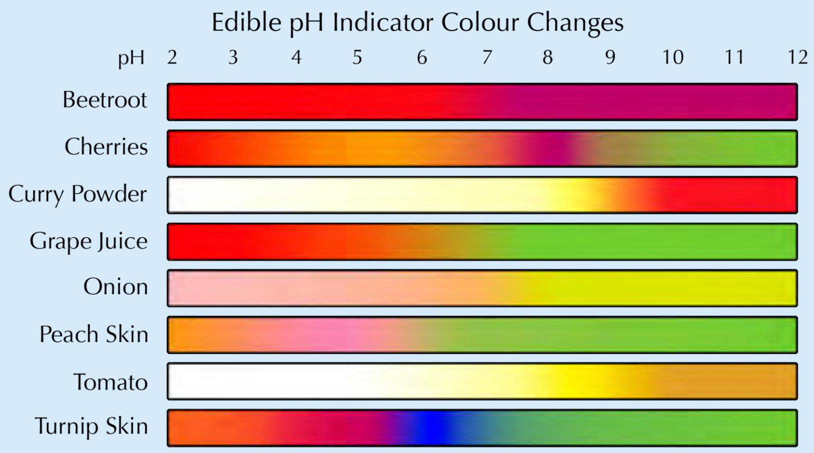
TEACHER'S NOTE

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

Acids and bases can change the colour of some substances. In the next activity, we are going to investigate a substance that changes colour when we mix it with an acid or a base.

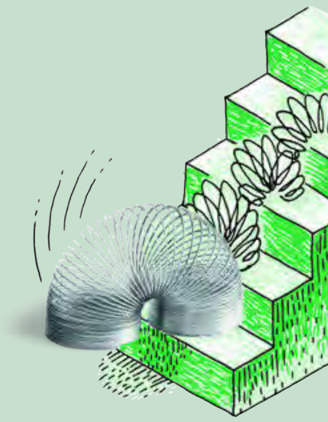
TEACHER'S NOTE

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



Have you ever eaten red cabbage? It is not only tasty, but also very healthy. We are going to see how red cabbage juice changes when we mix it with different substances.

ACTIVITY: Preparing and testing red cabbage juice with acid and base



TEACHER'S NOTE

You will need to buy a red cabbage prior to this activity. Red cabbages are available during winter and spring. One cabbage should make enough extract for an entire class of learners. You can prepare the extract in the class, or you could make it ahead of time and simply demonstrate the method (cutting the cabbage, boiling and straining it) to the learners without boiling the cabbage in class.

If you are not able to get red cabbage, you can try using some of the other foods listed in the previous table which are also natural indicators. Another example which is easy to use and obtain is black tea.

MATERIALS:

- one large, red cabbage
- pot with water for boiling
- hot plate (or stove)
- strainer
- sharp knife
- container for red cabbage juice (ice cream tub or large yoghurt tub will work well)
- white plate
- vinegar
- baking soda solution

INSTRUCTIONS:

Prepare the cabbage juice:

1. Cut the cabbage into thin slices and place it in the pot.

> **VISIT**
> This website has a list of other household products that will also change colour when mixed with acids or bases. Make sure you ask your parents if you may experiment before you start!
> bit.ly/195o6gF

2. Add just enough water to cover the cabbage slices.
3. Boil it over low heat for approximately 30 minutes, adding water to keep the cabbage covered if necessary.

4. Remove the pot from the heat and let it cool completely.
5. Strain the juice off the cabbage slices into the ice cream tub. The boiled cabbage slices can be eaten (or placed in the compost).

> **VISIT**
> Video on red cabbage and black tea as indicators
> bit.ly/19PBmsJ

6. If kept in the fridge the red cabbage juice will last about 3 days.

Test the cabbage juice indicator

1. Carefully place three large drops of the cabbage juice on a smooth, white surface (a white plate or tile will work well).
2. Pour a few drops of vinegar into one of the drops of cabbage juice. What do you see?
3. Pour a few drops of baking soda solution into one of the remaining drops of cabbage juice. What do you see?

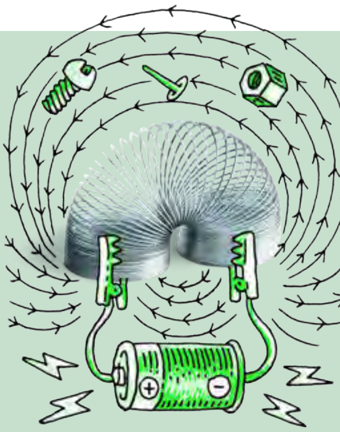
Red cabbage juice mixed with baking soda (left) and with vinegar (right). The blue drop at the top is the unmixed juice.

TEACHER'S NOTE

These demonstration videos extract the red cabbage juice by blending it with some water in a blender instead of boiling it. Both methods are equally effective in extracting the juice from the cabbage leaves.

In the next activity we are going to preserve the red cabbage juice by absorbing it on some filter paper, and drying it, so that we can use it later.

ACTIVITY: Making red cabbage indicator paper



TEACHER'S NOTE

If time permits, you can make these indicator strips in class with your learners using the cabbage juice from the previous experiment. If you do not have time, do this yourself outside of class and then just go through the steps below explaining to your learners what you did. If you do not have time to do it in class, you can also encourage learners to do it at home with their parents if they have capacity and resources.

MATERIALS:

- pieces of absorbent paper
- red cabbage juice from the previous activity in a container
- scissors
- container

TEACHER'S NOTE

Filter paper is best, or paper used for painting with watercolours (available from stationery or art supply shops); coffee filters or even paper towel would also work. The cabbage juice should not be too dilute; you can concentrate it by heating it over low heat for 20 minutes and allowing it to cool.

INSTRUCTIONS:

1. Place the absorbent paper in the cabbage juice.

2. After 30 minutes, remove the paper and leave it in a warm place to dry.

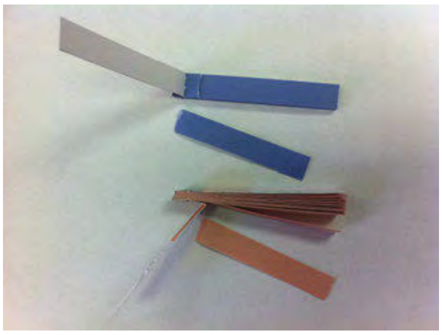
TEACHER'S NOTE

You can also dry the paper with a hair dryer, but do not leave it in direct sunlight.

3. When the paper has completely dried, cut it into strips (approximately 1 cm wide). You can keep the strips for a long time if you store them in a dry place.

We will use the red cabbage paper strips later, as part of an investigation.

Some other substances also change colour when an acid or a base is added to them. By changing their colour, they show that they have reacted with an acid or a base. That is why we call them **acid-base indicators**.The most well-known acid-base indicator is a substance called **litmus.**



Blue and red litmus paper.

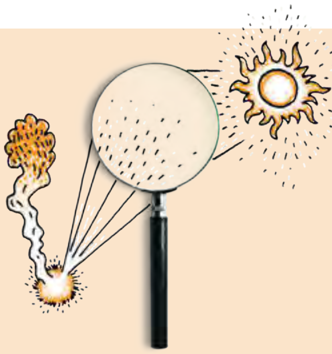
Litmus comes from pigments in the lichen which are found growing in many different places, mostly on rocks.

Litmus solution is most commonly soaked into paper, the paper is then dried and cut into strips we then call "litmus paper". It is just like the red cabbage paper we made earlier. Litmus paper is available in two colours: blue and red.

How does litmus paper indicate whether a substance is an acid or a base? In the next activity, we will investigate how litmus responds to some household acids and bases.

VISIT
Colourful chemistry with acids and bases using household products (video)
bit.ly/15QjCfd

INVESTIGATION: How does litmus respond to acids and bases?



TEACHER'S NOTE

CAPS suggests that you also test various beverages to see whether they are acids, bases or neutrals. A suggestion is to do this investigation presented here first where learners first determine how litmus responds to acids and bases, and then if you have time as an extension, get learners to test various drinks, such as water, Ceylon tea, rooibos tea, orange juice, milk, coffee and any fizzy drink to see whether they are acids, bases or neutrals.

AIM: To determine how litmus responds to some household acids and bases.

HYPOTHESIS: What is your hypothesis for this investigation?

TEACHER'S NOTE

Learners may not yet know how litmus reacts to acids and bases, so they may have to come back to propose a new hypothesis when they are writing their conclusions. They should not be encouraged to come back to this space, cross out the hypothesis and write a new one which they know to be true. This is an important concept in science investigations - a hypothesis is a proposed explanation, which needs to be **tested** further using the scientific method. One can then verify whether the hypothesis was true (and it is accepted) or it is false (and it is rejected) and you come up with a new proposed hypothesis.

MATERIALS AND APPARATUS:

TEACHER'S NOTE

It would be advisable to label the containers to prevent learners from confusing the substances.

- small containers (test tubes or yoghurt tubs) filled with the following substances:
  - water
  - soda water
  - vinegar
  - lemon juice
  - sugar water (1 tablespoon dissolved in a cup of water)
  - baking soda (1 tablespoon dissolved in a cup of water)
  - Handy Andy (1 tablespoon dissolved in a cup of water)
  - aspirin (Disprin) (1 tablet in 2 tablespoons of water)
  - dishwashing liquid (1 teaspoon dissolved in a cup of water)
  - any other substances commonly used at home that are not dangerous
- litmus paper (blue and red)
- glass or plastic rods (plastic teaspoons will also work well).

METHOD:

1. Cut a small piece (1 cm long) of blue and red litmus for each substance that you will be testing.
2. Use the plastic teaspoon or rod to place just 1 drop of water on the blue litmus. Do the same with a piece of red litmus.
3. Did the blue litmus change colour? Did the red litmus change colour? Write the new colours in your table, in the appropriate place.
4. Repeat the procedure to test all the substances you have been given. You must rinse the teaspoon or rod with water in between substances.
5. Save all your test substances, because you will need them for another investigation later.

RESULTS AND OBSERVATIONS:

Record your observations in the table. If you did not use some of these substances, cross them out and write headings for your substances in the empty rows.

Substance	Colour with blue litmus	Colour with red litmus
Water		
Soda water		
Vinegar		
Lemon juice		
Sugar water		
Baking soda		
Handy Andy		
Aspirin		
Dishwashing liquid		

ANALYSIS:

Let us now have a look at our observations to see what we can conclude.

1. How does the litmus paper indicate when a substance is an acid?
   In an acid, the blue litmus changed to red and the red litmus remained red.
2. Which of the substances you tested are acids?
   Depending on the substances you use, but according to those listed here, the acids are: soda water, vinegar, lemon juice and aspirin.
3. How does the litmus paper indicate when a substance is a base?
   In a base, blue litmus remains blue and red litmus changes blue.
4. Which of the substances you tested are bases?
   Depending on the substances you use, but according to those listed here, the bases are: baking soda, handy andy, dishwashing liquid.
5. How would you describe a neutral substance?
   Learner-dependent answer.
6. How does the litmus paper indicate when a substance is neutral?
   Neither the red or the blue litmus paper will change colour when a substance is neutral.
7. Which of the substances you tested were neutral?
   Water and sugar solution.
8. Why do you think you had to rinse the glass rod or teaspoon in between testing each substance?
   You need to do this to avoid contamination and mixing of the substances otherwise, for example, there might be some acid left over when testing a base which would change the litmus paper resulting in an incorrect result for the base.

CONCLUSION:

Write a conclusion based on your results in response to the initial aim for this investigation.

TEACHER'S NOTE

A conclusion must respond to the aim and hypothesis for the investigation. In this case the aim was to determine how litmus paper responds to some household bases and acids. Therefore a conclusion is: In response to some household acids and bases, red litmus paper turns blue in bases and remains red in acids, and blue litmus paper turns red in acids and remains blue in bases. Both red and blue litmus paper will remain red or blue, respectively, in the presence of neutral substances. Learners can see whether they reject or accept their hypotheses.

Extension: If you have time in class with your teacher, use your knowledge of how litmus responds to acids and bases to test some of the beverages that you drink every day. You can use litmus paper to indicate whether beverages such as ceylon tea, rooibos tea, orange juice, milk, coffee and fizzy drinks are acids, bases or neutrals. If you do so, record your findings here:

TEACHER'S NOTE

The first five minutes of this video (http://bit.ly/17zszF4) contains a very clear demonstration of acids and bases using a universal indicator. The entire video is more than an hour long and touches on a range of chemical experiments and demonstrations. The demonstrations are very well designed and executed and the video can be used as a very useful tool to illustrate many concepts of chemistry in the classroom, though only the first part is relevant to this chapter.

We can say the following about litmus:

- Blue litmus is used to test for acids:
  - acids turn blue litmus red.
  - Bases and neutral substances do not change the colour of blue litmus.
- Red litmus is used to test for bases
  - bases turn red litmus blue.
  - Acids and neutral substances do not change the colour of red litmus.

What about the red cabbage paper that we made earlier? Can these paper strips be used to tell if something is an acid or a base? Let's find out.

INVESTIGATION: Is red cabbage paper suitable as acid-base indicator?

TEACHER'S NOTE

This is an **optional, extension** activity.

AIM: To determine whether red cabbage is a suitable acid-base indicator.

MATERIALS AND APPARATUS:

TEACHER'S NOTE

Learners can use the saved substances from the litmus investigation they did earlier. Top up the solutions if necessary.

- small containers with the same substances as in the previous investigation
- red cabbage paper strips
- glass or plastic rods

METHOD:

1. Use a small strip (2 cm long) of red cabbage paper for each substance that you will be testing.
2. Dip a fresh piece of paper into each of the test solutions. Does the paper change colour? Write the colour of the paper with each substance in your table in the appropriate place.

RESULTS AND OBSERVATIONS:

Record your observations in the table.

Substance	Colour with red cabbage paper
Water	
Soda water	
Vinegar	
Lemon juice	
Sugar water	
Baking soda	
Handy Andy	
Aspirin	
Dishwashing liquid	

QUESTIONS:

1. Which of the test substances are acids? (Check the results from the litmus investigation that you did earlier.)
Learner-dependent answer.
2. What colour did the red cabbage paper turn in the test substances that were acids?
The red cabbage paper should turn a red-pink colour in an acid.
3. Which of the test substances are bases? (Check the results from the litmus investigation that you did earlier.)
Learner-dependent answer.
4. What colour did the red cabbage paper turn in the test substances that were bases?
The red cabbage paper should turn a blue-green colour in a base.
5. Did the red cabbage paper change colour with all the substances? If there were some substances that did not change the colour of the paper, write their names below.
Learner-dependent answer.
6. Are these substances acidic, basic or neutral (also check your litmus test results)?
Learner-dependent answer.
7. Do you think red cabbage paper makes a good acid-base indicator? Why do you say so?
Learner-dependent answer. They should note that a good indicator is something which can tell you if it is an acid or a base, in that the same

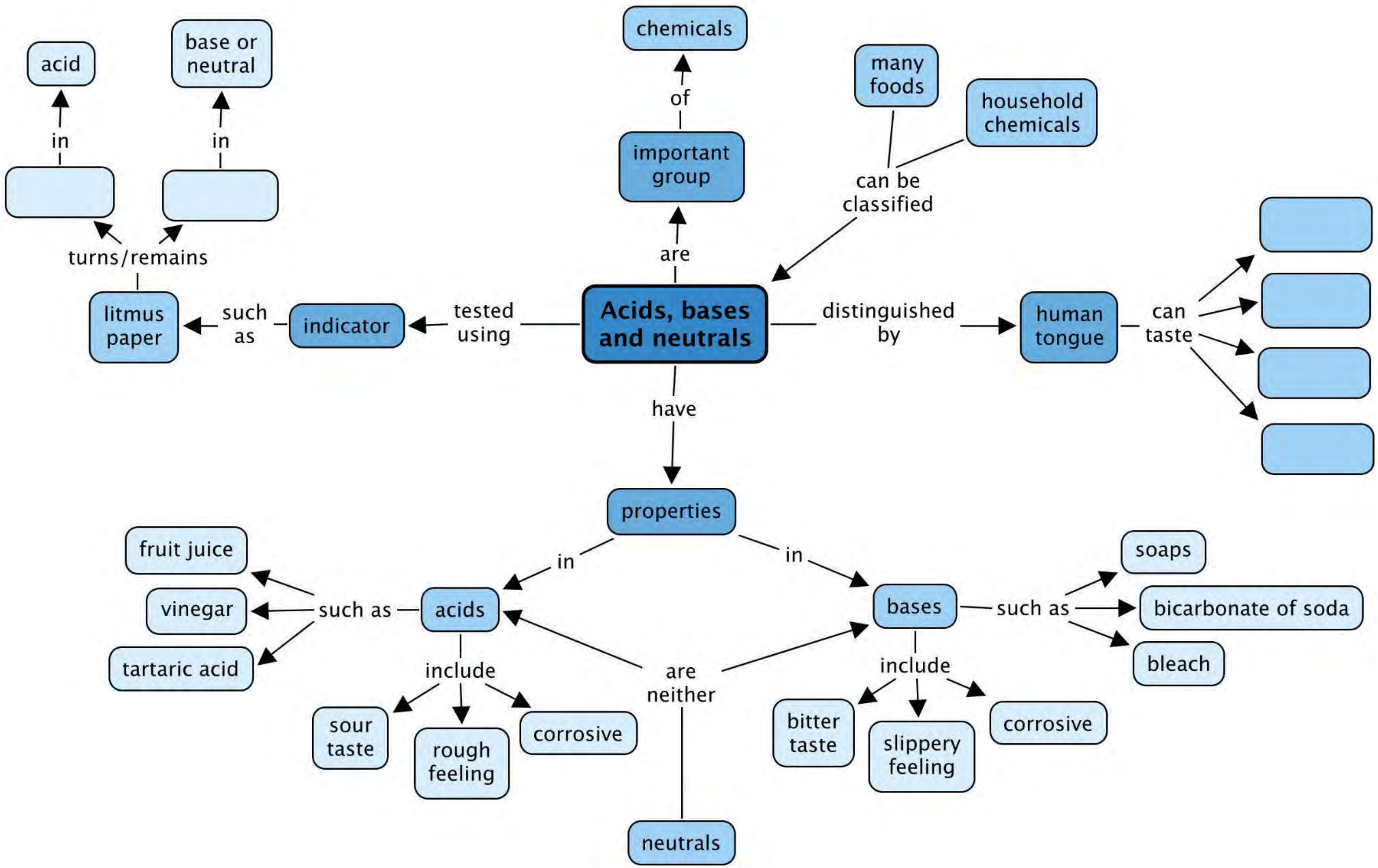
SUMMARY:

Key Concepts

- Our tongues can sense 4 different flavours namely, sweet, salty, sour and bitter.
- Our sense of taste protects us from eating foods that are harmful and stimulates us to eat foods that are nutritious and energy-rich.
- Acids and bases are chemical opposites of each other.
- Though it is not a good idea to taste chemicals, acids have a sour taste and bases taste bitter.
- When they are in solution with water, acids feel rough and bases feel slippery.
- Some acids and bases are present in foods and in household items. These are relatively safe to handle. Others are often very corrosive and should only be handled when you are wearing protective clothing.
- Substances which are neither acidic nor basic, are called neutral substances.
- When an acid is mixed with a base in the right quantities, they neutralise each other. That means they lose their power.
- Some substances change colour when they react with an acid or a base. These substances are called acid-base indicators. One household example of an acid-base indicator is red cabbage juice.
- Litmus is the best known of all acid-base indicators. It does not change colour in the presence of a neutral substance, but responds to acids and bases in the following way:
  - litmus is red in the presence of an acid; and
  - litmus is blue in the presence of base.

Concept Map

The human tongue can taste 4 main different tastes. What are these? Fill them in the spaces below. You also need to complete the section of the concept map about indicators. Can you work out how to do this? You need to fill in the colour that litmus turns (or remains) in each either an acid or a base (or neutral).



Acids, bases and neutrals
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litmus paper
turns/remains
in
acid
in
base or neutral
have
properties
in
acids
such as
fruit juice
vinegar
tartaric acid
include
sour taste
rough feeling
corrosive
in
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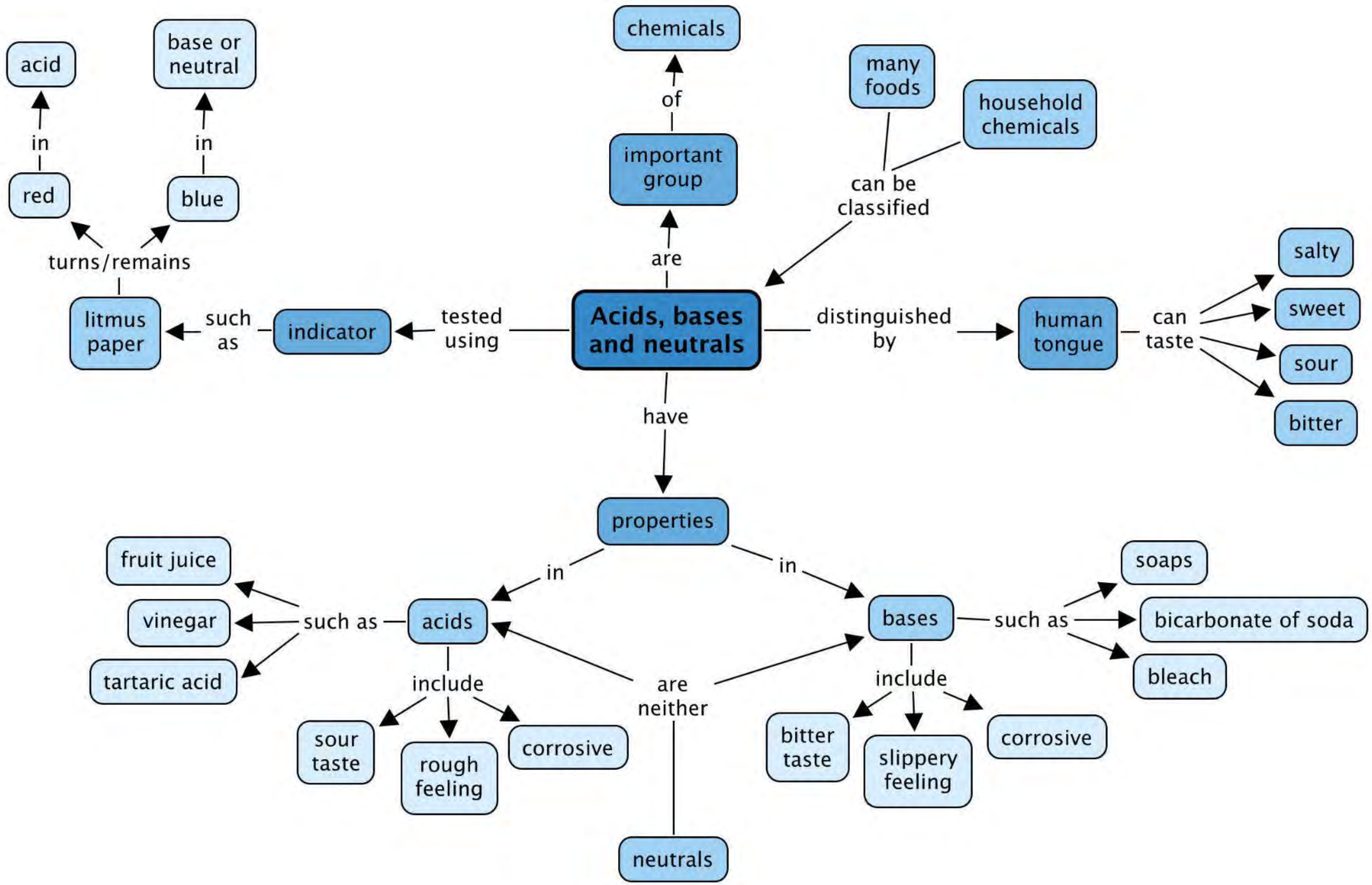
such as
soaps
bicarbonate of soda
bleach
include
bitter taste
slippery feeling
corrosive
are neither
neutrals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REVISION:

1. The box below is filled with ideas relating to acids and bases.

You must sort the ideas into two columns in the table. One column is labelled 'Acids' and the other is labelled 'Bases'. Write each idea inside the correct column. If an idea fits into both columns, you must write it in both. [16 marks]

Ideas

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

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

TEACHER'S NOTE

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

2. Here is another box; this one is filled with words.

You must use the words to complete the sentences that follow. Write out the sentences in full. Each word can be used only once. [11 marks]

Words
- Indicator
- Sour
- Red cabbage
- Bitter
- Poisonous
- Corrosive
- Neutralise
- Sweet
- Neutral
- Litmus
- Salty

a) The most well-known of all acid-base indicators is called __________ .
b) A substance that can eat away at other substances is called __________
c) Foods that are __________ often taste bitter.
d) Some scientists believe the human tongue can taste 4 flavours. These flavours are: __________, __________ ,__________, and__________.
e) An acid-base __________ is a substance that changes colour when it reacts with an acid or a base.
f) __________ substances are neither acids nor bases.
g) An acid will __________ a base (and vice versa).
h) The juice of the __________ makes a very good acid-base indicator.

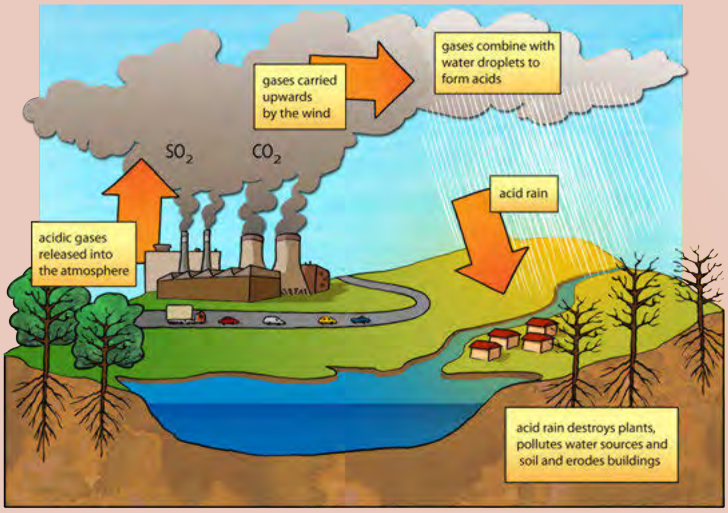
a) The most well-known of all acid-base indicators is called litmus.
b) A substance that can eat away at other substances is called corrosive.
c) Foods that are poisonous often taste bitter.
d) Some scientists believe the human tongue can taste four basic flavours. These flavours are: salty, sweet, bitter and sour (in any order).
e) An acid-base indicator is a substance that changes colour when it reacts with an acid or a base.
f) Neutral substances are neither acids nor bases.
g) An acid will neutralise a base (and vice versa).
h) The juice of the red cabbage makes a very good acid-base indicator.

3. Give an example of a strong acid and a strong base, commonly used in the laboratory. [2 marks]
Strong acids include hydrochloric acid, sulfuric acid, and a strong base is sodium hydroxide.

4. Write one or two sentences to explain what is meant by the term *neutralise*. [2 marks]
Learner's answer should contain at least 2 of the following ideas:
- *When an acid reacts with a base, the acid and the base will neutralise each other.*
- *That means they will both lose their strength/potency.*
- *The acid will not be an acid anymore, and the base will not be a base anymore.*
- *They will combine to form a neutral substance.*

5. Write a short paragraph to explain how laboratory acids should be handled. Your paragraph should contain the following words: corrosive; taste; clothes. [3 marks]
Learner's answer should contain at least the following ideas:
- *Laboratory acids should be handled very carefully because they are corrosive.*
- *Laboratory acids should never be tasted.*
- *You should protect yourself by wearing protective clothes, safety goggles and gloves when handling these acids.*

6. Would all acids burn your tongue or is it OK to taste some acids? Explain your answer. [2 marks]
   Some household acids can be tasted. Some household acids are in our food. Laboratory acids should never be tasted. (optional)
7. Give 2 examples of acids that are safe to taste. [1 mark]
   Examples of acids that are safe to taste are: vinegar, lemon juice, ascorbic acid (vitamin C), citric acid (any other acceptable examples; learner should name 2).
8. How you would be able to recognise an acid when you taste it? [1 mark]
   We recognise them as acids by their taste; acids have a sour taste.
9. How does our sense of taste warn us when food is not good to eat? [2 marks]
   Learner's answer should contain at least 2 of the following ideas:
   - *Most people don't like bitter food; that is because poisonous substances often have a bitter taste.*
   - *When food tastes sour, it may be a sign that the food has spoiled.*
   - *When food tastes strange (different from the way we remember it to taste) it may be a warning that the food has spoiled.*
10. Have you heard of acid rain before? Read the following information and study the diagram. Then answer the questions that follow.



    a) Which two gases are mentioned in the text and on the diagram which contribute to forming acid rain? [2 marks]
    b) Where do these gases come from? [2 mark]
    c) The gases then combine with water droplets in the atmosphere to make acids. What are some of the environmental impacts of acid rain? Study the diagram for some clues. [3 marks]
    a) They are sulfur dioxide and carbon dioxide.
    b) They come from factories, power stations and car exhausts.
    c) The impacts include:
      - *damage of plant life, both wilderness areas and also crops, depending on where the rain falls*
      - *the rain goes into soil, polluting it and making it more acidic*
      - *the rain can fall into various water sources and pollutes it.*
11. Acid rain can also damage buildings as it 'eats away' the stone. What property of acids allow it to do this? [1 mark]
    Acids are corrosive and so they can corrode surfaces over time.

Total [48 marks]

4 The Periodic Table of Elements

TEACHER'S NOTE

Chapter overview

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

Some important issues to note at this stage, namely:

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

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

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

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

Tasks	Skills	Recommendation
Activity: What do some of the elements look like?	Sorting and classifying, observing, identifying elements and properties, comparing	Suggested
Activity: Blitz revision of the properties of metals and non-metals	Sorting and classifying, identifying properties, comparing	Optional revision (suggested)
Activity: Classifying element X	Accessing and recalling information, reading, observing, identifying properties	Suggested
Activity: The regions of the Periodic Table	Accessing and recalling information, sorting and classifying, comparing	CAPS suggested
Activity: Uses of the elements	Accessing and recalling information, communicating, group work, making a poster	CAPS suggested

KEY QUESTIONS:

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

VISIT

A video to introduce us to elements and to the Periodic Table bit.ly/16C5ZyC

TEACHER'S NOTE

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

People have been interested in science from the earliest times. Early man discovered how to process natural ores into metals for ornaments, weapons and tools. At least 3000 years ago, ancient people were already using embalming fluids (chemicals) obtained from plants to preserve the bodies of dead people and animals!

Mankind has been studying and experimenting with materials to try to understand matter for thousands of years. Scientists especially, wanted some understanding of all the different substances that they were working with.

An ancient Egyptian mummy that has been embalmed to preserve it.

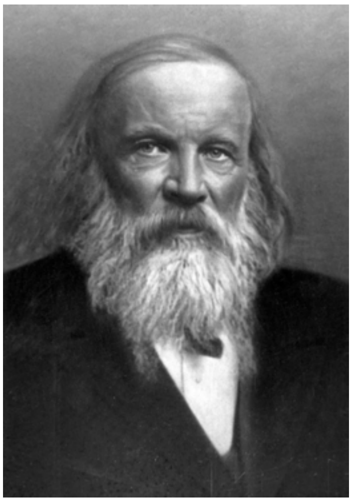
VISIT

An interesting video that tells us about how scientists solved the puzzle of the Periodic Table. bit.ly/1cMGnSw

Over time, many different elements were discovered by scientists all over the world. These elements make up all the materials around us. But what do we mean by the word element? An element is a pure substance which cannot be broken down any further. We will find out more about elements in this chapter.

VISIT

This video tells us more about how Dmitri Mendeleev listed and arranged the elements on the Periodic Table and why this was such an important event in the history of science as we know it. bit.ly/147QI9f



Dmitri Mendeleev.

Over time, our knowledge about the elements and their behaviour increased and scientists recognised the need to organise this information. They began to observe patterns and similarities in the way some groups of elements behaved and recorded these observations. Scientists wanted some way to **classify** the elements according to their properties that they were observing.

The version of the Periodic Table that we use today was first proposed by Dmitri Ivanovich Mendeleev in 1872. Mendeleev was a brilliant Russian scientist. While other scientists made many contributions to the design of the Periodic Table, Mendeleev was the one who first showed that the table could predict the existence and properties of elements that were still undiscovered at the time.

TEACHER'S NOTE

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

Alchemists, experimenting with materials in their laboratory.

4.1 Arrangement of elements on the Periodic Table

TEACHER'S NOTE

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

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

The Periodic Table is a classification system for the elements that make up the matter and materials in our world. Today, there are more than 100 different elements known! Each element has its own name, symbol, atomic number and position on the Periodic Table.

Element names

What is your name? Perhaps it is Thando. Or David. Or Megan. Perhaps you are lucky enough to be the only person in your class with that name. Perhaps you are lucky enough to be the only person in the world with that name! That would make your name unique.

Each element has a unique name. We can think of each name as a unique 'label' we can use to identify the element. There are two other unique labels that we can use to identify elements. They are the chemical symbol and the atomic number. We will learn more about these in the next section. Each element has some of its own unique properties and later on we will see that those with some similar properties can be grouped together.

VISIT

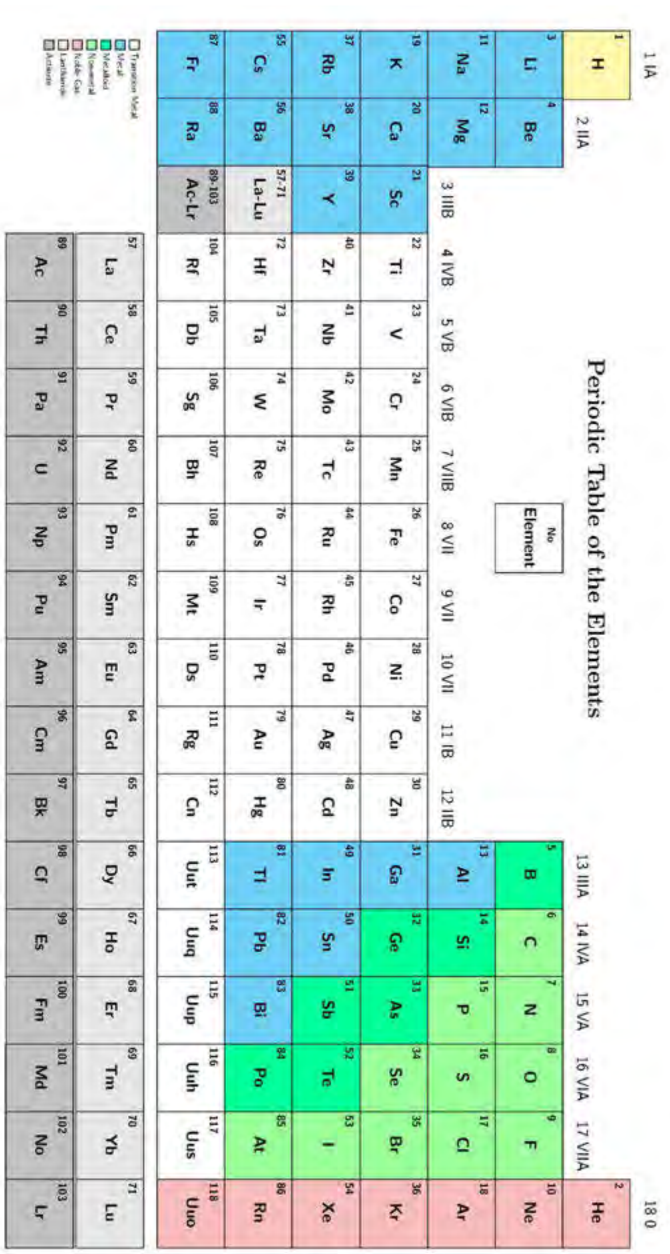
There are TWO songs to help you remember the elements of the Periodic Table. Which one is your favourite? Can you learn one (or both) of them? bit.ly/18d0bLl and bit.ly/11OuoPM

VISIT

A tour of the Periodic Table bit.ly/147Qzgx

TEACHER'S NOTE

The video above includes a bit more history about Dmitri Mendeleev, reviews Mendeleev's organisation of the period table and then moves on to relationships of elements on the Periodic Table. Just before the end of the video, the host mentions the importance of electrons (to be discussed in another video). Atoms, electrons and protons are concepts that are only discussed in Gr. 8.



The Periodic Table of elements as it is today.

TAKE NOTE

There is a bigger version of the modern Periodic Table of elements on the inside cover of your workbook. You can use it for easy reference.

Chemical symbols

If you are a scientist and you work with elements every day, writing out the names can become very tedious. To make writing about elements easier, scientists have given each element a short **symbol.** To make sure we do not become confused with different elements when we write about them, the symbol for each element must be unique, just like its name is.

TAKE NOTE

You need to know the names and symbols of these elements listed here.

The names and symbols for some common elements are shown in the following table.

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

VISIT

A game to learn about the Periodic Table

bit.ly/15QkMHn

The symbol for carbon is C, the symbol for sulfur is S and the symbol for nitrogen is N. It is easy to see why these symbols were chosen: they simply represent the first letter of each name. This letter is always capitalised (upper case).

What happens when the different elements all start with the same letter? For example: calcium, carbon, chlorine and copper all start with the letter 'C'! To ensure they all have a unique symbol, a second letter was added to their symbol. This letter is always a small letter (lower case).

Some chemical symbols are more difficult to understand. Na, for example, is the symbol for sodium. The Na comes from the Latin name for sodium, which is *natrium*. These symbols were chosen very long ago, when many subjects were studied in Latin. Can you imagine how difficult that must have been?!

Some simple rules to remember when using chemical symbols:

1. Every element has its own, unique symbol.
2. The symbol is usually (but not always) the first one or two letters of the name of the element.
3. The first letter of the symbol is always a capital letter.
4. If the symbol has two letters, the second letter is always a small letter.
5. Some elements have symbols that come from their Latin names.

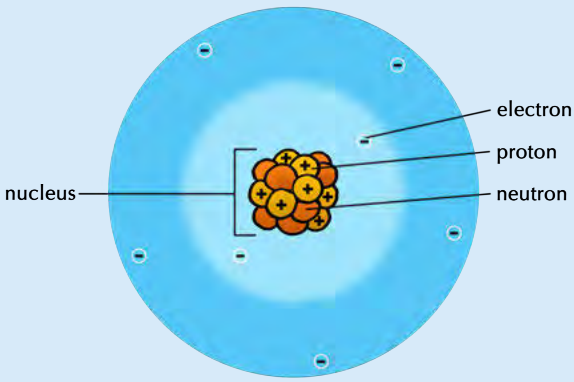
Atomic numbers

TEACHER'S NOTE

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

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

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



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

If you look at the Periodic Table, you will see that each element also has a unique number. This is called the **atomic number**. To properly understand what the atomic number is, we need to know what an **atom** is. We will learn more about atoms in Gr. 8, but for now, let's briefly go back to our history lesson!

Do you remember we said Mendeleev developed the first periodic table in 1869? Well before that, at the beginning of the 1800's, a man by the name of John Dalton said that all matter is made up of very small particles called atoms. These atoms vary in mass and size. Do you remember we said an element is a pure substance? We can now also say that an element is a substance that contains *only one particular type of atom.* The atoms of one element are different from the atoms of any other element.

TAKE NOTE

You do not need to know about the atom in detail for now. We will learn more about this in Gr. 8!

All atoms are made up of even smaller particles which we call subatomic particles. These are protons, neutrons and electrons. All you must remember for now is that the protons, electrons, and neutrons of one element *are exactly the same* as the protons, electrons, and neutrons of any other element. It is their number and arrangement that make the elements different.

The atomic number of an element refers to *how many protons* that element has in its atoms. Since each element has a different number of protons in its atoms, each element also has a unique atomic number.

Have a look at the Periodic Table. What is the atomic number of hydrogen? How many protons are there in its atoms?

TAKE NOTE

When things show a regular, repeating pattern, we say it is **periodic**. When the elements were arranged in order of increasing mass, Mendeleev observed a pattern in their properties, which allowed him to arrange the elements into rows and columns in a table, the **Periodic** Table. Elements in the same rows and columns in the table, have similar properties to each other.

TEACHER'S NOTE

Hydrogen has atomic number 1 and therefore has 1 proton.

What is the atomic number of carbon? How many protons are there in its atoms?

TEACHER'S NOTE

Carbon's atomic number is 6. It has 6 protons in its atoms.

Reihen	Gruppo I. — R^2O	Gruppo II. — RO	Gruppo III. — R^2O^3	Gruppo IV. RH^4 RO^2	Gruppo V. RH^3 R^2O^5	Gruppo VI. RH^2 RO^3	Gruppo VII. RH R^2O^7	Gruppo VIII. — RO^4
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Mendeleev's Periodic Table from 1872. The spaces marked with blank lines represent elements that Mendeleev thought existed, but they were not yet discovered at the time, so he left places for them.

Can you see how the elements are arranged so that their atomic numbers increase from left to right across the Periodic Table? This is not a coincidence! When Mendeleev first created the Periodic Table, he arranged the 60 elements that he knew of at the time in order of increasing mass. He then saw that there was a regular pattern in other characteristics of these elements. Mendeleev then grouped them into columns and rows according to their properties. These were physical and chemical properties which the scientists had observed from doing many different experiments. This resulted in the arrangement of the elements on the Periodic Table.

The Periodic Table that we use today looks a lot more modern than Mendeleev's original version. You will notice that there are no empty blocks in the modern version of the table. That tells us that all the elements that were still undiscovered in Mendeleev's lifetime, are now known.

In the next activity, we will compare Mendeleev's original Periodic Table with the version that we use today. This will help show us how scientific discovery is sometimes a slow process.

ACTIVITY: Comparing Mendeleev's table with the modern version of the Periodic Table

TEACHER'S NOTE

This is an optional, extension activity.

When Mendeleev first arranged the elements according to their mass and their properties, it resulted in there being some gaps in the rows. But, as a good scientist, Mendeleev did not see this as a problem! Instead, he thought it simply meant that there were elements that had not been discovered yet. And he was right!

Mendeleev put a blank line and the atomic number to show that he thought there is an element which should go there, but it had not been discovered. Look carefully at Mendeleev's original table. See if you can find where it says '__ = 44' in the table.

See if you can find the 2 other elements that had not been discovered at that time. Write their numbers down in the space below.

TAKE NOTE

In Life and Living, we looked at the classification of living organisms in our world. Now in Matter and Materials, we are looking at the classification system for elements!

TEACHER'S NOTE

They are 68 and 72.

Now look at the modern version of the Periodic Table. Can you find the elements with these numbers? What are their symbols? What are their names? Write your answers in the table provided.

As an extension of this activity you could look up the names of these elements, and research when they were discovered, and add this information to the table.

TEACHER'S NOTE

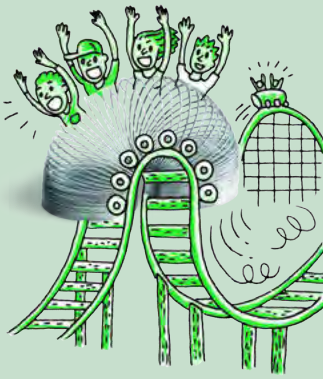
This final task could be shared in groups of 3 or 6 learners, who could then bring their data to class where it can be pooled. If the dates for each element do not correspond exactly, it provides an opportunity to discuss the validity of information. When is data 'the truth'? Can we always believe what we read? When is a source of data reliable?

TEACHER'S NOTE

Number of the element	Symbol of the element	Name of the element	When was this element discovered?
44	Ru	Ruthenium	1844
68	Er	Erbium	1843
72	Hf	Hafnium	1923

In the next activity we are going to use our new knowledge of element symbols and atomic numbers to hunt for a very valuable 'treasure'. We will find the treasure by following some clues about the Periodic Table.

ACTIVITY: Periodic Table treasure hunt



TEACHER'S NOTE

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

Your job is to follow the clues, in order to find the treasure. The instructions will help you to spell out the name of the treasure in the blocks below.

TEACHER'S NOTE

C	H	O	Co	La	Te

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

1. Clue 1: What is the symbol for carbon (atomic number 6)? Write this symbol in the first block above.
   C
2. Clue 2: Hydrogen is the lightest element. Can you find it on the Periodic Table? Write its symbol in the second block.
   Very first element on the Periodic Table (top left). The symbol for hydrogen is H.
3. Clue 3: Which element represents the gas that we breathe to stay alive? Here is a hint: It is represented by atomic number 8. Write its symbol in the third block and give the name of the element below.
   O (oxygen)

4. Clue 4: This element is in the fourth row and the ninth column of the Periodic Table. It is a metal that is used in magnets. Write its symbol in the fourth block. Do you know its name? Write its name below.
   Co (cobalt)
5. Clue 5: This element is represented by atomic number 57. Write its symbol in the fifth block. See if you can find out the name of this element and write it down below.
   La (lanthanum)
6. Clue 6: This element is represented by atomic number 52. It is a semi-metal that is used in the manufacture of solar panels. Write its symbol in the last (sixth) block. See if you can find out the name of this element and write it down below.
   Te (tellurium)
7. What is the 'treasure' that you have found?
   Chocolate

Complete the following sentence by replacing the names of the elements with chemical symbols. You would have to look up some of the symbols!

SCIENCE...Fluorine Arsenic Carbon Iodine Nitrogen Astatine Einsteinium... ME!

TEACHER'S NOTE

Science... F As C I N At Es (fascinates)... me!

Complete the following table to see how many of the names and symbols of the elements you remember. Try to do this without referring to the Periodic Table.

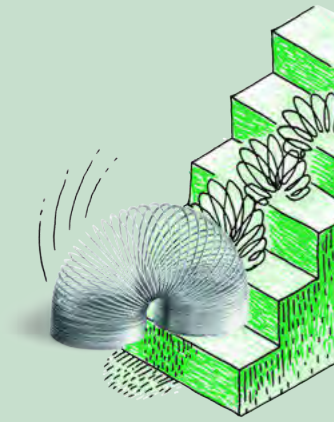
TEACHER'S NOTE

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

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

The Periodic Table is an amazing tool! Did you know that the position of an element on the Periodic Table can tell a scientist what properties the element can be expected to have? This is because the elements have not just been arranged randomly! But, rather, they are grouped and arranged according to similar properties. Let's find out what this means.

ACTIVITY: What do some of the elements look like?



TEACHER'S NOTE

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

Instructions for you to do this activity:

1. If possible, collect actual samples of the elements in this activity. You do not need all of the elements, but at least some of them listed here in the activity. You can use materials that you find around you such as a piece of coal or graphite stick (for carbon), a piece of copper piping, a tube with sulfur powder, a bottle of iodine solution from the chemist, a piece of aluminium foil, an iron/steel nail, etc.
2. Once you have collected your samples, preferably in little containers, arrange them on the table up front.
3. Next, stick up a blank cardboard cut out of the Periodic Table. You will need to create this yourself. You can draw out the table large on a sheet of cardboard, or else you can print one on a large piece of paper. There are many different websites where you can download blank Periodic Tables, such as this one: bit.ly/132NDb7. A blank Periodic Table has also been provided in the workbook for learners to write the symbols of the elements you discuss if you are not able to obtain samples and produce a large cardboard print out. They can still do this even if you do have the print out at the front of the class.
4. Then, go through the different elements that you have. Pass the sample around the class, or get learners to come up to your desk to look at them.
5. Ask for a volunteer from the class to come select an element and find its place on the Periodic Table by looking at the one in their workbooks. They must then stick the sample into the correct square on the blank cardboard table. Use adhesive tape or Prestik.
6. Do this for as many samples as you have. You can also print out some colour photos of different elements to do some more. Here is a website where you can download public domain images of the elements and print them: bit.ly/19PEEw3.

TEACHER'S NOTE

7. If you do not have actual samples, or colour print outs, some images have been provided in the workbooks which you can refer to, and then just write the symbols on the cardboard cut out.
8. Once you have done this for as many samples as you have, ask learners to describe what the elements on the left hand side of the table look like, and what those on the right hand side look like. This is the introduction to metals and non-metals. They should be able to see that those on the left are generally shiny and metallic (as they are metals), and those on the right are generally in powder form, brittle, dull, colourful, etc (as they are non-metals.
9. Learners must then answer the questions that follow at the end of the activity.

INSTRUCTIONS:

1. Your teacher will guide you through this activity. You will either look at real samples of some of the elements, or else refer to the photos below of some of the elements.
2. Your task as a class is to identify the different elements and find their place on the Periodic Table. You will either stick the real samples onto a large blank Periodic Table, or use the blank one here in your workbook, or both.
3. You must then look at what the different elements look like and see if you can identify any similar properties. The questions at the end will help guide you through this.

Here are some photos of the different elements:

Aluminium foil.

Carbon (graphite).

Copper.

Magnesium.

Sulfur.

Bromine in tube.

Chlorine gas.

Calcium.

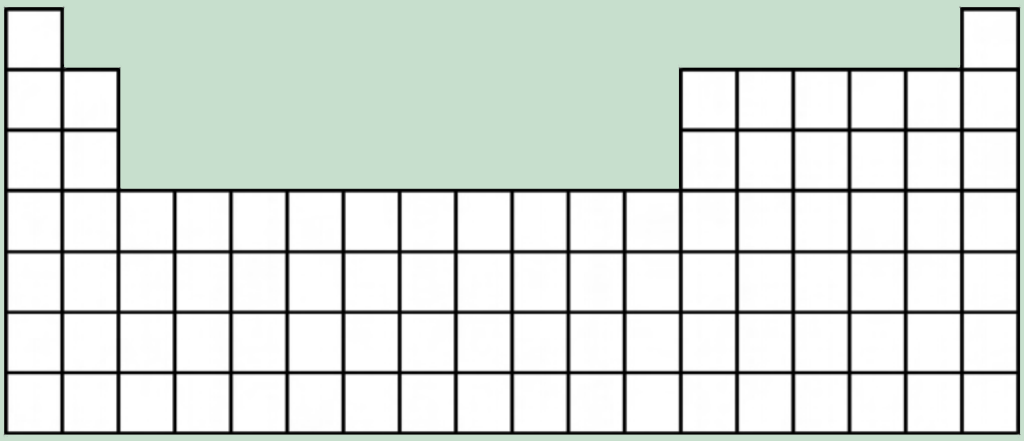
Phosphorus.

Potassium.

Nitrogen gas.

Iron.

If you do not have a large cardboard Periodic Table to work with at the front of the class, write the names of the elements you discuss on the blank table provided here:



After completing this activity, either by sticking actual samples onto a cardboard cut out, or looking at the photos provided here in your workbook and seeing where they are positioned on the Periodic Table, answer these questions.

QUESTIONS:

TEACHER'S NOTE

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

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

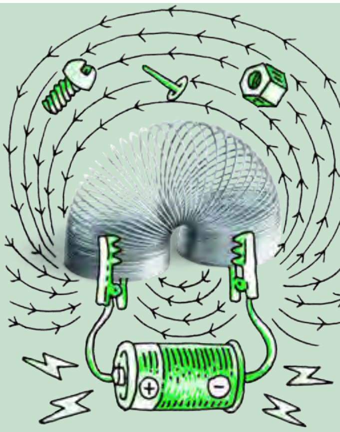
You probably saw from the last activity that there is a difference in the elements on the left and right of the Periodic Table. Were you able to identify what these elements are classified as. You have learnt about them before in previous grades. They are **metals** and **non-metals**.

Let's do a quick revision of what we have already learnt about metals and non-metals in previous grades.

The properties of metals and non-metals

Metals and non-metals have distinct properties. That means their properties are unique and different from each other. Can you remember what the unique properties of metals and non-metals are? The next activity will refresh your memory.

ACTIVITY: Blitz revision of the properties of metals and non-metals



Here is a block with different properties of metals and non-metals in it. They have been jumbled and are not sorted. You need to decide whether these properties describe metals or non-metals and sort them into the columns in the table which has been provided. Make sure that all the properties in the block are in your table. If you can think of properties that are not listed in the block, you may also add them to the table.

Properties

- shiny
- lustrous
- dull
- brittle
- malleable
- ductile
- conducts electricity
- conducts heat
- usually a solid
- can be solid/liquid/gas
- electrical insulator
- thermal insulator
- (other)

Do the activity as quickly (but also as neatly) as you can, and time yourself!

TEACHER'S NOTE

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

Most elements fall into one of these two categories: metals and non-metals. We use the *properties* of an element to categorise it as a metal or a non-metal.

Think of chromium, for example, which is shiny (lustrous), bends easily (malleable) and conducts heat and electricity well.

A piece of chromium.

1. What are the properties of chromium?
   Chromium is lustrous, malleable and conducts heat and electricity.
2. Based on these properties, would you categorise chromium as a metal or a non-metal?
   Chromium is a metal.
3. Can you find chromium on the Periodic Table? (Hint: It may help to find its symbol first.) What is its atomic number?
   24

Sulfur crystals forming on a rock wall inside a volcano.

Now think of sulfur.

Sulfur is usually a dull, yellow powder.

It does not conduct electricity or heat well and large crystals of sulfur break easily when they are dropped.

1. What are the properties of sulfur?
   Sulfur is dull, brittle and does not conduct electricity or heat well.
2. Based on these properties, would you categorise sulfur as a metal or a non-metal?
   Sulfur is a non-metal.
3. Can you find sulfur on the Periodic Table? (Hint: It may help to find its symbol first.) What is its atomic number?
   14

We have now looked at the properties of metals and non-metals. But, when scientists were doing their experiments to observe the properties of the elements, they sometimes found some elements which were difficult to classify as either a metal or a non-metal.

The properties of semi-metals

Some elements are not quite metals, but they are not quite non-metals either. They just don't fit into either category! Does this sound strange to you? Let us explore.

ACTIVITY: Classifying element X

Pretend that you are a member of a team of scientists that has just discovered a new element. The element has not been named yet, so it is simply referred to as 'element X'.

The team has a sufficient amount of element X to make several disks of the material. They create a file about element X. In the file, they place the following picture of one of the disks.

A disk of element X.

TAKE NOTE

Room temperature is 25°C.

Look carefully at the picture. How would you describe the appearance of element X?

TEACHER'S NOTE

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

The team performs experiments on element X and adds the following data to the file:

1. In an attempt to bend a disk of element X, the disk shattered, like glass. The same result was observed when a second disk was dropped from a height.
2. The material is found to be a poor conductor of heat and electricity at room temperature. Element X was then cooled down significantly by placing it in a freezer. At very low temperatures, it becomes a good conductor of electricity.

Fill out the following checklist for element X by placing crosses next to each property that was observed.

TEACHER'S NOTE

Metallic properties	**YES**	**NO**
Is the material shiny (lustrous)?	X	
Is the material malleable and ductile?		X
Does the material conduct electricity at room temperature?		X
Does the material conduct heat?		X
Non-metallic properties	**YES**	**NO**
Is the material brittle?	X	
Does the material have a dull appearance?		X
Is the material an insulator?		X
Additional comments (what else did you observe?):		
The material does not conduct electricity at room temperature. It does conduct electricity at very low temperatures.		

QUESTIONS:

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

Element X does not quite fit into either category. Some of its properties are metallic and others are non-metallic. Element X is a real element, and its name is tellurium (chemical symbol: Te). Can you find it on the Periodic Table?

TAKE NOTE

The semi-metals are also sometimes referred to as metalloids.

There are other elements, like tellurium, that are difficult to classify as either metals or non-metals. This is because they have some properties that are typical of metals and some properties that are typical of non-metals. A special category was invented for these elements: they are called **semi-metals**.

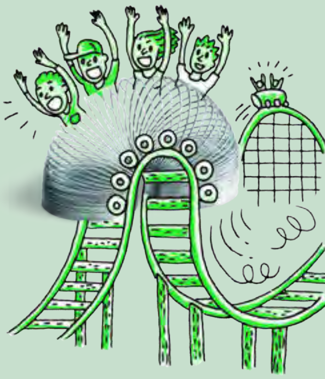
There are not many semi-metals. They are all listed in the following table. You do not have to remember all their names.

Names and symbols of the semi-metals:

Name	Chemical symbol	Atomic number
Boron	B	5
Silicon	Si	14
Germanium	Ge	32
Arsenic	As	33
Antimony	Sb	51
Tellurium	Te	52
Polonium	Po	84

Now that we have looked at some of the elements and where they are found on the Periodic Table, you might have already recognised that there is a trend in where the metals, semi-metals and non-metals are positioned on the Periodic Table. We are now going to do a colouring activity to see where on the Periodic Table we will find each of the categories of elements.

ACTIVITY: The regions of the Periodic Table



We are going to colour areas on the following version of the Periodic Table. This will help us identify the regions on the table where the metals, non-metals and semi-metals are located.

MATERIALS:

For this activity you will need coloured pencils or kokis or crayons in the following colours:

- Blue
- Yellow
- Red

INSTRUCTIONS:

1. **Semi-metals:**
   Find all the semi-metals on the Periodic Table. You will need to consult the table (names and symbols of the semi-metals) to help you remember which elements are semi-metals. Colour the block representing each of the semi-metals yellow.

TEACHER'S NOTE

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

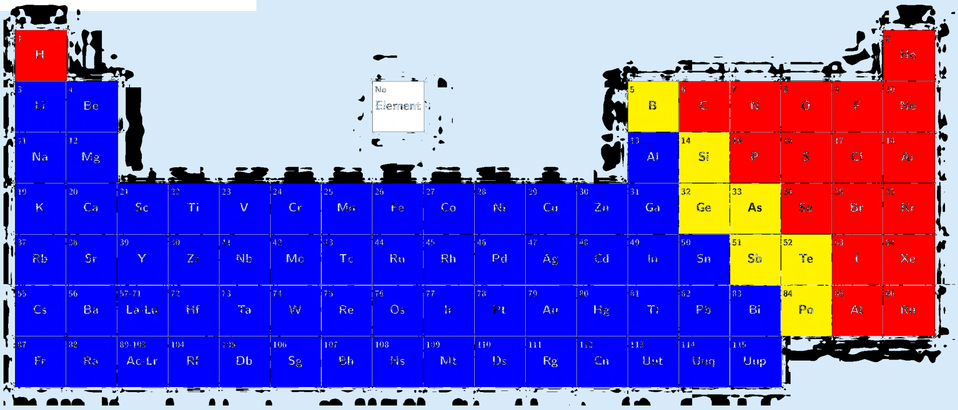
2. **Metals:**
   Colour all the blocks to the left of the semi-metals blue. Do not colour hydrogen (H), as it is not strictly a metal. All these elements are metals.

TEACHER'S NOTE

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

3. **Non-metals:**
   Colour all the blocks to the right of the semi-metals red. All these elements are non-metals. Now you can also colour hydrogen (H) red. On most versions of the Periodic Table hydrogen is placed with the metals, even though it has physical properties similar to those of the non-metals (it is a gas at room temperature). Hydrogen is placed with the metals, because it tends to behave like the other members of its column in chemical reactions.

TEACHER'S NOTE



Now answer the following questions, using your colourful Periodic Table.

QUESTIONS:

1. Which category contains the most (biggest number of) elements: metals, non-metals or semi-metals?
   Metals
2. Which category contains the least (smallest number of) elements: metals, non-metals or semi-metals?
   Semi-metals
3. State which category of material (metal, non-metal or semi-metal) each of the following elements belongs to:

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

We have learnt that the Periodic Table can be divided into regions where metals, non-metals and semi-metals can be found. This is useful information because the elements in different regions share similar properties. Their properties help us to decide what we can use them for. For example, metals are durable, malleable and shiny so they are suitable for making jewellery, pots and pans and motor car parts.

Let's look at some more examples. Where can we find all these elements in the real world? Where do they occur, and what are they used for?

We all know that oxygen (O) is one of the elements in the air we breathe. Rings and other jewellery are often made of gold (Au), silver (Ag) or platinum (Pt). But what do we know about calcium? And what is nickel used for?

1. Think about how long coins are used for. How are properties of metals useful to us when making coins?

Our South African coins are made from various metals and mixtures of metals, such as copper, nickel and stainless steel.

Metals are strong and durable which is what is needed for coins as they are used for many years in a country. They need to be strong so that they do not break and last a long time. Metals can also be melted and then harden again in a fixed shape. This is useful when making the coin shape and also creating the pattern on the faces.

2. Why do you think we make jewellery out of the metals gold, silver and platinum, and not for example out of a non-metal such as sulfur? What are the properties of these metals?

Jewellery is made from metals such as gold, silver and platinum.

Gold, silver and platinum are shiny, whereas non-metals are not. This makes these metals appealing to make jewellery. They are also hard and strong so they can be shaped, but they retain their shape and do not break.

3. Why do you think these electrical wires are made out of copper? What property of copper is useful in this situation?

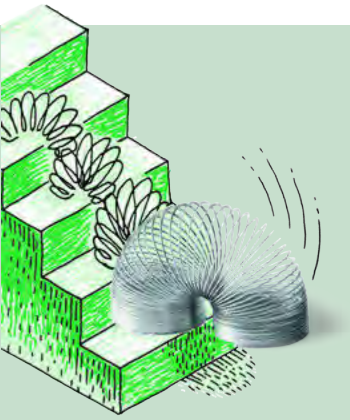
These electrical wires are made out of copper.

Metals, such as copper, conduct electricity, which is what is needed in an electrical wire.

4. Do you think you could make electrical wires out of a non-metal such as bromine or phosphorus? Why or why not?
No, you could not, as non-metals do not conduct electricity.

VISIT
These websites of the Periodic Table highlight some of the uses of the elements: bit.ly/1euHmVi and bit.ly/17zr35Q .

What do we use some of the non-metals for? We use carbon (coal) as a fuel, we use chlorine as a disinfectant to purify water, iodine is used as an antiseptic for wounds and helium is used to fill balloons. Arsenic, a semi-metal, is poisonous and therefore used as a pesticide for insects, bacteria and fungi. Another semi-metal, antimony, is used to make an alloy with lead which is very hard and has many applications. As you can see, the elements have many uses all around us! In the final activity of this chapter, we will explore some of the uses of the elements in more detail.



ACTIVITY: Uses of the elements

Your teacher will divide the class into small groups. Your group must choose one element from the Periodic Table (if you are unsure, your teacher will help you choose) and research the following questions about this element:

1. Where is this element found?
2. What do we use this element for?
3. What are some of the properties if the element?

Your group must make a poster to present all the information you found about your element.

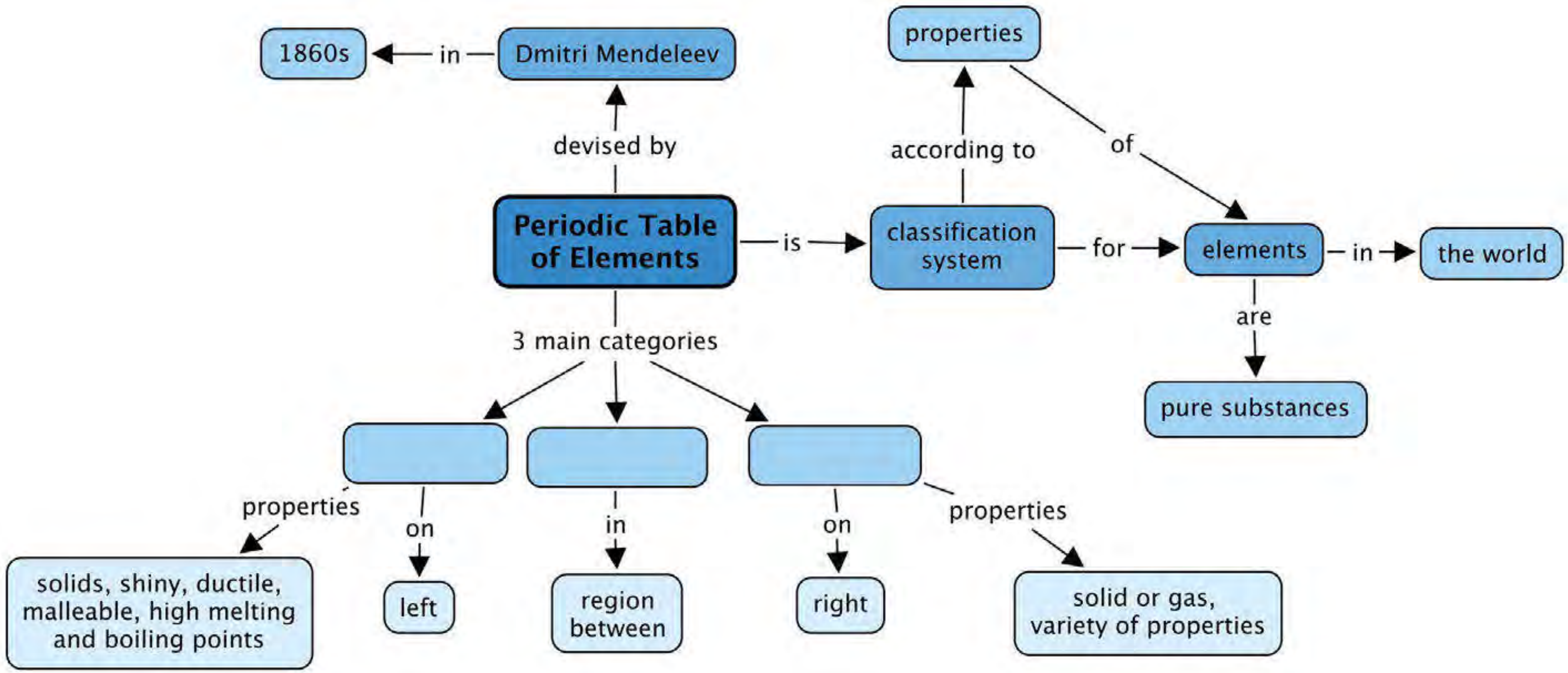
SUMMARY:

Key Concepts

- All the elements that are known, can be arranged in a table called the Periodic Table.
- The discoveries of many scientists over many years contributed to the information in the Periodic Table, but the version of the table that we use today was originally proposed by Dmitri Mendeleev in the 1800s.
- Each element has a fixed position on the Periodic Table. The elements are arranged in order of increasing atomic number, with the lightest element (hydrogen: H) in the top left hand corner.
- An element's position on the Periodic Table tells us whether it is a metal, a non-metal or a semi-metal.
  - metals are found on the left hand side of the table;
  - non-metals are found on the far right hand side of the table; and
  - semi-metals are found in the region between the metals and non-metals.
- An element can be identified in 3 different ways:
  - each element has a unique name;
  - each element has a unique chemical symbol; and
  - each element has a unique atomic number.
- Metals are usually shiny, ductile and malleable. Most are solids at room temperature, and have high melting and boiling points.
- Non-metals can be solids, liquids or gases at room temperature. They have a great variety of properties that usually depend on the state they are in.
- The semi-metals are all solids at room temperature. They usually have a combination of metallic and non-metallic properties.

Concept Map

We learnt that the elements in the Periodic Table fall into 3 main categories. What are these? Fill these in the concept map by looking at the concepts which come after each category.


1860s
in
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Periodic Table of Elements
is
classification system
according to
properties
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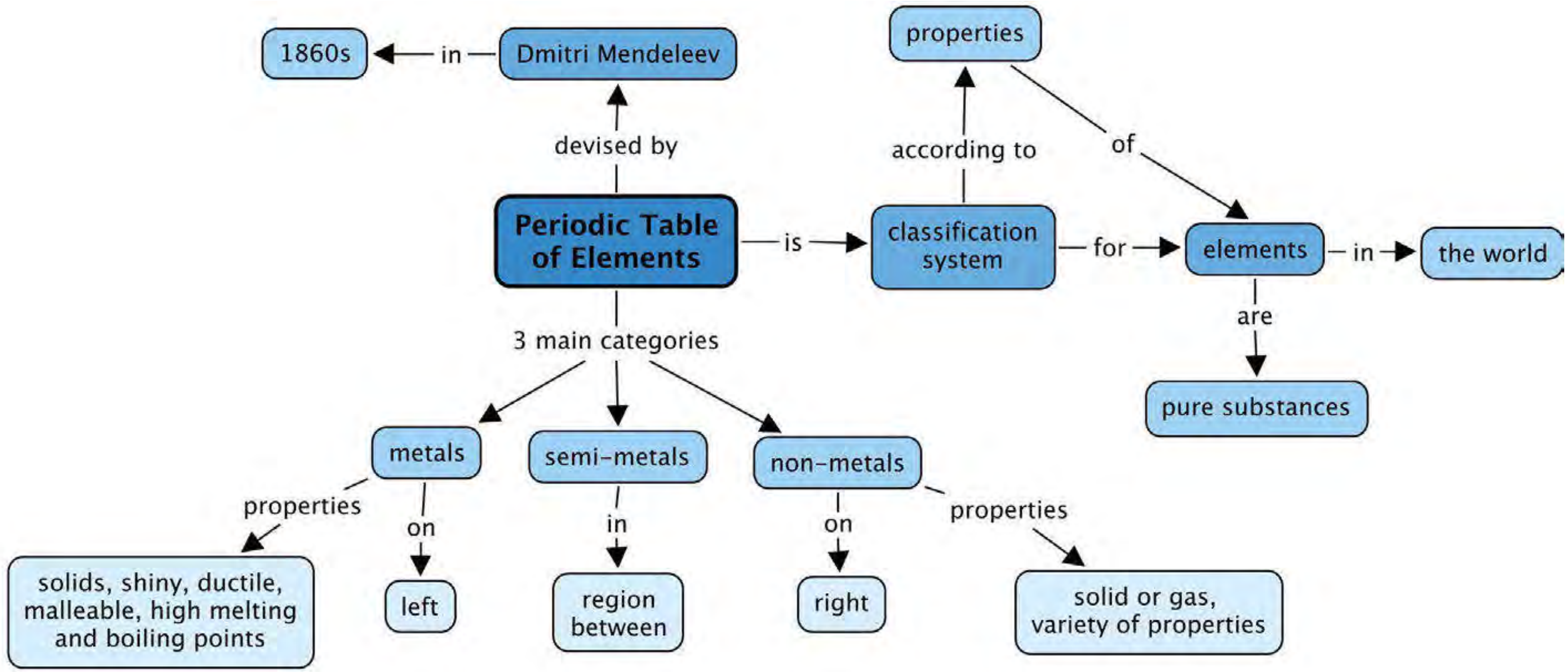
in
the world
are
pure substances
3 main categories
properties
solids, shiny, ductile, malleable, high melting and boiling points
on
left
in
region between
on
right
properties
solid or gas, variety of properties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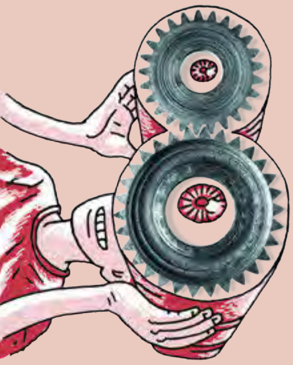

REVISION:

1. What information can we tell from an element's position in the Periodic Table? In other words: [2 marks]
   a) What does it tell us when an element occurs on the left hand side of the Periodic Table?
   b) What does it tell us when an atom occurs on the right hand side of the Periodic Table?
   a) It tells us that the element is a metal (hydrogen is an exception here). The metals occur on the left hand side of the Periodic Table.
   b) It tells us that the element is most likely a non-metal. The non-metals occur on the right hand side of the Periodic Table.
2. There are 3 unique 'labels' that can be used to identify an element. The first is its name. What are the other two? [2 marks]
   The chemical symbol of the element and the atomic number of the element.
3. What is the relationship between the atomic number of an element and its place on the Periodic Table? [1 mark]
   The elements are arranged in order of increasing atomic number.
4. Which element has the lowest atomic number? Write both its name and its symbol. [2 marks]
   Hydrogen, H.
5. Extension question: What does the atomic number of hydrogen tell us about it? [1 mark]
   It means it has 1 proton in its atoms.
6. Write the chemical symbols of all the elements that are in the same column as the element with the atomic number 9. (Note: The columns on the Periodic Table are called Groups.) [2 marks: 1/2 mark each]
   F, Cl, Br, I, At
7. The following table contains some names of elements. There is also a box of chemical symbols. You should place the chemical symbols in the right hand column of the table so that they match the names in the left hand column. [8 marks]

Chemical symbols

- C
- Na
- Si
- N
- He
- Cl
- S
- O

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

8. Write a short paragraph to explain what a semi-metal is. Also give an example of one semi-metal and say where in the Periodic Table the semi-metals can be found. [3 marks]
Learner's answer should contain at least the following information:
   - *Semi-metals are elements that have some properties of both metals and non-metals.*
   - *They are found in a diagonal strip that separates the metals form the non-metals, towards the right hand side of the Periodic Table.*
   - *Learner should give one example from the following list: boron (B), silicon (Si), germanium (Ge), arsenic (As), antimony (Sb), tellurium (Te) or polonium (Po).*
9. Name two properties of metals and two properties of non-metals. [4 marks]
Metals: Any two of the following properties:
Usually solid, shiny (lustrous), ductile, malleable, have high melting and boiling points, good conductors of heat and electricity.
Non-metals: Any two of the following properties:
Most often gases and liquids (but can be solid), dull, brittle, poor conductors/good insulators.

Total [25 marks]

GLOSSARY

abundant: when something exists, or is available, in large quantities; plentiful

acid: a substance which is corrosive, has a sour taste and feels rough (grippy) between your fingers

alkali: a base that is dissolved in water

alloy: a mixture of two or more metals (stainless steel is an example of an alloy)

altitude: the height of a place above sea level; places that are inland, or on mountains, are said to be at a higher altitude than places on the coast

ascorbic acid: a natural acid that occurs in some fruits and vegetables; also known as Vitamin C

atomic number: a unique number that represents a given element and shows its position on the Periodic Table

base: a substance that can also be corrosive, has a bitter taste, and feels slippery between your fingers

boiling point: the temperature at which a particular material changes from the liquid to the gas state (boils)

capillary action: the process by which liquid is drawn up in a narrow tube

chemical formula: a representation of chemicals using symbols that tell us which elements a compound contains and in what ratio

chemoreceptor: a sensory nerve cell or sense organ that detects chemical signals

chromatogram: the pattern formed on the paper by the components separated by chromatography

chromatography: a process in which a mixture carried by a liquid is separated into components

citric acid: a natural acid that occurs in citrus fruit

clear: transparent; see-through

concern: (noun) something that you are worried about

condensation: the process of changing a gas to a liquid

condense: when particles come together; to change from the gaseous state to the liquid state

constant: a variable, or physical quantity, that is constant or does not change over time

contract: (verb) the physical size of an object gets smaller

controversial: controversial issues are issues that people do not agree about; issues that people argue about because they hold different opinions

corrosive: a corrosive substance damages ('eats away') other materials by chemical action (the related verb is corrode)

dependent variable: a dependent variable is one that we do not directly choose values for, but can only measure as we go along

disperse:	to spread evenly throughout
distillation:	a technique for separating the components of a liquid solution through evaporation and condensation
ductile:	the property of a material that allows it to be pulled and stretched out into thin wires
durable:	a material that is durable can last for a long time without breaking down
element:	a pure substance which cannot be broken down further
emulsion:	a mixture of two or more liquids that usually do not mix, such as tiny oil droplets in water
environmental concerns:	worries about the negative effects on habitats and ecosystems in our environment, caused by humans and their activities
essential:	necessary and important; required
evaporation:	the process of changing a liquid to a gas
expand:	(verb) the physical size of an object gets bigger
filtrate:	the liquid that has passed through a filter is called the filtrate
filtration:	the process of passing something through a filter
flavour:	the taste and smell of food in the mouth
flexible:	a material that is flexible will change shape easily without breaking when it is bent, and will return to its original shape when it is released
formic acid:	a natural acid found inside the bodies of some ant species
grain:	a very small piece of something
heat:	is the transfer of energy, from a hotter object to a colder object
immune system:	the biological system inside our bodies that protects us from disease and infection
impact:	to have an effect on something else
independent variable:	an independent variable is one whose values we can choose (manipulate); we still have to be able to measure it
indicator:	a substance that changes colour in the presence of another substance, showing that that substance is present
instinct:	a natural or inborn way of responding to something
litmus:	a well known acid-base indicator that turns red when mixed with an acid and blue when mixed with a base
magnetic:	a property of some materials that allows them to be attracted to a magnet
malleable:	the property of a material that allows it to be shaped by flattening with a hammer or squeezing it between rollers
melting point:	the temperature beyond which a particular material changes from the solid to the liquid state (melts)

mixture:	matter consisting of two or more components (substances) that retain their own properties
moulding:	a process that involves melting a substance and then pouring it into a specially shaped hollow container (mould) that will give it that particular shape when it cools down and returns to the solid state; clay can also be moulded
neutral substance:	a substance that is*neither* acidic *nor* basic
neutralise:	to make something chemically neutral
opaque:	something that we cannot see through is opaque; opaque is the opposite of transparent
Periodic Table:	a table in which the chemical elements are arranged in order of increasing atomic number
pigment:	a substance that gives colour to other materials
property:	a distinctive attribute, characteristic or quality (of a certain material)
residue:	the substances that are left behind in the filter after filtering
savoury:	refers to salty or spicy food (not sweet)
semi-conductor:	a material that conducts electricity only under special conditions, for instance at very low temperatures
semi-metal:	an element that has properties of both metals and non-metals
sense:	to become aware of something (specifically through our sense organs, e.g. by smelling tasting, feeling, hearing or seeing something)
sieve:	a device with small holes through which finer particles of a mixture may be passed to separate them from coarser ones
solute:	the substance that is dissolved in a solvent to make a solution, for example sugar (solute) dissolved in water (solvent)
solution:	when a solid, liquid or gas dissolves in a liquid, we call the resulting mixture a solution; a mixture that has no cloudiness
solvent:	the substance that the solute is dissolved in to make a solution
soot and ash:	small particles of burnt material that are the solid components in smoke
still:	the apparatus used for distillation
suspension:	a mixture in which the tiny clumps and pieces are mixed in a liquid but they are undissolved; all suspensions are milky/cloudy in appearance
symbol (or element symbol):	a unique letter (or letters) that represents a given element
taste buds:	taste buds are very small structures contained within papillae on the surface of the tongue responsible for taste
temperature:	a measurement of how hot or cold something is

thermometer:	a device for measuring the temperature of an object or a material
tongue map:	a map of the human tongue, showing which areas on the tongue are sensitive to which flavours; some scientists do not believe that the 'tongue map' is accurate

Here is your chance to discover the possibilities. What else can this beaker be?

A Assessment rubrics

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 understand-ing of the investigation	Some understand-ing of the investigation	Understands the investigation	Insightful understand-ing 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

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