Natural Sciences

Grade 9-A (CAPS)

sasol
reaching new frontiers

EXPLORE

A World Without Boundaries

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

Periodic Table of the Elements

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

No
Element

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

Natural Sciences

Grade 9-A

CAPS

developed by

SIYAVULA
TECHNOLOGY-POWERED LEARNING

funded by

sasol inzalo foundation

Developed and funded as an ongoing project by the Sasol Inzalo Foundation in partnership with Siyavula and volunteers.

Distributed by the Department of Basic Education

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.

Siyavula Coordinator and Editor
Megan Beckett

Siyavula Team
Ewald Zietsman, Bridget Nash, Melanie Hay, Delita Otto, Marthélize Tredoux, Luke Kannemeyer, Dr Mark Horner, Neels van der Westhuizen

Contributors
Dr Karen Wallace, Dr Nicola Loaring, Isabel Tarling, Sarah Niss, René Toerien, Rose Thomas, Novosti Buta, Dr Bernard Heyns, Dr Colleen Henning, Dr Sarah Blyth, Dr Thalassa Matthews, Brandt Botes, Daniël du Plessis, Johann Myburgh, Brice Reignier, Marvin Reimer, Corene Myburgh, Dr Maritha le Roux, Dr Francois Toerien, Martli Greyvenstein, Elsabe Kruger, Elizabeth Barnard, Irma van der Vyver, Nonna Weideman, Annatjie Linnenkamp, Hendrine Krieg, Liz Smit, Evelyn Visage, Laetitia Bedeker, Wetsie Visser, Rhoda van Schalkwyk, Suzanne Grové, Peter Moodie, Dr Sahal Yacoob, Siyalo Qanya, Sam Faso, Miriam Makhene, Kabelo Maletsoa, Lesego Matshane, Nokuthula Mpanza, Brenda Samuel, MTV Selogiloe, Boitumelo Sihlangu, Mbuzeli Tyawana, Dr Sello Rapule, Andrea Motto, Dr Rufus Wesi

Volunteers
Iesrafeel Abbas, Shireen Amien, Bianca Amos Brown, Dr Eric Banda, Dr Christopher Barnett, Prof Ilsa Basson, Mariaan Bester, Jennifer de Beyer, Mark Carolissen, Tarisai Chanetsa, Ashley Chetty, Lizzy Chivaka, Mari Clark, Dr Marna S Costanzo, Dr Andrew Craig, Dawn Crawford, Rosemary Dally, Ann Donald, Dr Philip Fourie, Shamin Garib, Sanette Gildenhuys, Natelie Gower-Winter, Isabel Grinwis, Kirsten Hay, Pierre van Heerden, Dr Fritha Hennessy, Dr Colleen Henning, Grant Hillebrand, Beryl Hook, Cameron Hutchison, Mike Kendrick, Paul Kennedy, Dr Setshaba David Khanye, Melissa Kistner, James Klatzow, Andrea Koch, Grove Koch, Paul van Koersveld, Dr Kevin Lobb, Dr Erica Makings, Adriana Marais, Dowelani Mashuvhamele, Modisaemang Molusi, Glen Morris, Talitha Mostert, Christopher Muller, Norman Muvoti, Vernusha Naidoo, Dr Hlumani Ndlovu, Godwell Nhema, Edison Nyamayaro, Nkululeko Nyangiwe, Tony Nzundu, Alison Page, Firoza Patel, Koebraa Peters, Seth Phatoli, Swasthi Pillay, Siyalo Qanya, Tshimangadzo Rakhuhu, Bharati Ratanjee, Robert Reddick, Adam Reynolds, Matthew Ridgway, William Robinson, Dr Marian Ross, Lelani Roux, Nicola Scriven, Dr Ryman Shoko, Natalie Smith, Antonette Tonkie, Alida Venter, Christie Viljoen, Daan Visage, Evelyn Visage, Dr Sahal Yacoob

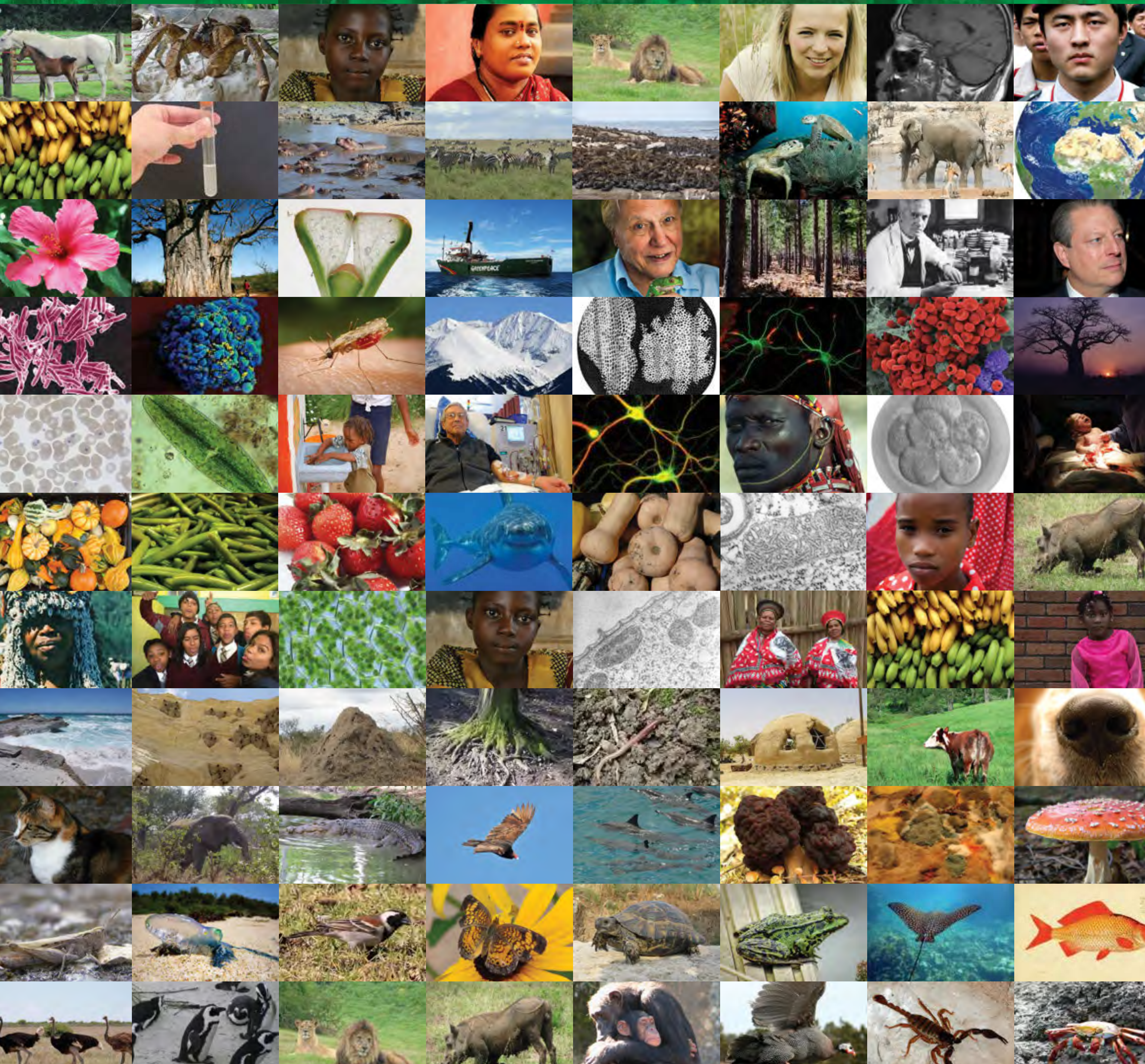
A special thanks goes to St John's College in Johannesburg for hosting the first planning workshop for these workbooks and to Pinelands High School in Cape Town for the use of their school grounds for photography.

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

www.sasolinzalofoundation.org.za

Table of Contents

LIFE AND LIVING



1 Cells as the basic units of life

KEY QUESTIONS:

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

In this chapter we will learn about the basic units of life which enable all of functions within living organisms - cells.

NEW WORDS

- cell
- cytoplasm
- eukaryote
- membrane
- microscope
- microscopic
- nucleus
- organism
- prokaryote

1.1 Cell structure

What are cells?

All living **organisms**, including plants, animals, bacteria and fungi, are made up of **cells**. Cells are the smallest parts of all living organisms.

If we look at all the living organisms in the world we see that there are two main types of organisms based on the structures of their cells. The most important difference in structure is the presence of a **nucleus**. Cells that contain a nucleus are classified as **eukaryotic** cells, while those without a nucleus are **prokaryotic** cells. In this chapter we will specifically look at eukaryotic cells that make up organisms such as plants and animals. Examples of organisms with prokaryotic cells are bacteria.

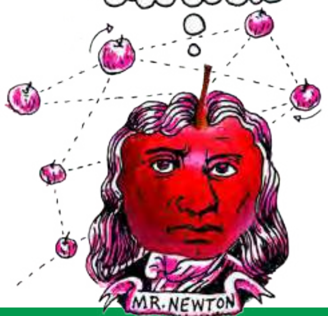
We can say that cells are the basic *structural* and *functional* units of all living organisms. You cannot see individual cells with the naked eye, because they are too small - you need to use a **microscope** to be able to see cells. We say cells are **microscopic** because they can only be seen under a microscope.

Robert Hooke (1635 - 1703)

Robert Hooke was the first cytologist to identify cells under his microscope in 1665. He decided to call the microscopic shapes that he saw in a slice of cork *"cells"* because the shapes reminded him of the cells (rooms) that the monks in the nearby monastery lived in.

DID YOU KNOW?

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



ACTIVITY: Brainstorm the Seven Functions of Life

Do you remember the test you learnt about in previous grades to decide whether an organism is living or non-living? Perhaps you had an mnemonic to remember the seven processes, such as "MRS GREN".

1. Work in your group and see how many of the seven functions of life you can remember. Write them down below.

____

____

____

____

____

____

____

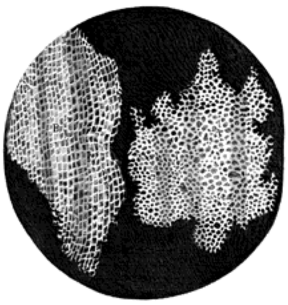
2. Do you think that an individual cell is living? Explain your answer.

____

____

TAKE NOTE

In this section you'll often read the prefix ***cyto-*** as in cytoplasm, cytosol or cytoskeleton. **Cyto-** means 'cell' so if you read cytoskeleton it actually says: '*cell-skeleton*'.



Robert Hooke was the first to use the term 'cell' when he studied thin slices of cork with a microscope.

Robert Hooke's microscope that he used to first view cells.

TAKE NOTE

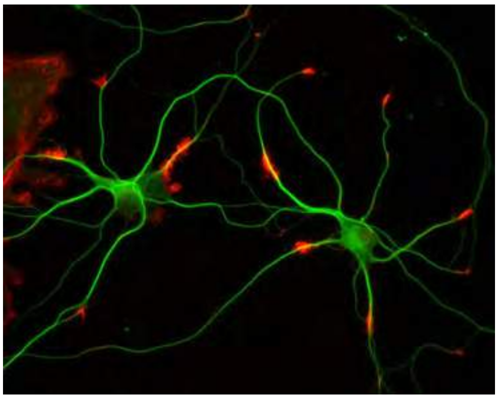
The **Visit** boxes in the margins contain links to interesting websites and videos. Simply type the link exactly as it is into the address bar in your browser.

Different types of cells

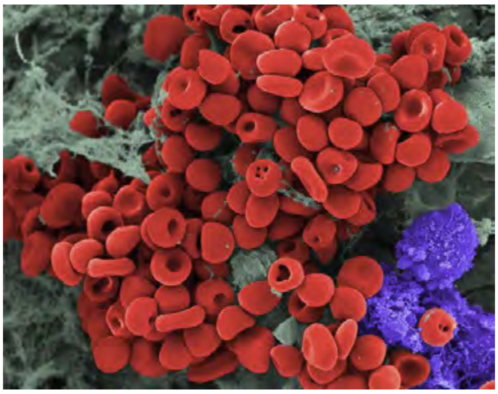
NEW WORDS

- carbon dioxide
- cell membrane
- cellular respiration
- DNA
- hereditary
- inherited
- medium
- mitochondria
- nuclear membrane
- nucleolus
- organelle
- oxygen
- protein
- selectively permeable
- specialised
- species
- vacuoles
- variation

Your body is made up of many different kinds of cells. We say your cells are **specialised** to perform a specific function. Depending on the function of the cell, it can be specialised by having a different shape or size or may have some components which other cells do not have. Have a look at the differences between nerve cells and red blood cells in the images.



These nerve cells appear green under a fluorescence microscope.



Red blood cells have a round, biconcave shape.

DID YOU KNOW?

We call the study of cells **cytology**, *cyto-* meaning 'cell' and *-logy* meaning 'study', while *-logist* refers to the person who does the studying.

The cytoplasm (cytosol and organelles) and the nucleus together is referred to as **protoplasm**.

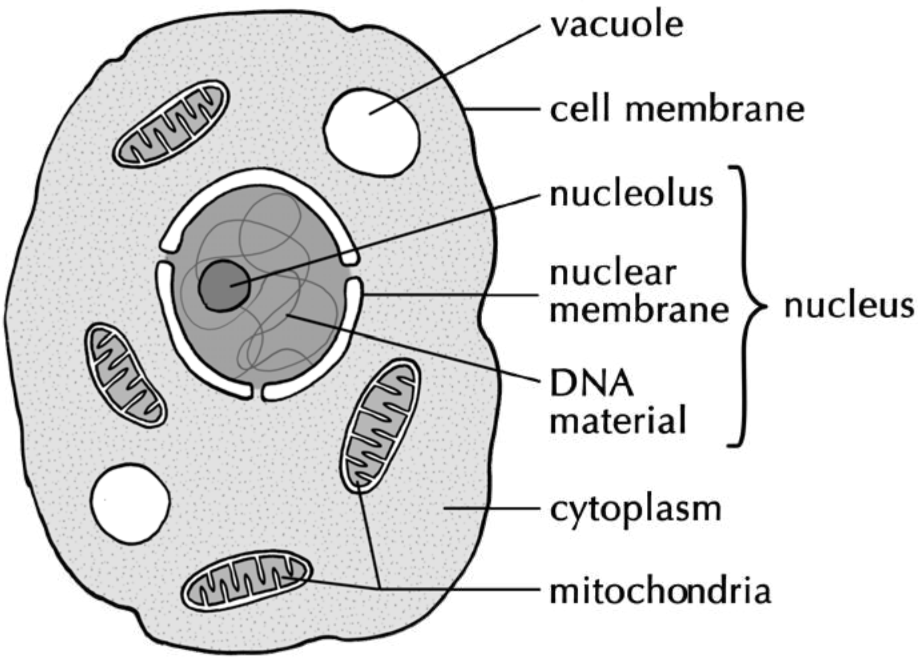
Even though there are many different types of cells, there are components of the cell structure which are common to all cells. There are also some structures which most, but not all, cells have. Let us take a look at this in the next section.

Cell Structure

As we have mentioned before, all cells have some common structures. These are:

- a **cell membrane**
- **cytoplasm**; and
- in most eukaryotic cells, a nucleus

Let's now have a look at the structure of these components of the cell, and some of the other organelles common to cells. An **organelle** is a specialised structure within the cell that performs a function for the cell. Examples of organelles in cells are **vacuoles** and **mitochondria**. Look at the diagram which identifies the different components in a simple animal cell.



A drawing of a typical animal cell

VISIT

Videos about the cell and cell organelles.
bit.ly/14k3Q5S and
bit.ly/19bsCKt

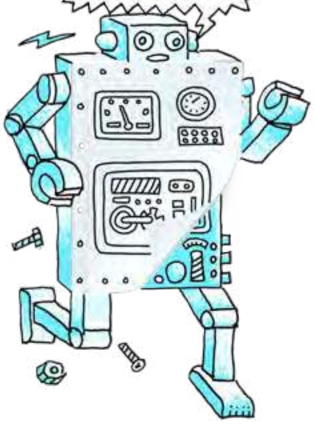
Cell membranes

All cells have a cell membrane around them. The cell membrane is a thin layer that encloses the cell's contents and separates the cell from its environment.

Many different substances have to pass in and out of a cell in order for it to function. The cell membrane controls which substances are allowed to enter and leave the cell. We say the cell membrane is **selectively permeable**. The organelles are also surrounded by membranes.

TAKE NOTE

If something is 'permeable', then it means that substances, such as gases and liquids, can pass through it freely.



Cytoplasm

The cytoplasm includes all living parts of the cell within the cell membrane, but excluding the nucleus. The cytoplasm is made up of the cytosol and the cell organelles. The cytosol is a watery, jelly-like medium made of 70%-90% water, and is usually colourless.

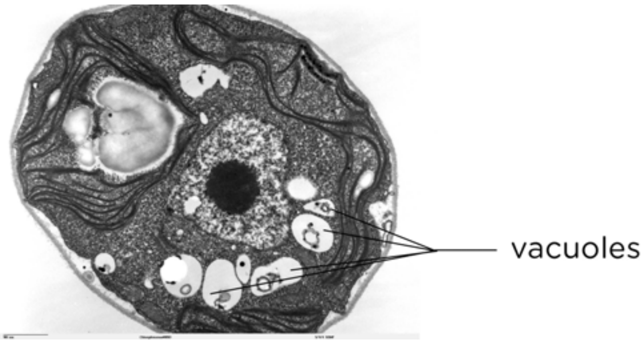
The cytosol is a mixture of different substances dissolved in water. Do you remember what a mixture is from Matter and Materials? These substances within the cytosol include salts, various elements, such as sodium and potassium, and more complex molecules, such as **proteins**.

The cytosol is also where many chemical reactions take place. Next term, in Matter and Materials, we will learn more about chemical reactions.

The cell organelles making up the cytoplasm include mitochondria, chloroplasts and vacuoles. Vacuoles are organelles enclosed by a membrane and contain mostly water with other molecules in solution. The size and number of vacuoles within a cell varies greatly and depends on the type and function of the cell.

TAKE NOTE

In Natural Sciences we speak of a **medium** when we talk about a solution in which organelles, cells or organs are grown or suspended. Can you think of other meanings for the word medium?



This is a micrograph of a plant cell. Can you see the clear, white organelles, which are the vacuoles? The cytoplasm appears very granular in this image.

TAKE NOTE

The difference between eukaryotic and prokaryotic cells is that eukaryotic cells have a nucleus which contains the genetic material surrounded by a membrane. Prokaryotic DNA floats in the cytoplasm without a membrane.

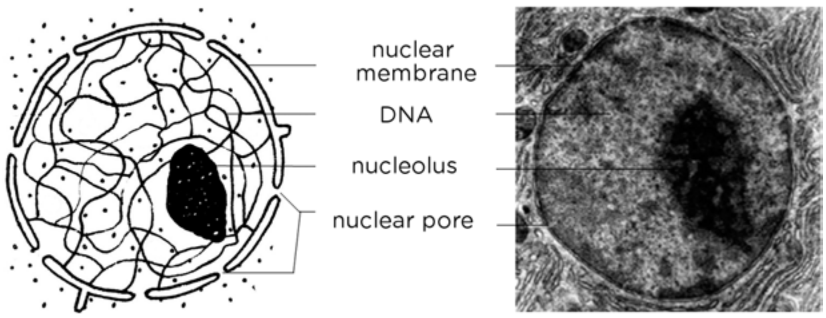
Nucleus

Plant and animal cells have a **nucleus** inside the cytoplasm. It controls all the processes and chemical reactions that take place inside the cell. The nucleus also contains the cell's genetic material which is organised into long **DNA** molecules.

The nucleus is structured as follows:

- A double membrane called the **nuclear membrane** encloses the DNA. This nuclear membrane contains pores (holes) for substances to pass through.
- There is a **nucleolus** inside the nucleus. This is often seen as a darker area within the nucleus.
- The DNA contains information about **inherited** characteristics (**hereditary**), such as whether the person will have blue, brown or green eyes.

Have a look at the micrograph of a nucleus and the diagram of the nucleus.



Left) A Diagram of a nucleus. Right) A micrograph of a cell nucleus.

DID YOU KNOW?

Identical twins come from the same fertilised egg which splits in two. They have the same DNA. However, they are not *exactly* the same due to environmental factors that can influence how they develop. Non-identical twins developed from two different eggs and two different sperm.

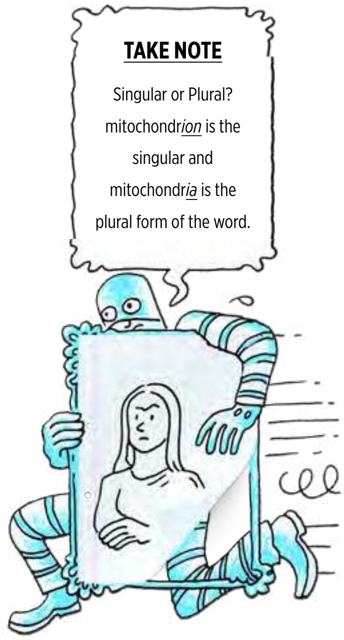
DNA is a very important part of all cells and therefore of all life. DNA contains information that encodes all our inherited traits or characteristics. This refers to characteristics which are passed down in families, such as your skin and eye colour, whether you have allergies and also the likelihood of contracting different types of illnesses.

Every organism has unique DNA. The difference in DNA that occurs between individuals is called **variation**. Even the slightest difference in DNA might cause significant variations within **species** and between species. Within species DNA differences or variations can lead to albino animals or the transference of similar illnesses, like sickle cell anemia.

An albino (white) lion lacks pigment due to an alteration in the lion's DNA.

Mitochondria

Do you remember that we spoke about food as the energy source for our bodies? Just as wood is burned to use the stored potential energy to make a fire to heat some water, the food that we eat needs to be broken down in order to release the energy so that our bodies can function. **Mitochondria** are responsible for doing this.



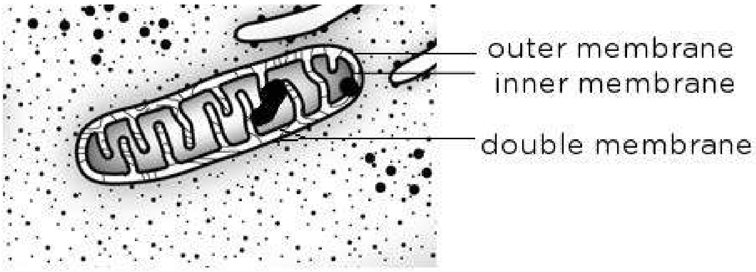
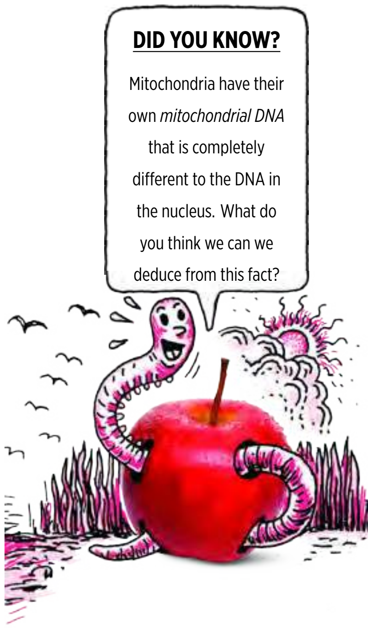
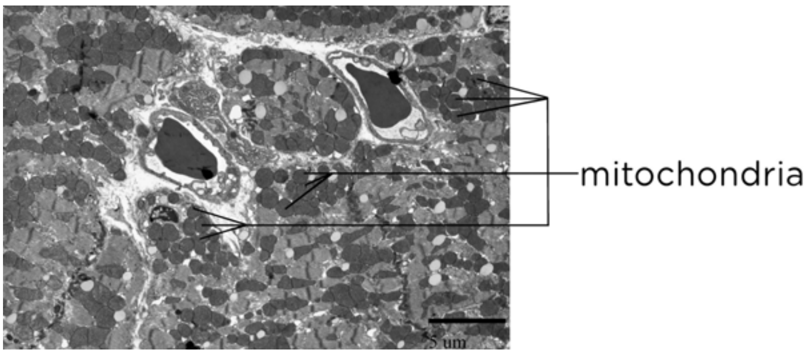


Diagram of a mitochondrion.

Mitochondria are organelles enclosed by a double membrane. Cells that are very active would typically have more mitochondria than cells that are less active. Which type of cell, do you think, will have more mitochondria: a muscle cell or a bone cell?





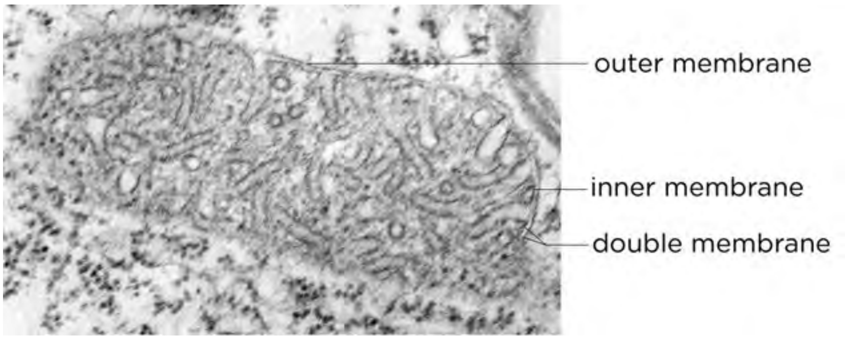
A micrograph of muscle tissue in a mouse. Can you see all the darker grey circles? These are mitochondria.

Once food molecules enter the cells and pass into the mitochondria, they are used by the mitochondria in a process called **cellular respiration**. During respiration the mitochondrion can combine molecules from food with **oxygen** to release energy that the cell can use. **Carbon dioxide**, water and waste materials are by-products of this process.

VISIT

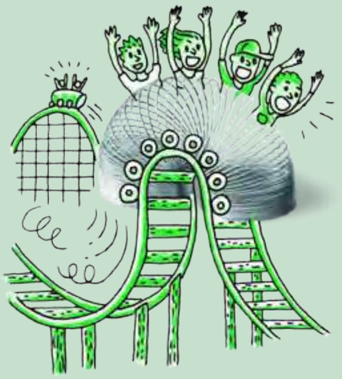
If you would like to find out how mitochondrial DNA (mtDNA) is responsible for 'old age', read this article by Dr Barry Starr from Stanford University

bit.ly/164z730



Micrograph of a mitochondrion within a cell.

Look at the micrograph of the mitochondrion in the image. What differences can you see between this mitochondrion and the diagram shown previously? In the diagram, it was very clear that the inner membrane folds, whereas in the micrograph it is not as easy to see this. This is because of the way that the cell was sectioned (cut) before it was viewed on the transmission electron microscope. In a diagram, we show an ideal representation of the organelle. But, when we view an actual organelle under a microscope, it may look quite different depending on how it was cut into a very thin section to view.



ACTIVITY: : Summarise what you have learnt

Now that you've studied the internal structure of a cell, let us summarise what we have learnt so far. Complete this table filling in the main function of each of the cell structures.

Cell Structure	**Function(s)**
Cell membrane	
Cytoplasm	
Nucleus	
Mitochondrion	
Vacuole	

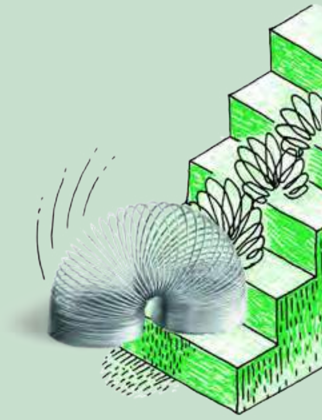
1.2 Difference between plant and animal cells

Now that we know what the main similarities are between all plant and animal cells, let's see how they are different.

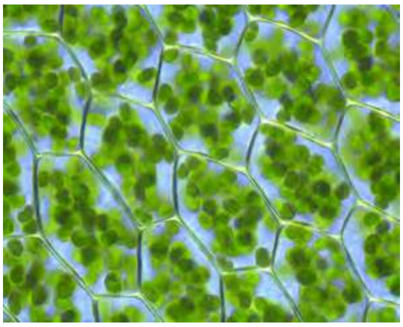
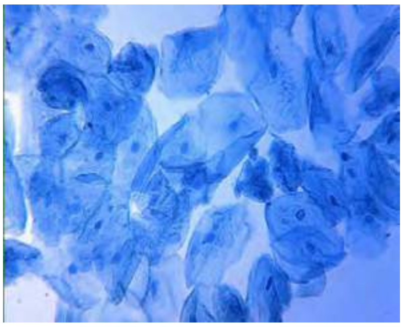
Plant cells differ from animal cells

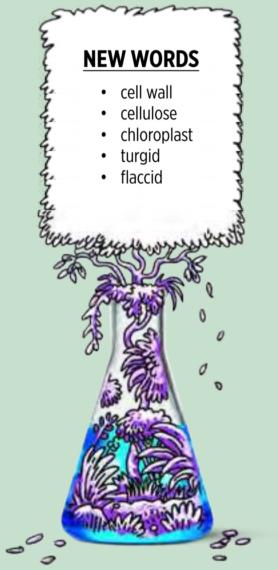
Why do plant and animal cells have differences? Plant and animal cells differ because they have to perform different functions.

ACTIVITY: Identify differences between plant and animal cells



1. Study the pictures below. On the left is a picture of plant cells and on the right is a picture of some animal cells, which have been stained blue.
2. Write differences that you observe in the table below the pictures of the cells.

Plant cells	Animal cells
	



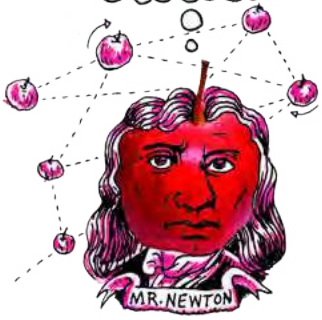
Cell wall

All animal and plant cells are enclosed or surrounded by a cell membrane as we learned before. However, as you probably noticed in the previous activity, animal cells often have an irregular shape, whereas plant cells have a much more regular, rigid shape.

Plant cells have an additional layer surrounding the cell on the outside of the cell

DID YOU KNOW?

Other organisms also have cell walls, like bacteria or fungi, but in these organisms their cell walls are not the same as plant cell walls. Only plant cells are made of cellulose.



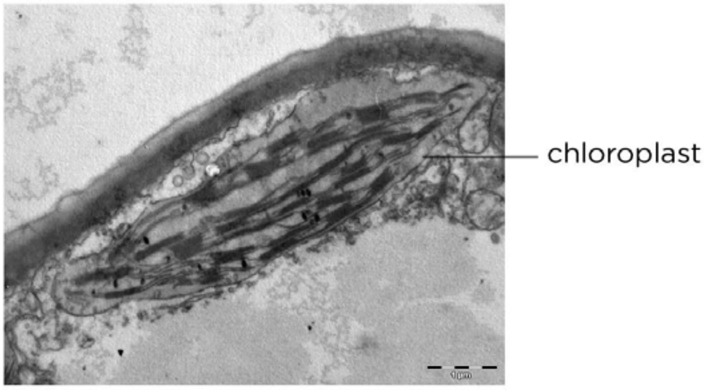
membrane. This is called the **cell wall**. This wall provides a protective framework for support and stability for the plant cell.

The cell wall is formed from various compounds, the main one being **cellulose**. Cellulose helps maintain the shape of the plant cell. This allows the plant to remain rigid and upright even if it grows to great heights.

Chloroplasts

You might remember learning about photosynthesis in previous grades. Can you still remember why photosynthesis is so important to all life on earth?

Did you notice the green organelles present in plant cells which were not there in the animal cells in the previous activity? These are **chloroplasts**. Chloroplasts are the only cell organelles that can produce food from the sun's energy. Only plants with chloroplasts are able to photosynthesise because they contain the very important green pigment, **chlorophyll.** Chlorophyll can absorb radiant energy from the sun and convert this to chemical energy that plants and animals can use. Animal cells lack chloroplasts and are not able to photosynthesise.



A large chloroplast next to the cell wall is visible in this section of a cell.

DID YOU KNOW?

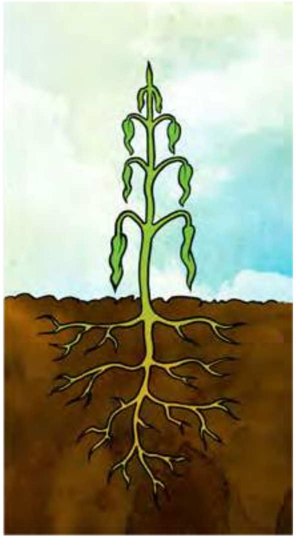
The sea slug, *Elysia chlorotica,* has evolved to take up the chloroplasts from the algae that it eats and incorporate them into its own cells where the chloroplasts function as if in a plant!

Vacuoles

Does a plant have a skeleton? Turn to a friend and discuss what could possibly be used in a plant cell as a skeleton. Think for example of a blade of grass or a long stemmed rose.

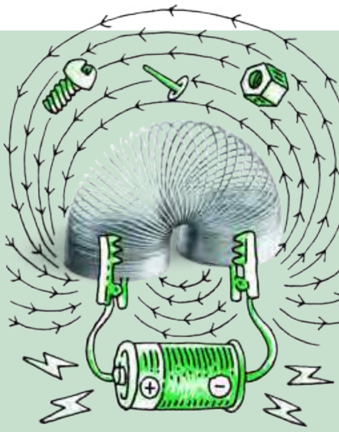
Vacuoles in plant cells are usually quite large organelles that can occupy as much as 90% of the cell's volume. The liquid in the vacuole, called cell sap, helps to support the plant. The full vacuoles push out against the cell wall and make the cells, and therefore the plant, rigid. We say the cells are **turgid** in this condition. The opposite to turgid is **flaccid**.

You can easily see when a plant's vacuoles are full and when they are not. When the vacuoles are full the plant's stem and leaves will be held upright and firm. However, if the leaves and stem are drooping, the vacuoles might have lost a lot of water because the soil is too dry and the cell was forced to use up this water to survive.



Left: A plant with turgid vacuoles is rigid and stands upright. Right: A plant with flaccid vacuoles droops (called wilting).

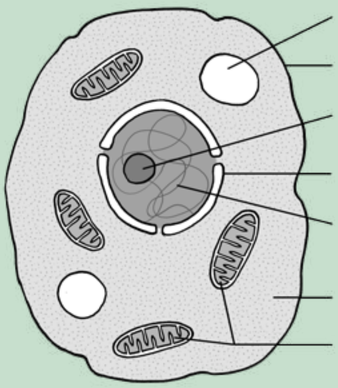
Vacuoles are only present in some animal cells and they are typically very small and have a short life-span.



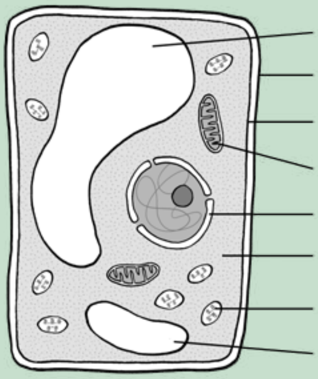
ACTIVITY: Comparing plant and animal cells

Study the two diagrams of plant and animal cells below.

1. Draw a table of differences between the two cell types in the space provided. Give your table a suitable heading.
2. Also provide labels for the different cell structures and organelles.



A typical animal cell.



A typical plant cell.

ACTIVITY: 3D model of a cell

In a 3D cell model, we will be making built models out of materials where we will use other objects to represent the actual parts of the cell.

INSTRUCTIONS :

1. You must create a 3D model of a cell.
2. You may use whatever materials or 'media' you choose to create your cell.
3. Your model must clearly show the following:
    - cell membrane
    - nucleus with nuclear membrane
    - cytoplasm
    - mitochondria
    - vacuoles
    - chloroplasts
    - Any other organelles that you might have learnt about

Requirements for your cell model:

- Your model and the examples of the organelles need to show some resemblance to the real organelle that we have learnt about so far.
- Your model needs to be clearly marked with a heading and your name.

- Each organelle needs to be clearly labelled and with each label you need to add a description of the function of that particular organelle.
- You also need to make an accompanying drawing (at least the size of an A4 page) including the labels of the structure of a basic plant and animal cell.
- Your teacher will assess your model according to a rubric.

1.3 Cells in tissues, organs and systems

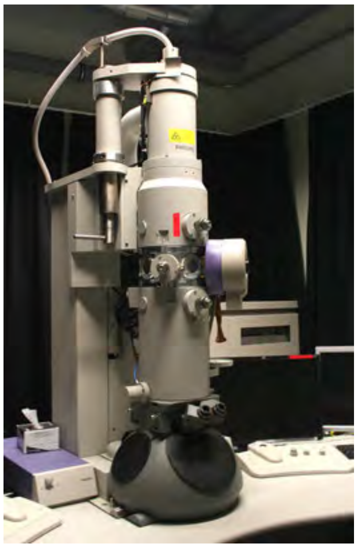
NEW WORDS

- multicellular organisms
- cover slip
- slide
- specimen
- unicellular
- wet mount

Now that you have learnt all about different cells, are you ready to see them for yourself?

Observing cells under a microscope

Have you ever used a microscope before? Microscopes are instruments that are used to look at and study objects that are too small to be seen with the naked eye. Since the days of Hooke's observations, the development of microscopes has come a long way. Today we have incredibly powerful microscopes called electron microscopes which use electrons instead of light to observe very fine detail - even as small as a single column of atoms!



A modern electron microscope

VISIT

Citizen science: Help out in cancer research from your own home!

bit.ly/16DCU45

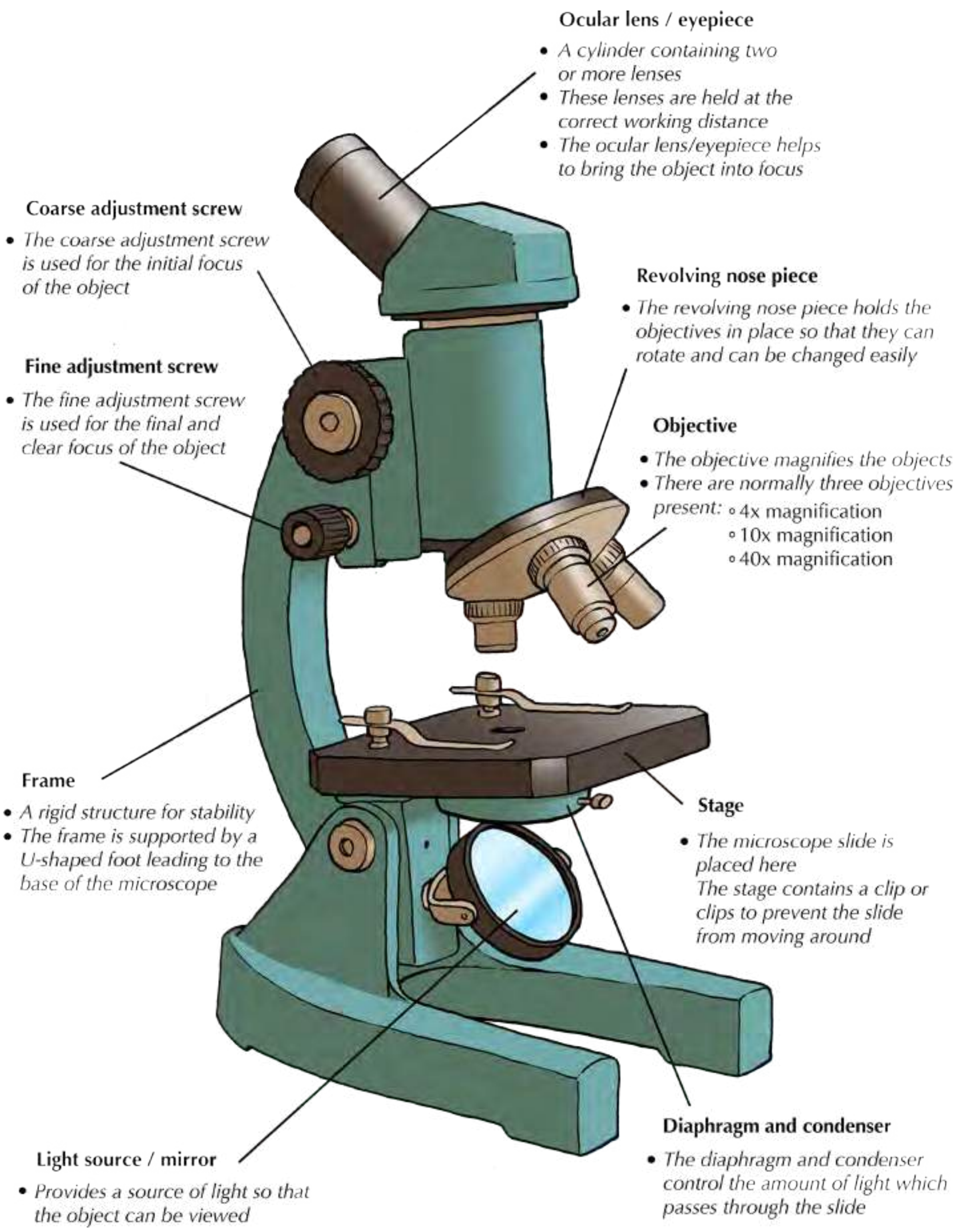
Before we start working with microscopes, let's have a look at the different parts of a basic light microscope and the safety precautions we need to follow when using these pieces of equipment.

A basic light microscope

A microscope allows you to see detail in specimens that you cannot see with the naked eye. The image you see needs to be:

- well lit with enough light provided to see the specimen
- well focused
- contrasted with its surroundings to clearly see details

The next image explains the different parts of a light microscope and what they are used for.



When you use a microscope, make sure to follow these safety precautions:

1. There is a special way to carry the microscope: one hand supports the base and the other holds the frame of the microscope.
2. Put it down on a stable, horizontal, clear counter.
3. Before using the microscope, clean the lenses with proper lens paper. Do not touch the lenses with your fingers! Make sure the stage and slides are clean.
4. When handling the slides, do not use broken or cracked slides and handle cover slips by the edges.
5. When focusing with the objectives:
    • Focus smoothly and slowly
    • Be careful with the objectives and do not scratch them
6. When you are done:
    • Always turn the lowest magnification objective into place before storing the microscope.

- Make sure that the stage and slides are clean before putting everything away.
- Always store the microscope in a box or covered with a dust jacket to avoid dust from settling on the lenses.

To view cells under a microscope, we need to make and prepare something called a **specimen** on a **slide**.

A specimen is a small part or slice, or an example of an organism that we want to examine. When we view a specimen under a microscope it needs to let light pass through the specimen so we can see it. Therefore we need to prepare the specimen and cut extremely thin slices of less than 0.5 mm. Specimens are then placed on a glass slide.

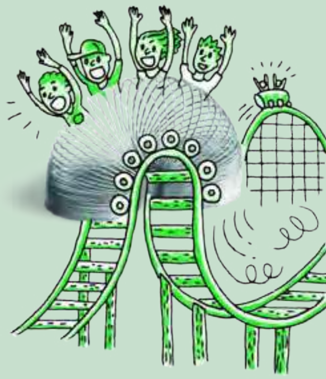
We can prepare samples or specimens on a slide using these different techniques:

- **wet mount** - good for observing living organisms and is especially used for aquatic samples
- **dry mount** - good for observing hair, feathers, pollen grains or dust
- **smears** are often made of blood or slime that is smeared over the slide and allowed to dry before observing them.
- **stains** are added to wet or dry mounts by dropping colouring chemicals onto the specimens, like iodine solution, methylene blue or crystal violet. We use staining to improve the colour contrasts on the slide.

DID YOU KNOW?

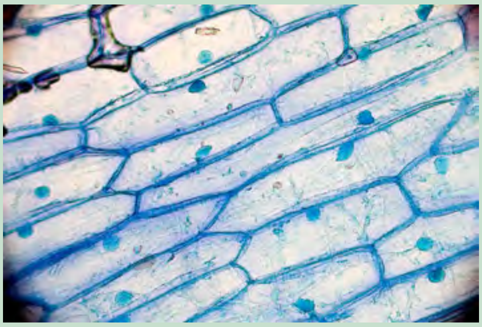
We can use water, brine (salt water), glycerine or immersion oil for wet mounts.

ACTIVITY: Evaluating microscopic images



INSTRUCTIONS:

1. Carefully study this image of onion cells that have been stained blue. Evaluate this image in terms of the focus, light and contrast visible in the photo.



____

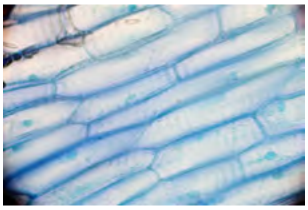
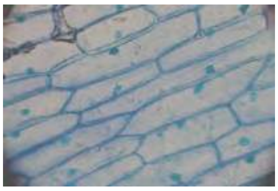
____

____

____

____

2. These same onion cells were viewed under a microscope which had not been adjusted properly and the following photos were taken. Identify what is wrong with the photograph compared to the one above.

Image	What is wrong with the image?	How could the image have been adjusted and corrected, using what part of the microscope?
		
		
		

ACTIVITY: Making a wet mount with onion and cheek cells

There is a very specific way to prepare slides for viewing under a microscope. You will use this technique very often in Life Sciences to study specimens.

MATERIALS:

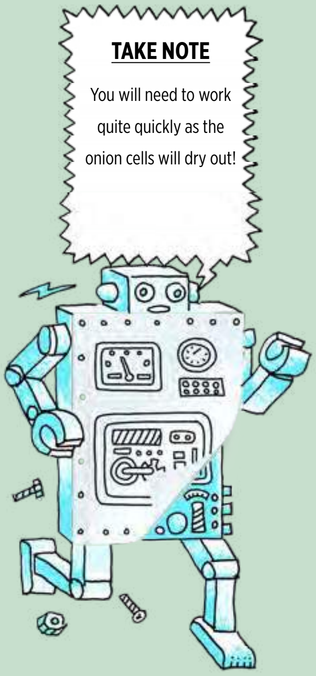
- onion
- scalpel or knife
- dissecting needle
- forceps
- microscope slides
- coverslips

- dropper
- tissue paper or filter paper
- distilled water
- iodine solution
- light microscope

INSTRUCTIONS:

Step 1: Prepare your microscope and slides as discussed in the safety methods above.
Step 2: Cut the onion into blocks of about 1 cm square with a sharp knife or scalpel.

Cutting the onion to expose the layers.



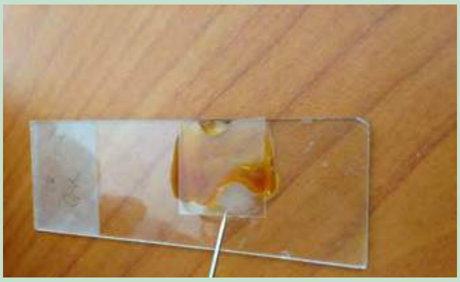
Step 3: Use forceps to pull or peel a small piece of the very thin membrane-like epidermis lining off one of the **inner** layers of the onion.

Carefully pulling the lining off the onion layer.

Step 4: Place a drop of iodine solution onto the slide.

Adding iodine solution to the slide.

Step 5: Place the membrane directly in the drop on the slide.



Step 6: Gently lower a coverslip at an angle onto the onion cells. Hold the coverslip up with a dissection needle and gently lower the slip. This prevents air bubbles from getting trapped under the cover slip.

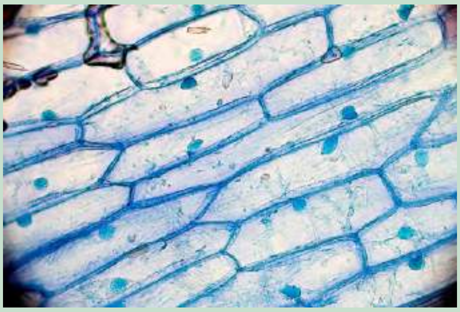
TAKE NOTE

If you accidentally trapped an air bubble, gently press on the middle of the coverslip to get rid of any trapped air using the dissecting needle or drop some extra fluid right next to the edge of the coverslip.

Step 7: Wipe off excess fluid around the edge of the coverslip with tissue paper or filter paper.
Step 8: Make sure the lowest power objective lens (this is the shortest lens) is in line with the eyepiece. Switch on the lamp or use the mirror to reflect the light onto your stage. Place the prepared slide onto the stage and secure it with the stage clips.

The slide secured on the microscope stage.

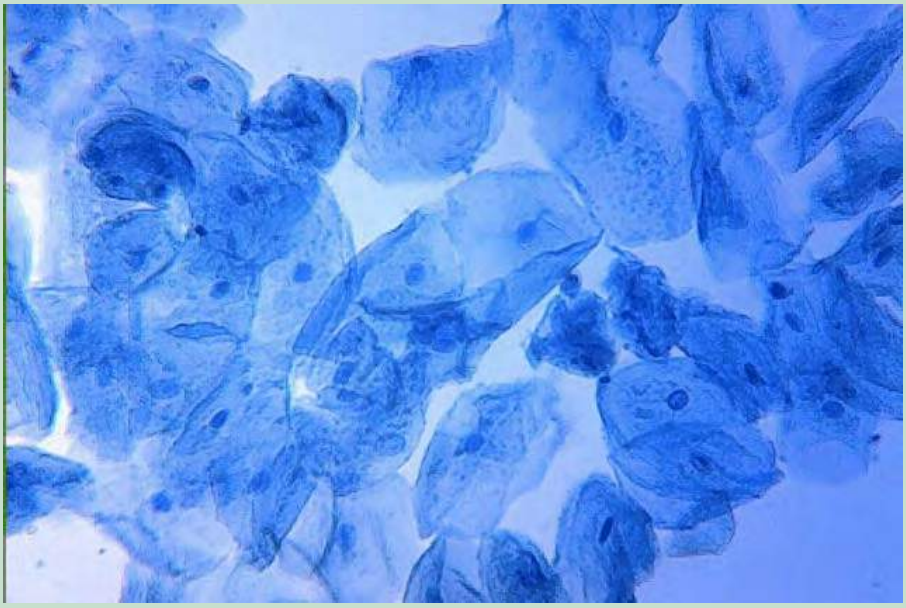
Step 9: While on the low power, look from the side and lower the objective lens to just above the coverslip. Then look through the eyepiece and use the fine focus to focus your image.
Step 10: Magnify your cells by swapping the objective lens to a higher powered lens. Only use the fine focus adjustment to focus clearly.
Step 11: Make careful drawings of your observations in the space below and remember to label what you see. Add a heading including the specimen, the stain used and the magnification.



Onion cells.

Now that you have prepared slides of onion cell specimens, use a toothpick to *gently* scrape the inside of your cheek to collect cheek cells using the side of the toothpick or ice cream stick. Follow the same instructions as above to prepare the cheek cell specimen and to view it under the microscope. Draw and label the cheek cells that you viewed under the microscope in the space below.

Did you see something like this?



Some cheek cells stained with methylene blue

1. What are some of the differences and similarities you noted between the animal and cheek cells?

ACTIVITY: Research the discovery of light and electron microscopes

The invention and improvement of microscopes has lead to incredible cellular discoveries (among others) in the last 400 years. Without microscopes, many of the microscopic organisms we know of today would never have been identified!

INSTRUCTIONS:

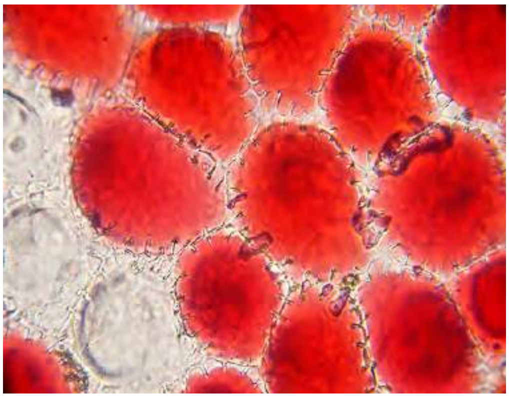
1. You can work individually or in groups for this task.
2. Research the history and discovery of the light and electron microscopes and how they are used today.
3. Design a brochure for the local Science museum where you tell visitors about the history of the development of microscopes.
4. Remember that a brochure must be informative, but not contain too much text.
5. Include some photographs or drawings.

Cells differ in shape and size

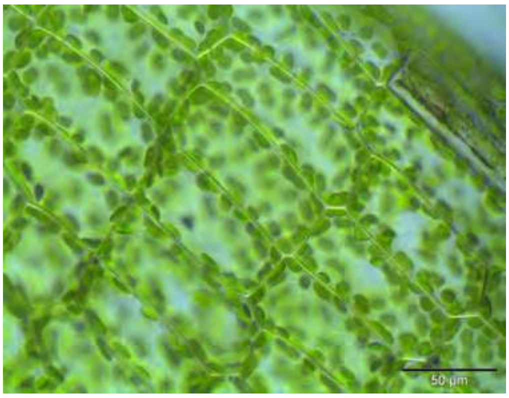
We looked at the basic differences between plant and animal cells. However, not all plant cells and not all animal cells are the same. Cells within an organism need to have different shapes and sizes because they fulfill different functions.

Look at the photo of the rose. Do you think the cells in the roots, stem, leaves, and petals of the rose all look the same?

The cells in the different parts of the rose all have to perform very specific functions and therefore have different sizes and shapes.



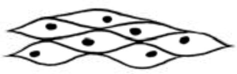
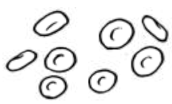
The rose's petals are red due to pigments in the vacuoles of the petal cells which are round.

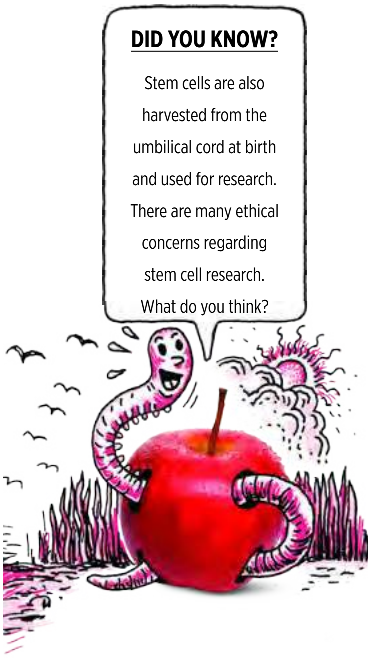


Cells in the leaves are full of chloroplasts for photosynthesis. They are long and rectangular in shape.

Your body contains a great number of **specialised** cells, meaning they have different functions. They have differences in their structures allowing them to have different functions. We say they have **differentiated**.

Do you remember we spoke about nerve cells and red blood cells briefly in the beginning of the chapter? Some of them are summarised in the following table.

Specialised cell	Structure	Function
Epithelial cells - they are mostly flat		They cover the surface of the body for protection.
Muscle cells - some are long and spindle shaped		Muscle cells can contract and relax allowing for movement within your body
Nerve cells - the are very long and have branched ends		Nerve cells are specialised to carry messages that coordinate the functions of the body.
Red blood cells - Round and biconcave shape		Red blood cells carry carry oxygen and carbon dioxide throughout the body.



Stem Cells

Stem cells are unspecialised cells which can divide and develop into many different types of specialised cells. Stem cells are quite amazing as they can divide and multiply while at the same time keeping their ability to develop into any other type of cell. Embryonic stem cells are the little ball of 50 -150 cells that forms 4-5 days after conception. Embryonic stem cells are very special as they can become absolutely any cell in the body, for example, blood cells, nerve cells, muscle cells or brain cells.

For this reason, scientists are using stem cells to conduct research. There are many benefits in doing this, but there are also many controversial and ethical issues surrounding stem cell research.

Are you curious about stem cell research? Find out more and discover the possibilities!

TAKE NOTE

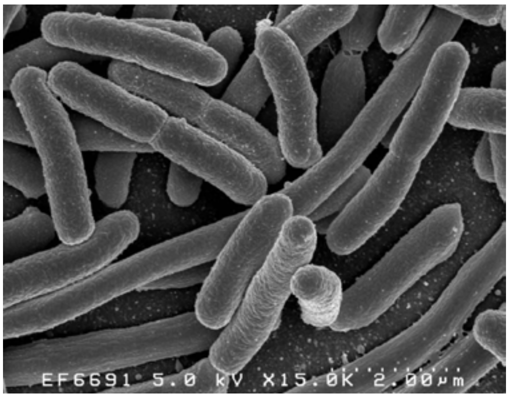
Microscopic and macroscopic describe whether an organism can be seen with the naked eye, while unicellular and multicellular refer to the number of cells an organism has.

Microscopic and Macroscopic organisms

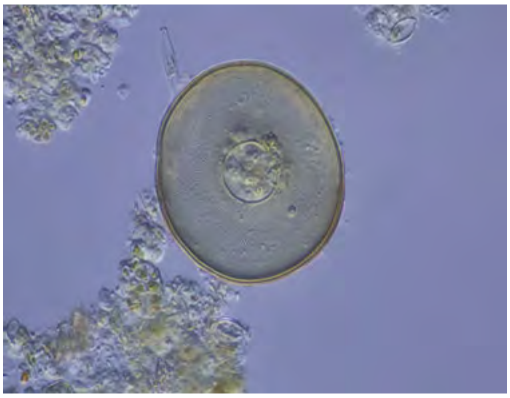
We have just looked at specialised cells within organisms. The organisms that we discussed, plants and animals, consist of many, many cells. Your body has millions of cells! Did you know that there are some organisms which consist of only a single cell? We have many different specialised cells to perform the different functions within our body whereas in a single-celled organism, all the functions it performs are done in this one cell. We can make a distinction between organisms that are made of one cell (**unicellula**r) and those that are made of many cells (**multicellula**r).

Microscopic organisms

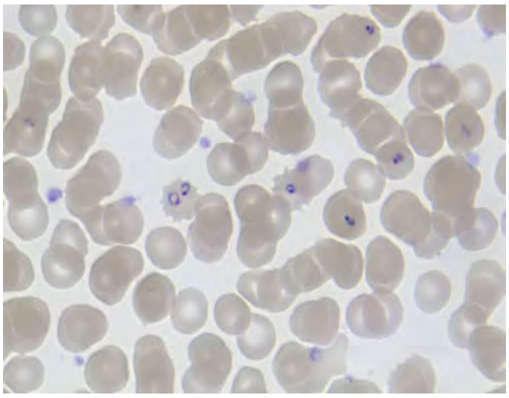
We call one cell organisms that can only be seen with the help of a microscope **microscopic organisms**. There are many single-celled microscopic organisms. Have a look at the images.



A group of Escherichia coli bacteria which are found in the intestines of many animals.



An amoebae which is a single cell organism that lives in water.



Red blood cells showing some which have been infected with malaria (purple dots).

A single-celled algae called a desmid.

Macroscopic organisms

In contrast to microscopic single-celled organisms, **macroscopic organisms** are visible to the naked eye and consist of many cells. Macroscopic organisms can have a few cells working together or trillions of cells that form larger organisms.

Organisation of cells in macroscopic organisms

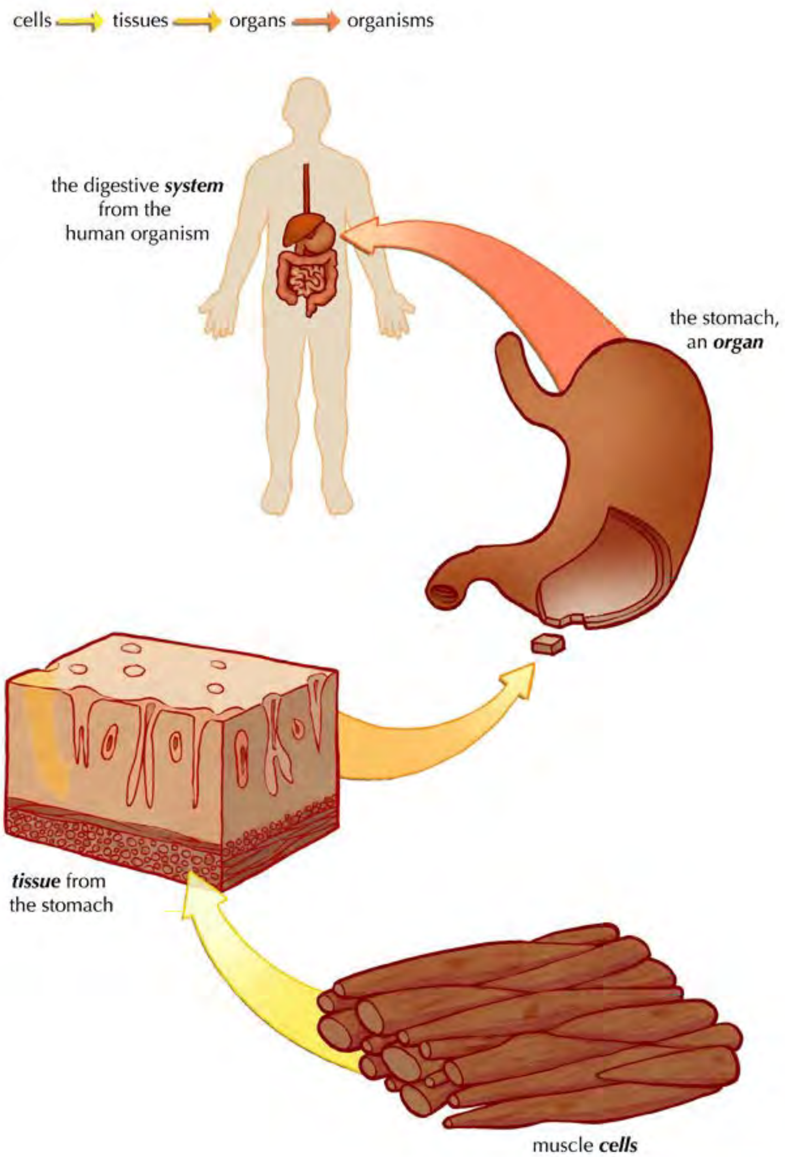
In microscopic single-celled organisms, the individual cell has to perform all the life processes for that microscopic organism.

So what about the cells in macroscopic organisms that consist of many cells? We have already learnt about specialised cells in macroscopic organisms, so we know that not all cells perform all the processes - they are specialised to perform a specific function.

Specialised cells that perform a specific function, group together to form a **tissue**. For example, muscle cells will group together to form muscle tissue, epithelial cells will group together to form the skin, and nerve cells will group together to form the brain and nerves.

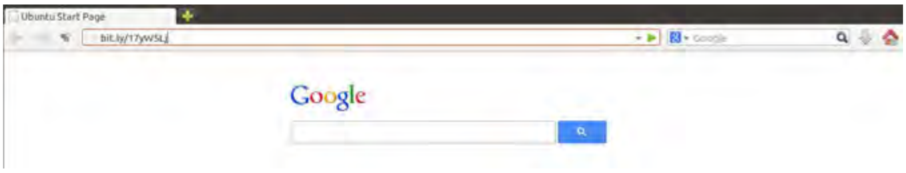
Groups of tissues that work together form **organs**. Think of the stomach for example - it is made of many different specialised cells that form muscle tissue to make it contract and epithelial tissue (made from specialised epithelial cells) which lines the inside of the stomach and produces mucus.

When organs work together we say they form **systems** or **organ systems**. There are many different systems in your body where specific organs work closely together to make your body function. Have a look at the following diagram which shows how cells are organised into tissues in the stomach which form part of the digestive system in a human (the organism).



All the systems work together to form an **organism**. We will be looking at some of these systems later on in the term.

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

- Cells are the basic structural and functional units of all living organisms.
- Cells are microscopic and can only be seen under a microscope.
- Plant and animal cells have cell membranes, cytoplasm, a nucleus and organelles such as mitochondria and sometimes vacuoles.
- The cell membrane encloses the contents of the cell and separates it from its environment.
- Cell membranes are selectively permeable, which means they only allow certain substances to pass into and out of the cell.
- The cytoplasm includes the organelles and the cytosol. The cytosol is the jelly-like medium in which many chemical reactions take place in the cell. Everything inside the cell membrane, except the nucleus, is considered the cytoplasm.
- The nucleus in eukaryotic cells is enclosed by a nuclear membrane and contains the DNA.
- DNA contains inherited characteristics of an organism and controls the cell's activities. It is unique to each organism, resulting in variation within a species.
- Mitochondria are responsible for cellular respiration, which is the release of energy from food.
- Plant cells have a cell wall around the cell membrane that is rigid and provides support and protection of the cell's content.
- Plants have chloroplasts with the pigment chlorophyll to photosynthesise and produce glucose.
- Plant cells also have large vacuoles to store water and glucose, and to provide support for the plant.
- Vacuoles in animal cells are temporary (or absent) and much smaller.
- Cells come in many different shapes and sizes.
- Stem cells are cells that have the ability to divide and develop into many different cell types.
- Microscopic organisms can only be seen under a microscope. All single-celled organisms, such as bacteria, are microscopic. However, some multicellular organisms such as dust mites are also too small to see with the naked eye.
- Macroscopic organisms consist of many cells and can be seen with the naked eye.
- Specialised cells perform special functions. Specialised cells that work together to perform a specific function form a tissue.
- A group of different tissues makes up an organ.
- Organs working together in groups form systems or organ systems.
- Organ systems make up an organism, such as a human,

Concept Map

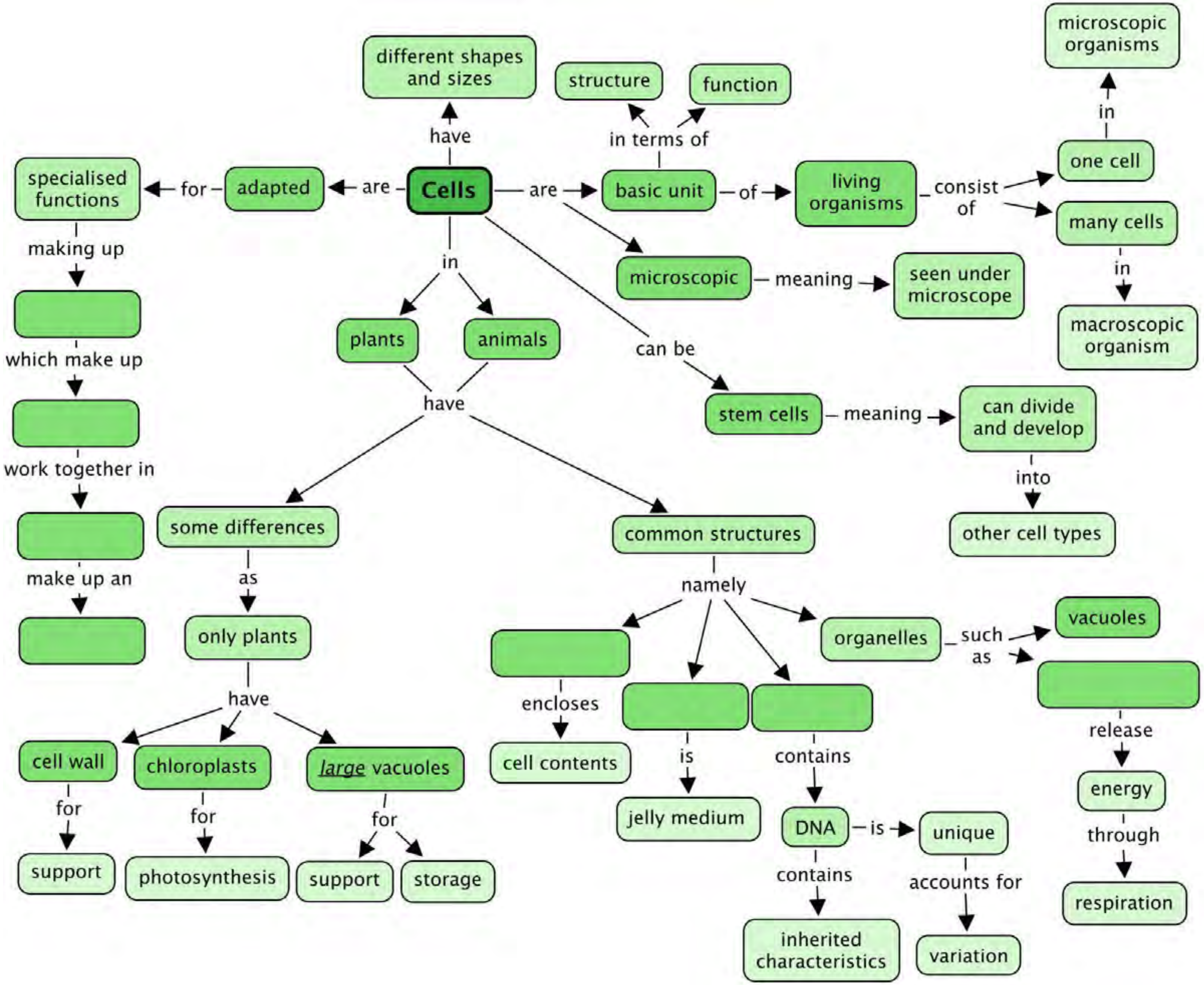
This year in Natural Sciences, we are going to learn more about how to make our own concept maps.

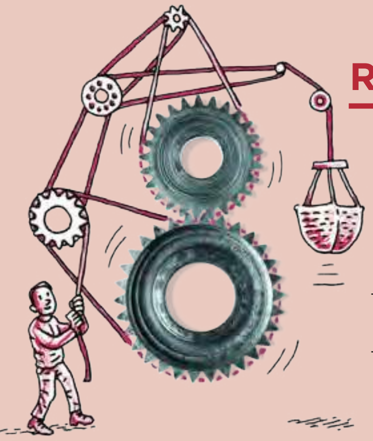
In the summary, we first have the "Key concepts" for this chapter. This is a written summary and the information from this chapter is summarised using words. We can also create a concept map of this chapter which is a map of how all the concepts (ideas and topics) in this chapter fit together and are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

Different people like to learn and study in different ways; some people like to make written summaries, whilst others like to draw their own concept maps when studying and learning. These are useful skills to have, especially for later in high school and after school!

Have a look at the concept map which shows what we have learned about the cell in this chapter and how these concepts link together. Can you see how the arrows show the direction in which you must "read" the concept map?

There are some empty spaces in the concept map that you need to fill in. For example, some of the common structures in cells have been left out. You need to look at the concepts linking from these bubbles to work out which structure goes where. For example, what structure in a cell encloses the cell contents? Write the answer in the correct space. On the left hand side of the concept map there are also empty spaces - can you see that this describes the hierarchy of how cells are organised into tissues, which are organised into organs, and so on? Fill in each level of organisation into the spaces.


Cells
have
different shapes and sizes
are
basic unit
in terms of
structure
function
of
living organisms
consist of
one cell
in
microscopic organisms
many cells
in
macroscopic organism
microscopic
meaning
seen under microscope
can be
stem cells
meaning
can divide and develop
into
other cell types
are
adapted
for
specialised functions
making up
which make up
work together in
make up an
in
plants
animals
have
some differences
as
only plants
have
cell wall
for
support
chloroplasts
for
photosynthesis
large vacuoles
for
support
storage
common structures
namely
encloses
cell contents
is
jelly medium
contains
DNA
is
unique
accounts for
variation
contains
inherited characteristics
organelles
such as
vacuoles
release
energy
through
respiration



REVISION:

1. Why would you say cells are considered to be the smallest unit of life? [2 marks]

2. Explain what **selectively permeable** means when referring to the cell membrane. [1 mark]

3. Eukaryotic and prokaryotic cells differ. What is the main difference between these two types of cells? [2 marks]

4. What is the main function of the nucleus and what is the function of the DNA? [2 marks]

5. When a Gr. 9 learner labelled one of the cell organelles 'Powerhouse', their teacher marked it wrong. What should the learner rather have written? [1 mark]

6. A plant and an animal cell are similar in some ways yet very different in others. Compare the two types of cells in a paragraph. [10 marks]

7. Make two drawings to show the differences between plant and animal cells using the examples of plant and animal cells you studied under the microscope. Follow the drawing guidelines for making scientific drawings. [10 marks]

8. There are different types of specialised cells and tissues in plants and animals that perform different functions. Match each function to the corresponding tissue. [3 marks]

Smooth muscle tissue	receives and sends messages and helps the body respond to stimuli
Nerve cell	carry oxygen around the body in mammals
Red blood cells	contracts and enables movement

9. Use words from this box to complete the sentences below. Write the sentences out in full. [4 marks]

- organs
- tissues
- organ systems
- specialised cells

Macroscopic organisms consist of many different _______________ that are made of individual _______________ that work together in a very particular way. These are formed from _______________that are in turned created when groups of _______________ function together in a specific way.

____

____

____

____

____

____

Total [35 marks]

Here is your chance to discover the possibilities. What can this apple become?

2 Systems in the human body

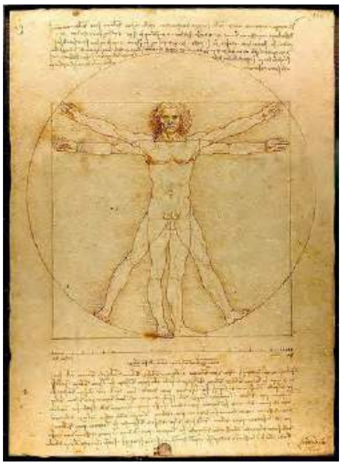
KEY QUESTIONS:

- How does the body do the things it does, such as breathe, move and think?
- What happens when one of the systems in our bodies does not work properly and has a 'system error'?
- Is it possible to prevent ourselves from getting sick?
- How can you best look after your body?

The human body has been studied by artists and scientists, mechanical engineers and medical practitioners throughout history. The mechanical beauty and operation of each and every part in the human body has fascinated human beings throughout history. Be curious and get ready to be fascinated!

NEW WORDS

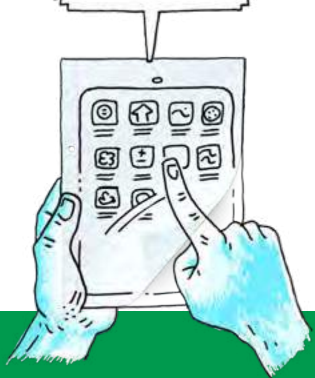
- integrate



Leonardo da Vinci did many drawings and studies of the human body in the 1400's, such as this one called the 'Vitruvian Man.'

TAKE NOTE

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



Body systems

The human body consists of several integrated systems that must work together for the body to function as a whole.

In the following pages we'll study seven of the main organ systems in our bodies. At the end of each organ system you will need to make a summary of that organ system to show:

- the main purpose or function of the system in the body;
- the main processes that take place in the system;
- the main components (organs) that make up the system; and
- the main health issues that relate to that particular system.

Therefore pay close attention and make notes as you study each organ system to help you with your summary.

ACTIVITY: Research and writing about health issues

INSTRUCTIONS:

1. You are going to learn about many of the health issues related to each of the different systems. Choose one of these health issues to research.
2. You will need to:
    a) Consult at least 3 different resources to find out more about that particular health issue.
    b) Suggest ways that this health issue may be prevented (if this is possible).
    c) Suggest treatment for the health issue in question.
3. Present your findings on an A3 poster as part of an oral presentation (of 3 - 4 minutes) to the class.

2.1 The digestive system

NEW WORDS

- absorption
- alimentary canal
- carbohydrates
- digestion
- dissolve
- fats
- glucose
- minerals
- nutrients
- protein
- transport
- vitamins

Our cells need **protein**, **carbohydrates**, **fats**, **vitamins** and **minerals** to function. Yet we eat large pieces of food that are too big to pass through the selectively permeable cell membranes. So how does the food we eat eventually get to our cells in a small enough form to be absorbed?

Purpose of the digestive system

Our digestive system is responsible for breaking down the food that we eat into small particles that can be **absorbed** into the bloodstream. They are then **transported** to the cells throughout our body.

The digestive system is made up of the different parts of the **alimentary canal**. This canal is a long, twisting pipe-like structure (about 9 meters in total) that starts at the mouth and ends at the anus. Along the way the food is broken down from chunks into molecules small enough to pass through cell membranes and supply energy to cells.

Main processes in the digestive system

DID YOU KNOW?

Our digestive system is sometimes also referred to as the *gastrointestinal tract*, the *digestive tract* or *alimentary canal*.

There are four main processes that occur in the digestive system at different parts along the alimentary canal. They are:

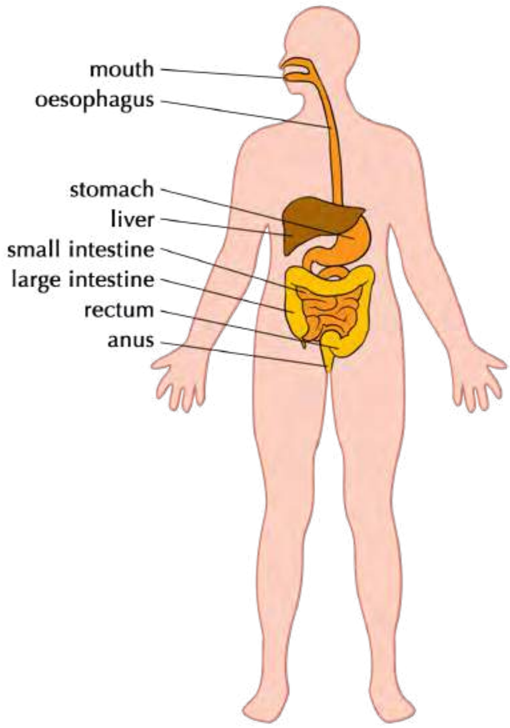
- **Ingestion**: This occurs when you take food into your body through your mouth by eating or drinking it.
- **Digestion**: This is the process of breaking down large food pieces into particles that are small enough to be absorbed and pass through cell membranes.
- **Absorption:** This is when the digested particles move into the cells of the digestive tract (they are absorbed) and move to the bloodstream from where they are carried to all the cells in the body.
- **Egestion**: Any undigested or unwanted particles that travel through the digestive tract are later passed out as faeces. This process is known as egestion.

NEW WORDS

- anus
- chemical digestion
- egestion
- faeces
- fibre
- ingestion
- jaundice
- metabolic
- saliva
- small intestine
- stomach
- ulcer

Components of the digestive system

Have a look at the following diagram which gives an overview of the different parts making up the digestive system.



DID YOU KNOW?

Bacteria that live in the large intestine produce Vitamin K and some Vitamin B.

1. The mouth and oesophagus

Digestion starts in the mouth as food is chewed and mixed with saliva. It then travels down the oesophagus when you swallow.

2. Stomach

The chewed food enters the stomach and is further digested. The stomach has substances called enzymes to help digest the food. The stomach also contracts to break the food down further into a liquid.

3. Small intestine

Most of the digestion takes place in the small intestine. Absorption of the food particles also takes place in the small intestine.

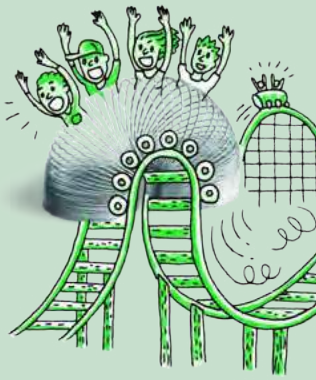
4. Large intestine (or colon)

By the time the food reaches the large intestine, most of the nutrients have been absorbed. What is left is water, salts and indigestible fibre. The water that is left is absorbed in the large intestine.

5. Rectum and Anus

The remaining substances (called faeces) are passed into the rectum and then out through the anus. This is called egestion.

ACTIVITY: Flow diagram of the digestive system



Flow diagrams are diagrams that show how the different sets of a process fit together in a sequence. They show the direction (flow) by using arrows. These are important tools to help you think about processes in Science.

INSTRUCTIONS:

1. Draw a flow diagram to represent the passage of food from the time it is taken into the body to the time it is egested from the body.

1. The blocks must show the main components involved in digestion, listed in order with arrows in between. Under each component include the main processes that occur at each of these stages.

TAKE NOTE

There is a difference between egestion and excretion. Egestion is when undigested particles are passed out as faeces. Excretion is when the body gets rid of metabolic waste formed from chemical reactions taking place in the body.

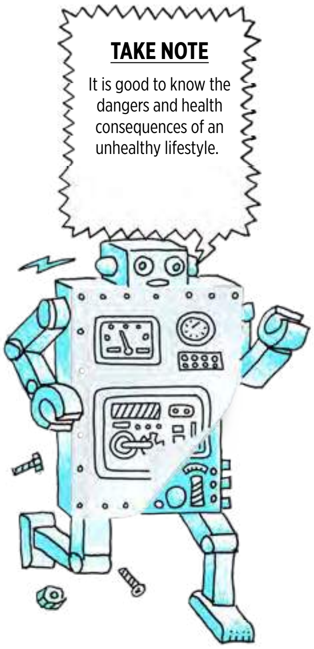
Health issues involving the digestive system

Common diseases of the digestive system include :

Ulcers: Sometimes open sores or ulcers develop on the lining of the mouth, oesophagus, stomach or upper portions of the small intestine. Ulcers can be very painful. They are generally caused by bacterial infections and some medications.

Anorexia nervosa: This is one of many eating disorders. People who suffer from this eating disorder have an abnormal fear of gaining weight and therefore starve themselves on purpose. This can lead to many health issues such as bone thinning, kidney damage, heart problems and even death.

Diarrhoea: Someone who passes very frequent, loose, watery stools has diarrhoea. Many diseases cause undigested food to pass through the large intestines too quickly for water to be absorbed and cause diarrhoea.



Do not forget to wash your hands with lots of soap and water!

Liver cirrhosis: This disease slowly replaces healthy liver tissue with scar tissue and eventually prevents the liver from functioning properly. Alcohol abuse and fatty liver caused by obesity and diabetes are the most common causes of liver cirrhosis.

NEW WORDS

- arteries
- blood
- blood vessels
- capillary
- closed blood system
- deoxygenate
- excrete
- gaseous exchange
- heart
- lungs
- network
- oxygenate
- temperature
- veins

2.2 The circulatory system

Did you know that the blood moving throughout your body forms a system? To "circulate" means to move around, and so we have the circulatory system within the human body which transports blood.

Purpose of the circulatory system

The circulatory system is responsible for transporting blood with oxygen (O_2) from the lungs to cells and then transporting blood with carbon dioxide (CO_2) back to the lungs. It also has to distribute nutrients from the digestive system to the cells in the body and remove waste products to be excreted.

Components of the circulatory system:

The circulatory system is composed of the heart and a system of blood vessels, including arteries, veins and capillaries.

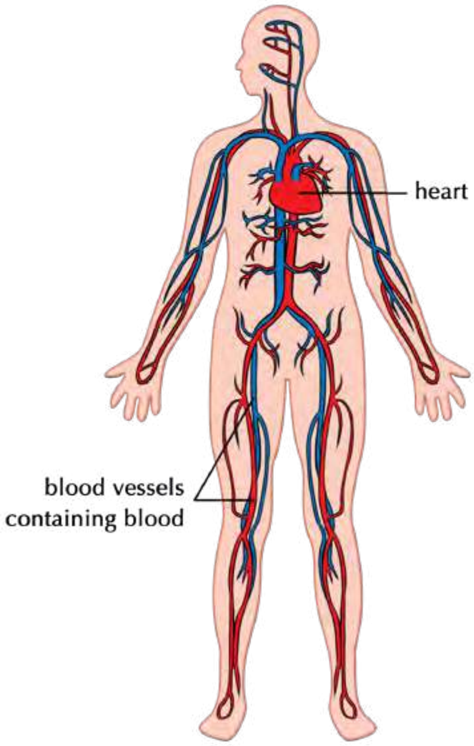
1. Heart

The heart is a very strong muscle and pumps blood throughout the body. There are four chambers in the heart that receive and send blood to all parts of the body. The top two chambers are called *atria* (singular= atrium) and the bottom two chambers are called *ventricles*.

2. Blood vessels

There are various blood vessels which carry the blood throughout the body. These are:

- arteries
- capillaries
- veins



The circulatory system is composed of the heart and blood vessels

3. Blood

The blood is transported throughout your body and carries various substances. The substances can be dissolved in the blood liquid (plasma), such as carbon dioxide, nutrients and waste products, or else within red blood cells, such as oxygen.

Main processes in the circulatory system

Our circulatory system is actually made up of two systems that function together:

- a short system that circulates blood between the lungs and the heart; and
- a much longer system that circulates blood from the heart throughout the body and back again.

This process occurs as follows:

- Blood is circulated from the heart to the lungs. At the lungs, carbon dioxide (CO_2) leaves the blood and oxygen (O_2) enters the blood. This process is known as **gaseous exchange**. Since the blood now contains more oxygen than carbon dioxide, we say it is **oxygenated**. This oxygenated blood returns back to the heart again.
- Once in the heart the oxygenated blood is then circulated to deliver the oxygen to all the cells in the body before returning back to the heart. At the same times as it delivers oxygen, the blood also collects carbon dioxide from the cells. This blood has more CO_2 than O_2, so it is **deoxygenated** blood. The carbon dioxide is excreted when it next returns to the lungs.

This process occurs over and over again throughout your life, thousands of times a day!

DID YOU KNOW?

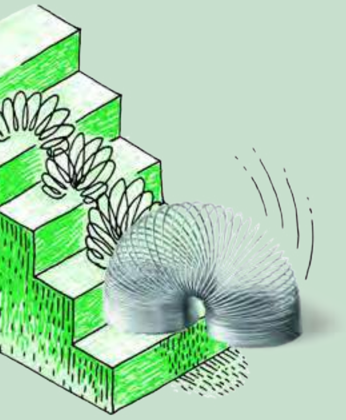
The first heart transplant in the world was done by Dr Chris Barnard in South Africa in 1967!

DID YOU KNOW?

On average your heart beats about 100 000 times a day and 30 million times a year. If you live to age 70, your heart would beat an average of 2.5 billion times!

VISIT

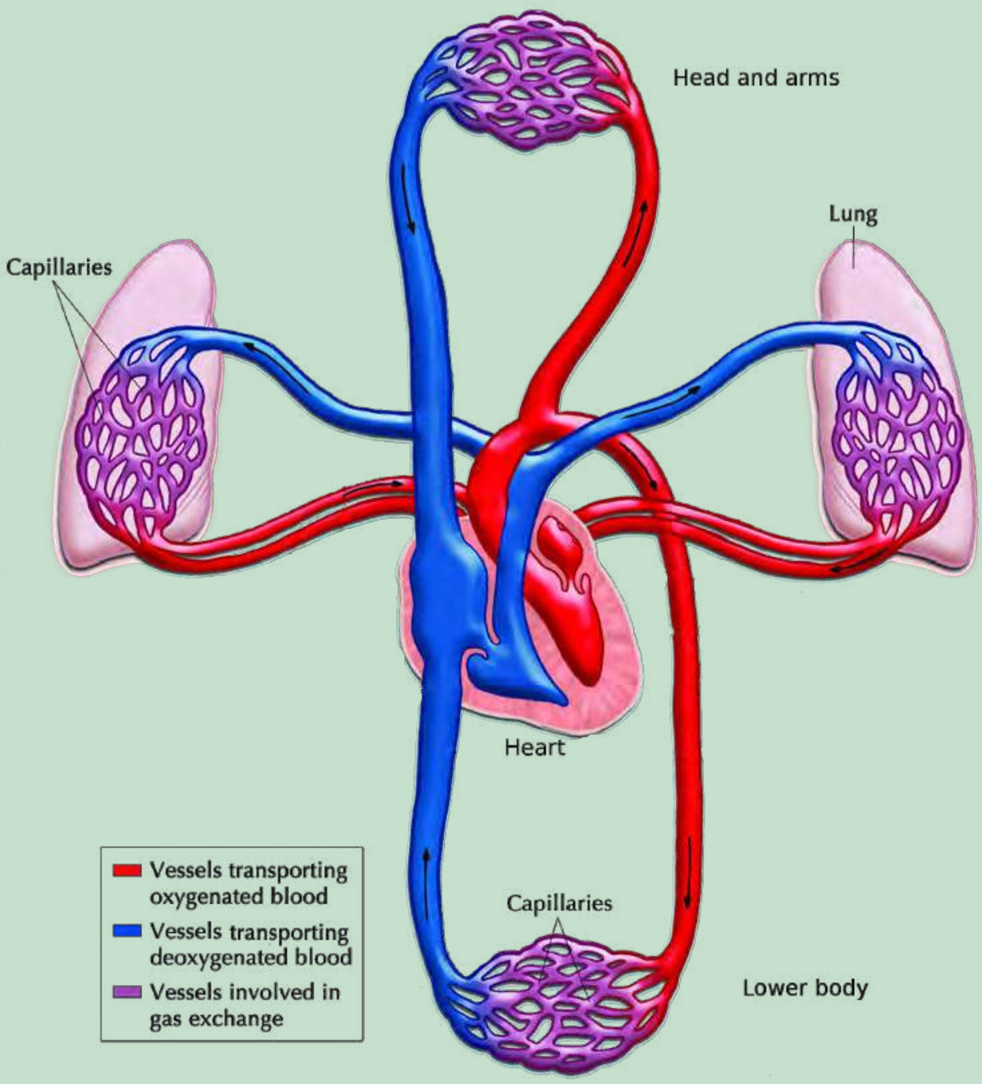
Watch a video that shows the direction of blood flow through the four chambers of the heart.
bit.ly/14Fccfa
Watch a video on the circulatory system.
bit.ly/19Wf2Od



ACTIVITY: Chart the circulatory system

INSTRUCTIONS :

- Study the diagram below that explains the circulatory process.



TAKE NOTE

In diagrams we generally use red to indicate blood vessels that contain oxygenated blood and blue to show blood vessels with deoxygenated blood.

- Use the diagram above to draw a circular diagram in the space provided to show how blood travels through the circulatory system (composed of two systems).
- Your circular diagram will form a complete circle.
- Add arrows to show the direction the process occurs in.

TAKE NOTE

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

NEW WORDS

- blood pressure
- deprived
- rupture

Health issues involving the circulatory system

Common diseases of the circulatory system include:

High Blood Pressure: This occurs when the force with which the blood pushes against the walls of the blood vessels is too high and can cause damage to the capillaries and several organs.

Heart Attacks: Occur when a narrowing or blood clot develops in one of the blood vessels that supplies the heart muscle with blood. If the narrowing or blood clot is big enough it can stop the blood flow to the heart muscle and can stop the heart from pumping which is called a heart attack. The person can die.

Strokes: Occur when cells in your brain are deprived of oxygen. This often occurs as a result of a blockage in the blood vessels leading to the brain, or when one of these vessels rupture (break or burst open).

2.3 The respiratory system

Closely linked to the circulatory system is the respiratory system. The circulatory system maintains the circulation of blood in the body while the respiratory system deals with the exchange of gases in your body.

Purpose of the respiratory system

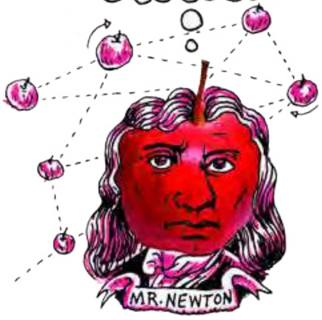
The respiratory system is responsible for supplying the body's cells with oxygen and for removing carbon dioxide.

NEW WORDS

- alveoli
- breathing
- bronchi
- cilia
- diaphragm
- exhale
- inhale
- lungs
- mucus
- pharynx
- trachea

DID YOU KNOW?

A sneeze travels at more than 160 km/hour.

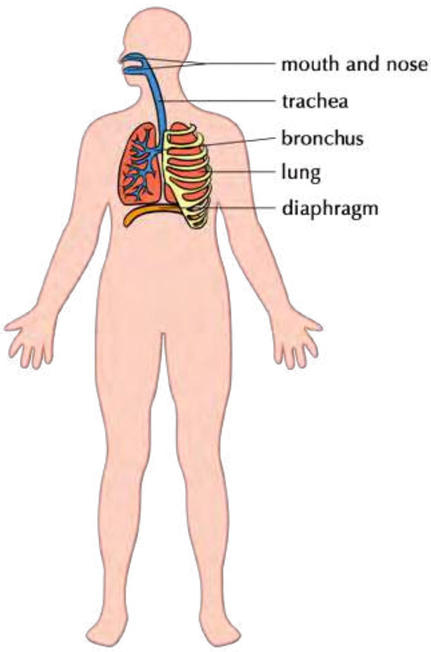


DID YOU KNOW?

Using a patient's own stem cells, surgeons were able to develop and transplant the first human trachea in 2008.

Components of the respiratory system:

Various organs play a vital role in the respiratory system.



A diagram of the structures that make up the respiratory system

1. Mouth and nose

Oxygen rich air enters the body through the mouth and nose where it is warmed.

2. Trachea (also called the windpipe)

The trachea is a tube that enters the chest and allows air to flow from the mouth into the bronchi and from there into the lungs. It is kept open by cartilage rings. When dust particles and germs in the air enter the trachea during inhalation, the mucus lining the trachea traps these particles and the **cilia** work together to move them out of the body. When you sneeze or cough you expel the mucus and foreign particles from your body.

3. Bronchi

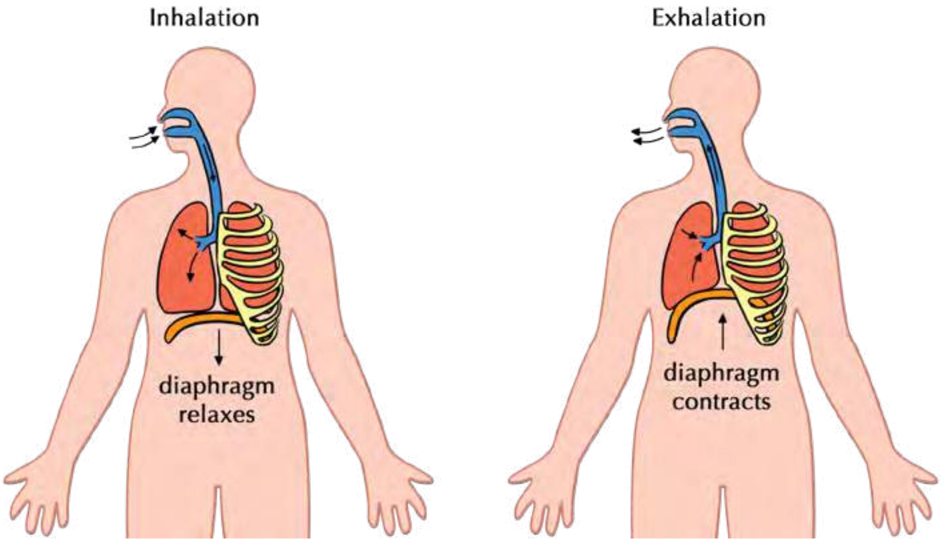
The trachea splits into two air tubes, called bronchi that connect to each of the lungs. These tubes divide even further into smaller and smaller tubes that connect with the tiny air bags (alveoli) of the lungs.

4. Lungs

The main organs of the respiratory system are the lungs. The tiny alveoli or air bags in the lung are surrounded by small capillaries where gaseous exchange takes place.

5. Diaphragm

This dome shaped muscle below the lungs enables you to breathe. When it contracts, it moves downwards and your lungs fill with air. When it relaxes again it moves upwards and forces the air out of your lungs. This is the main muscle used for breathing.



This diagram helps us to understand how breathing occurs showing how the diaphragm contracts and relaxes.

VISIT

Visit this animation and watch how the ribcage changes shape and size during inhalation and exhalation

bit.ly/11WaP8h

Main processes in the respiratory system

Three distinct processes occur in the respiratory system:

- **Breathing** occurs when we take oxygen into the body (lungs) and push carbon dioxide out of the body. Breathing therefore occurs in two phases:
  - Inhalation - drawing air in
  - Exhalation - pushing air out
- **Gaseous exchange** takes place at two locations by a process called **diffusion**:
  - in the alveoli, oxygen diffuses into the blood from the lungs and carbon dioxide diffuses from the blood back into the lungs
  - at the body tissues oxygen diffuses from the blood into the cells and carbon dioxide from the cells diffuses into the blood
- **Cellular respiration** occurs within the mitochondria of cells to release the chemical energy in food.

TAKE NOTE

People often confuse respiration with breathing. Breathing is taking air into the body through the lungs. Respiration or cellular respiration takes place inside the cells to release energy when oxygen is combined with glucose and other nutrients.

Health issues involving the respiratory system

Some common health issues of the respiratory system are:

- **Asthma:** caused by allergies that inflame and narrow the airways
- **Lung cancer:** a disease that mostly results from smoking or severe air pollution
- **Bronchitis:** swelling of the lining of the bronchi due to infection which causes coughing and makes it difficult to get air into the lungs
- **Pneumonia:** an infection in the lungs where the alveoli fill with fluid
- **TB (Tuberculosis):** an infectious disease caused by the bacteria, *Mycobacterium*

NEW WORDS

- brittle
- cartilage
- collagen
- contract
- fracture
- frame structure
- joint
- ligament
- mineral salts
- muscle
- tendons

VISIT

A video on muscle contraction and relaxation in the arm.

bit.ly/13ZIlUd

2.4 The musculoskeletal system

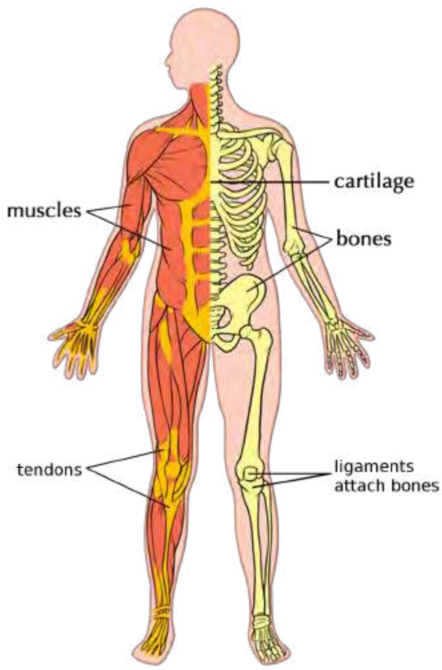
All the movements that your body performs rely on a system of muscles, tendons, ligaments, bones and joints that work together. These are the components of your musculoskeletal system.

Purpose of the musculoskeletal system

Muscle tissue is responsible for producing movement in the body, however muscles need to be attached to a frame structure to produce movement.

The bones of the skeleton provide a frame for muscles to attach to, so that movement is possible. The skeleton also protects the body, especially the soft, fragile organs like the heart, lungs and brain.

Components of the musculoskeletal system



The components of the musculoskeletal system help bring about movement.

DID YOU KNOW?

You use 200 muscles when taking only one step!

The components of the musculoskeletal system include the following:

1. Muscles

Muscles allow us to move because they are able to contract (become shorter) and relax (become longer).

2. Bones

Bones provide support and help to form the shape of the body. The place where bones meet is called a joint - think of your knee or elbow joint, or your finger and toe joints.

3. Cartilage

Cartilage is stiff yet flexible and is found between bones in joints and between the ribs and breastbone (as indicated in the diagram). It also forms the ears, nose and bronchial tubes, and forms discs between the bones of the spinal column.

4. Tendons

Your muscles attach to the bone with strong cords called tendons. You can feel some of the tendons in your body, for example behind your ankle (called the Achilles tendon).

5. Ligaments

Ligaments occur between bones at joints and hold bones together within the joint. Ligaments are extremely strong.

Main processes in the musculoskeletal system

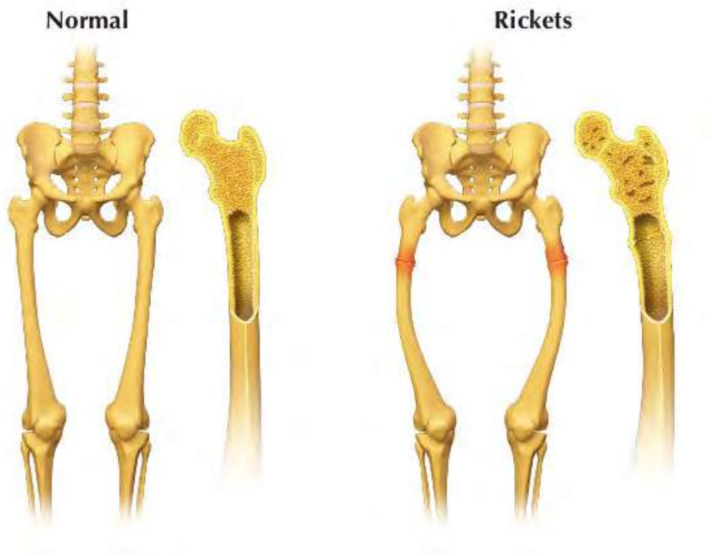
We can move our entire bodies from one place to another through self-propulsion. This is called **locomotion**. Locomotion is different to movement. Movement is the change in shape, direction, position or size of a part of the body. Animals show movement and locomotion. What about plants? Do you think plants show movement and locomotion?

Locomotion and movement are made possible through the contraction and relaxation of muscles. Muscles are stimulated by nerves to contract.

Health issues involving the musculoskeletal system

Common disorders of the musculoskeletal system include:

Rickets: This disorder is caused by a lack of vitamin D, calcium or phosphate which results in soft, weak bones. A typical symptom in children who have rickets is a bowing (bending outwards) of the bones of the legs.



Can you see how the shape of the bones changes when a person has rickets?

Arthritis: This is a condition where the joints in the body become inflamed, painful and swollen. The cartilage between the joints breaks down causing the bones to rub against each other which is very painful.

Osteoporosis: This occurs when the bone tissue becomes brittle, thin and spongy. These fragile bones can break easily, and they start to crumble and collapse. Although osteoporosis is common in older people (especially older women), teenagers and young adults may also develop it.

NEW WORDS

- bowing
- locomotion
- self-propulsion

DID YOU KNOW?

The muscle that moves the fastest in your body is the muscle that controls your eyelids! There is a reason why we use the phrase "in the blink of an eye" to mean very fast!

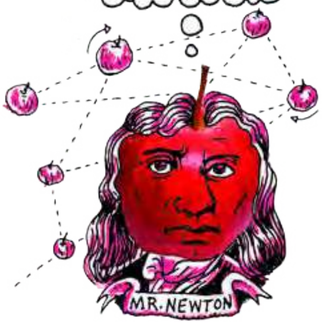
VISIT

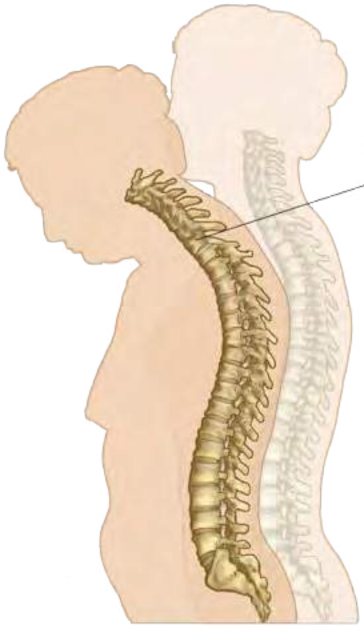
An innovative use of 3D printers to help repair fractures in bones!

bit.ly/13Q6hBw

DID YOU KNOW?

Babies are born with 305 bones while adults only have 206 bones. As babies grow into adults, many smaller bones fuse together to form bigger bones.





As this woman got older, she developed osteoporosis causing her vertebral column to crumble and collapse and so she now stoops over.

2.5 The excretory system

We will now be looking at the excretory system. This is often confused with egestion, which we previously learned about.

ACTIVITY: Differentiating between excretion and egestion

Do you remember learning about the difference between excretion and egestion? Explain what you understand the difference between these terms are.

1. Egestion is...

___

___

2. Excretion is ...

___

___

Purpose of the excretory system

Our cells use oxygen and nutrients to function and in the process also produce various metabolic waste products including:

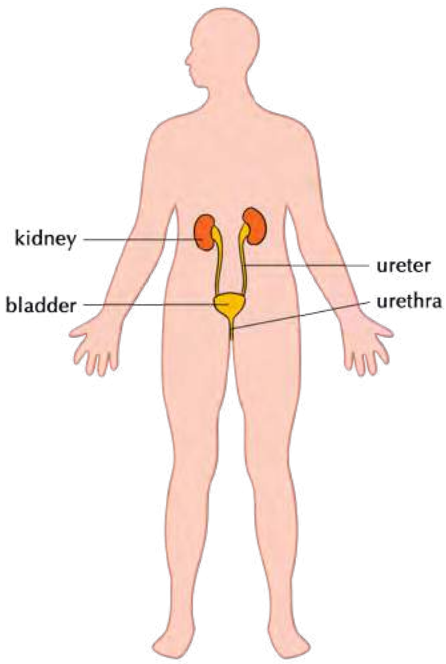
- **urea:** a substance that is formed when protein is broken down in the liver
- **carbon dioxide**: a by-product of cellular respiration

The organs of the excretory system are responsible for removing these harmful metabolic waste products from the blood so that they do not build up to high concentrations. But, in the process, they have to retain the nutrients and water for the body to function. One of the main functions of the excretory system is to prevent too much or too little water in the body.

NEW WORDS

- bladder
- excretion
- kidney
- metabolic waste products
- metabolise
- toxic
- urea
- ureter
- urethra
- urinate

Components of the excretory system



The excretory system is responsible for removing metabolic waste products from the blood

DID YOU KNOW?

The first kidney transplant occurred in 1954.

We already know that the lungs excrete carbon dioxide (CO_2) when you exhale. Another organ that excretes waste is the skin. When you sweat, your skin excretes excess water, salts and a small percentage of urea. In this section, however, we will focus on the excretory system to remove metabolic waste from our blood in the form of urine.

DID YOU KNOW?

On average, your kidneys produce 1.5 liters of urine each day.

To do this, the body uses the urinary system that consists of four main parts.

1. Kidneys

The kidneys filter all the blood in your body to remove urea from the blood. You have two kidneys, each about the size of your fist and bean-shaped. Your kidneys produce urine which is a combination of excess water and waste products.

2. Ureters

There are two ureters (thin tubes) which connect each kidney with the bladder and carry the urine from the kidney to the bladder.

DID YOU KNOW?

Your kidneys filter about 125 ml of blood every minute! Since you have about 7 to 8 litres of blood in your body, all your blood gets filtered 20 to 25 times per day through your kidneys!

3. Bladder

The bladder is a balloon-like organ that collects the urine before excreting it during urination.

4. Urethra

The urethra is a tube that connects the bladder to the outside of the human body through which the urine is excreted.

Main processes in the excretory system

There are four main processes discussed below.

1. Filtration: All the blood in the body passes through the kidneys as part of the circulatory system. The kidneys filter the blood to remove unwanted minerals and urea, and also excess water. Some water is removed so that the metabolic waste products can be excreted in solution in the liquid urine.

2. Absorption: Once the blood is filtered by the kidneys, the substances that the body needs are re-absorbed back into the blood so that they are not lost in the urine.

3. Diffusion: The substances are transported into and out of the specialised cells of the kidney through the process of diffusion.

4. Excretion: The kidneys funnel the liquid urine through the ureters to the bladder where it is stored. When the bladder has filled up, it uses muscles to force the urine out of the body through the urethra. This is called excretion.

NEW WORDS

- antibiotic
- infection

Health issues involving the excretory system

Common diseases of the excretory system include:

A patient receiving dialysis to filter his blood because the kidneys are not working as they should.

Kidney Failure: When this happens the kidney loses its ability to properly filter and remove metabolic waste which allows this waste to build up in the body. This is very harmful and may be fatal. In such cases the patient needs to undergo very regular kidney dialysis. Dialysis involves using a machine which filters the blood for the patient to remove waste products.

VISIT

A summary video of the excretory system.

bit.ly/160u9IA

Kidney Stones: Kidney stones form when fluid intake is too low, resulting in the concentration of solutes (salts and minerals) in the kidney becoming too high. This can result in a small crystal (stone) forming. The kidney stone may stay in the kidney or move down the ureter to be excreted in the urine. A larger stone may however cause severe pain along the urinary tract and may even get stuck, blocking the flow of urine and causing severe pain or bleeding.

A kidney stone which is about 4.5 mm in diameter.

Bladder infection: This is one of the most common infections in women but is quite rare in men. Bacteria can enter the bladder and cause an infection. This causes swelling and pain when urinating.

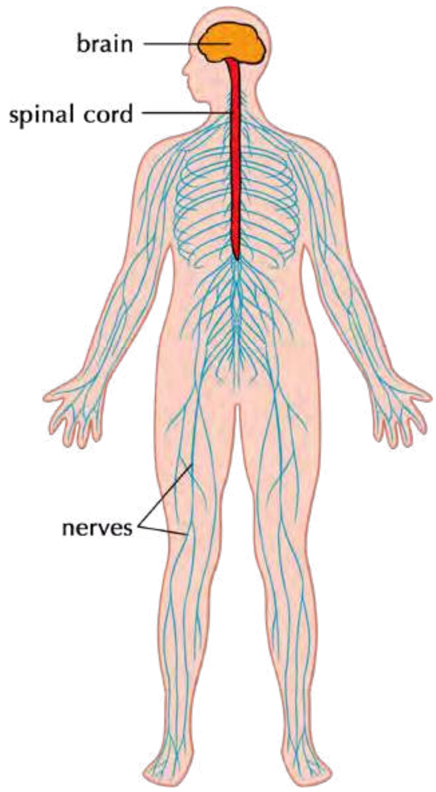
2.6 The nervous system

Purpose of the nervous system

Our nervous system is a complex network that transmits nerve impulses between different parts of the body. The nerves in our body receive **stimuli** from inside the body or from the environment (from the ears, eyes, skin or tongue for instance). These are turned into **impulses** to the brain and spinal cord.

Components of the nervous system

The nervous system consists of various parts.



1. Nerves

Nerves are the long fibres which transmit messages from the brain and spinal cord to the rest of the body and back. Each nerve is actually an enclosed bundle of nerve cells, called neurons. The nerves work together to carry messages throughout the body. They make up the nerve tissue in the nervous system.

2. Brain

Your brain is located inside your skull. The brain is part of your central nervous system and sends messages to the rest of your body. There are different areas in the brain that have different functions. All these different areas also communicate with each other.

NEW WORDS

- auditory
- brain
- conduct
- degenerative
- impulse
- nerve
- neuron
- optic
- stimulus
- transmit
- vision

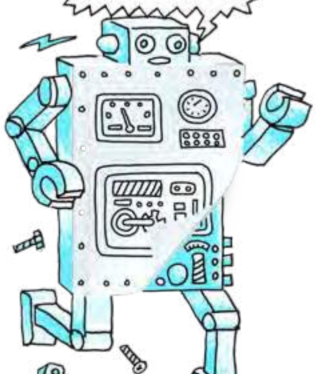
VISIT

A song about the nervous system.

bit.ly/13ZsGIR

TAKE NOTE

Stimuli is the plural form of the word stimulus.



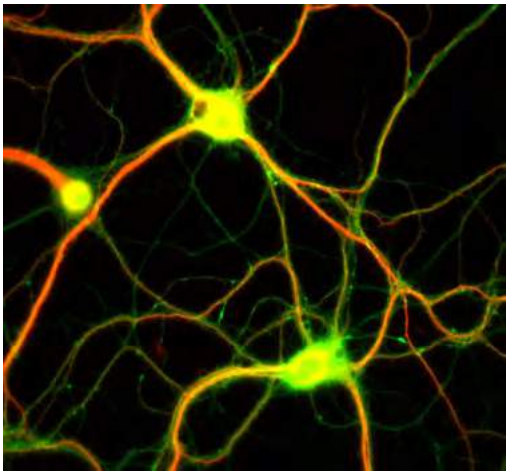
VISIT

Citizen science: Play a game to help MIT map the brain!

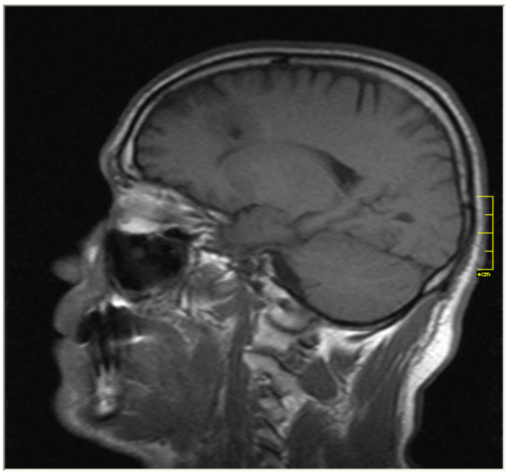
bit.ly/160udlh

Learn more about the brain and participate in the interactive activities to stimulate the brain

bit.ly/13stpSU



This fluorescent image shows nerve cells, from a rat brain, which were grown in the laboratory.



A MRI (magnetic resonance imaging) scan of a person's head showing the position of the brain within the skull.

3. Spinal cord

The spinal cord runs from the brain through your spine, protected by your vertebral column. The spinal cord is a bundle of nervous tissue and other support cells. Together with the brain, the spinal cord also forms part of your central nervous system.

TAKE NOTE

"Peripheral" means on the outside. So the peripheral nervous system is on the outside of the central nervous system.

4. Sensory organs

We have mentioned that there is a central nervous system (made up of the brain and spinal cord). The second part of the nervous system within our bodies is the peripheral nervous system.

The peripheral nervous system connects the central nervous system to the muscles and organs. Various sensory organs are responsible for collecting information and sending it via sensory nerves to the central nervous system.

Our sensory organs are our:

- ears
- nose
- eyes
- skin
- tongue

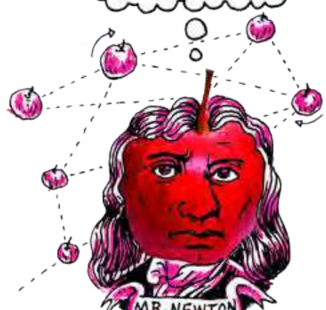
Main processes in the nervous system

The nervous system is responsible for key processes in the body. These are discussed next.

Sending and receiving impulses: Nerve cells in the brain send and receive multiple messages from multiple sources at any given moment. These are transmitted as electrical impulses.

DID YOU KNOW?

The amount of electricity used by the brain to send and receive messages can power the light in your refrigerator!



The central nervous system interprets these signals and this is how we sense the world around us. These processes are:

- **Hearing:** In the ear, sound waves are transformed into electrical signals that travel along the auditory nerve to the brain. This allows us to understand what we are hearing.

- **Seeing:** Seeing and understanding what you see are complex processes. Light enters your eye and stimulates specialised cells within your eye. These cells transmit signals to the brain along the optic nerve, where they are interpreted as sight.
- **Feeling:** The skin allows us to feel and experience the world around us through touch. Millions of nerve endings in the skin, called receptors, cover the skin, muscles, bones and joints, as well as internal organs and the circulatory system. These receptors respond to pressure, pain, temperature and movement.
- **Tasting:** Taste buds in your tongue and parts of your mouth can distinguish between the different flavours: sweet, sour, bitter, salty. These receptors work very closely with the receptors in the nose. Together the taste and odour of food is sent to the brain where it is processed and interpreted.
- **Smelling:** Nerve cells in the lining of your nose respond to molecules in the air. They send messages to the brain which interprets the smell accordingly and recognises any one of about 10 000 different smells!

VISIT

Want to learn more about the eye and sight?

bit.ly/16IIRhU

Regulating: An important part of the nervous system is to maintain a balance within the human body. This includes regulating our body temperature. Our bodies need to be kept at about 37°C to work effectively. If the body is too hot the brain might try and cool the body through increased sweating. If you are very cold, your body will start to shiver to generate heat energy. These responses to changes in body temperature are controlled by your nervous system.

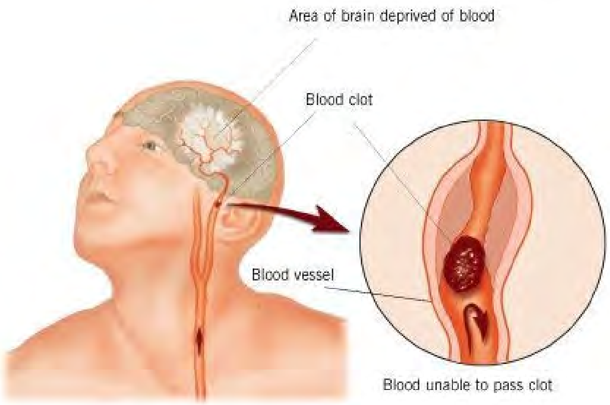
DID YOU KNOW?

Nerve impulses travel to and from the brain at 274 km per hour.

Health issues involving the nervous system

Trauma and injuries to brain and spinal cord: Any damage to the brain or spinal cord can have devastating effects on the human body. For example, people who break their necks in an accident, often damage their spinal cord. This prevents the brain from sending and receiving messages to the body and the person can become paralysed.

Stroke: If blood flow to the brain is stopped, brain cells begin to die, even after just a few minutes without blood or oxygen. This can lead to a stroke where a part of the brain function is lost.



When the brain is deprived of blood and oxygen due to a blood clot, the person may suffer from a stroke.

DID YOU KNOW?

Your brain makes up less than 2% of your total body weight, yet it uses 20% of your body's energy!

Degenerative disorders: There are several problems associated with the nervous system that cause a gradual loss of function over time (degenerative). These conditions include Alzheimer's Disease, Parkinson's Disease and Multiple Sclerosis.

VISIT
The effects of drug and alcohol on the adolescent brain
bit.ly/14k6icr

Mental health problems: Examples include depression, anxiety disorder and personality disorders.

Sensory organ problems: We have discussed the various sensory organs that are associated with the nervous system. These organs can also have problems, such as:

- Deafness
- Blindness
- Short sightedness

Effects of drug and alcohol on the brain: Different types of drugs target different areas in the brain and it is mostly the brain's reaction(s) that make people want to take drugs and/or alcohol.

Alcohol and drug abuse can cause irreversible brain damage, a loss of memory, decreased learning capability, an increased risk of strokes and heart attacks, and a variety of emotional and mental health problems.

2.7 The reproductive system

NEW WORDS
- ejaculation
- fertilization
- ovary
- ovulation
- ovum
- penis
- puberty
- reproduction
- scrotum
- sperm
- testes
- uterus
- vagina
- womb

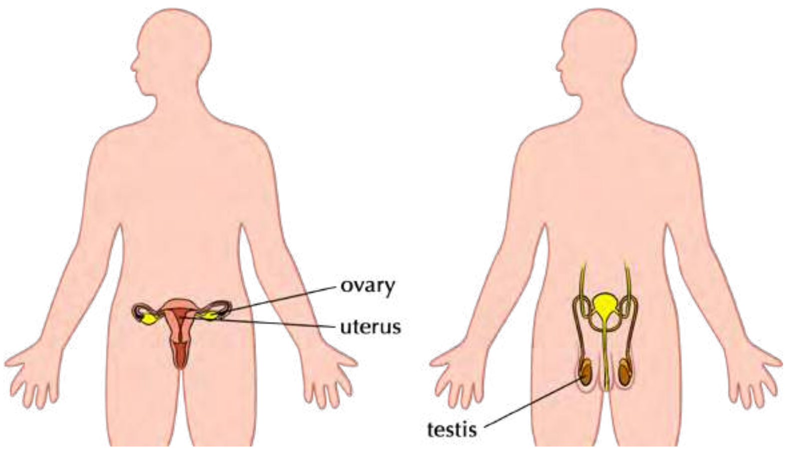
Purpose of the reproductive system

In humans, as in other eukaryotic organisms, the main purpose of the reproductive system is to produce sex cells to ensure the continuation of the species.

Components of the reproductive system

We will be looking at the reproductive organs in more detail in the next chapter. For now, let's get an overview of the main components in the reproductive system.

The female (left) and male (right) reproductive organs differ:



DID YOU KNOW?
The largest cell in the human body is the ovum (egg cell) and the smallest cell is the sperm cell.

1. Ovaries

The ovaries are located inside the female's body in the lower abdomen and produce mature egg cells (ova).

2. Uterus

The uterus (also known as the womb) is present in females. It has a thick lining and muscular wall. This is where a fertilised egg will implant and develop during pregnancy.

3. Testes

The sex organs in males are located in the scrotum, a pouch of skin that hangs between the legs. During puberty the testes start to produce sperm cells.

Main processes in the reproductive system

During sexual reproduction, the egg and sperm have to combine to form a new individual. Let's do an activity to find out about the main processes in the reproductive system.

ACTIVITY: Defining the main processes involved in reproduction

INSTRUCTIONS :

- Below is a list of the main processes involved in the reproductive system.
- Look up each term, either in your dictionary or on the internet and write a brief description on the lines provided.
- The first three have been done for you.
- Growth

Growth is the increase in size and mass of an organism as it develops over time.

- Cell division

Cell division is the process when a parent cell divides into two daughter cells. In the reproductive system, cell division occurs within the ovaries and testes to produce gametes (sperm and egg cells)

- Maturation

Maturation is the process of becoming mature. In humans, this refers to puberty where sexual organs mature so that they are able to reproduce.

1. Copulation

___

___

2. Ejaculation

___

___

3. Ovulation

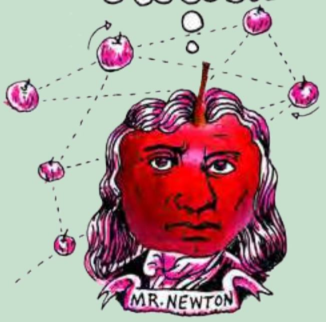
___

___

4. Menstruation

DID YOU KNOW?

Some of the strongest muscles in the female body are found in the uterus! Can you think of reasons why this is?



5. Fertilisation

6. Implantation

Health issues involving the reproductive system

Infertility: About 10% of heterosexual couples have problems falling pregnant and may even be completely unable to sexually reproduce. This is infertility and it affects both men and women.

Foetal Alcohol Syndrome: When a pregnant mother drinks alcohol during her pregnancy, the alcohol may cause serious birth defects in the unborn baby. This will affect the child throughout their entire life and in most cases cannot be reversed.

Sexually Transmitted Diseases (STDs): Many life-threatening diseases such as HIV/AIDS, syphilis and gonorrhoea can be transferred during sexual intercourse.

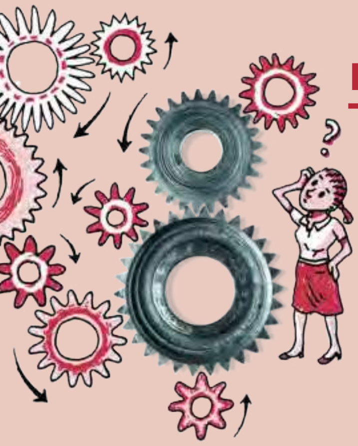
SUMMARY:

Key Concepts

- There are many complex systems functioning in our bodies.
- Each system has very specific organs and tissues that are key components in making the system function optimally.
- Different processes take place that are dependent on the key components in each system.
- There are various health issues that affect the systems of the body and that can often be prevented with a healthy lifestyle and wise (informed) life choices.

Concept Map


Systems in the human body
include
digestive system
processes
ingestion, digestion, absorption, egestion
components
mouth, oesophagus, stomach, intestines, liver
health issues
ulcers, anorexia nervosa, diarrhoea, liver cirrhosis
circulatory system
processes
circulating blood
components
heart, blood vessels, blood
health issues
high blood pressure, heart attacks, strokes
respiratory system
processes
breathing, gaseous exchange, respiration
components
nose, mouth, trachae, lungs blood
health issues
asthma, lung cancer, bronchitis, asbestosis
musculoskeletal system
processes
muscle contraction and relaxation, locomotion, movement
components
muscles, bones, cartilage, tendons, ligaments
health issues
rickets, arthritis, osteoporosis
excretory system
processes
filtration, absorption, diffusion, excretion
components
kidneys, bladder, uterus
health issues
kidney failure, bladder infection, kidney stones
nervous system
processes
hearing, seeing, feeling, tasting, smelling, sending and receiving impulses, regulating temperature
components
brain, spinal cord, nerves, ears, nose, eyes, skin, tongue
health issues
deafness, blindness, drugs and alcohol effects
reproductive system
processes
growth, cell division, copulation, ejaculation, ovulation, menstruation, fertilisation, implantation
components
testes, ovaries, uterus
health issues
infertility, foetal alcohol syndrome, STDs.



REVISION:

1. What does digestion mean? [4 marks]

2. List the four main processes involved in the digestive system. [4 marks]

3. Describe the different components of the digestive system and their function. [15 marks]

4. Diarrhoea is can be very dangerous in babies. Why do you think this is so? How it can be prevented? [3 marks]

5. Distinguish between inhalation and exhalation. [2 marks]

6. Is carbon dioxide in your body excreted or egested? Explain why you say so. [3 marks]

7. Draw a simple diagram to show how blood is circulated around the body in a closed system. [10 marks]

8. What is the difference between breathing and respiration? [5 marks]

9. Give two parts of your musculoskeletal system you use when you have to climb stairs. [3 marks]

10. What are the functions of the bones in the skeleton? [2 marks]

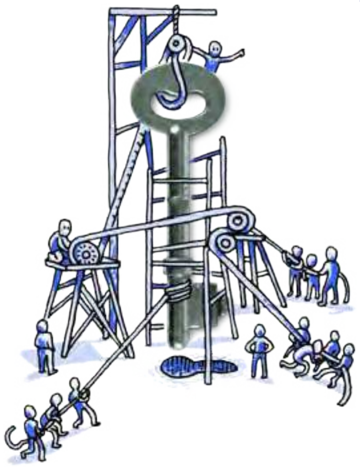
11. Drugs and alcohol have various negative effects on the body. List at least 3. [3 marks]

12. Explain why it is so dangerous for a pregnant woman to drink alcohol during pregnancy. [2 marks]

Total [56 marks]

Curious? Use your imagination and show what this key can be.

3 Human reproduction



KEY QUESTIONS:

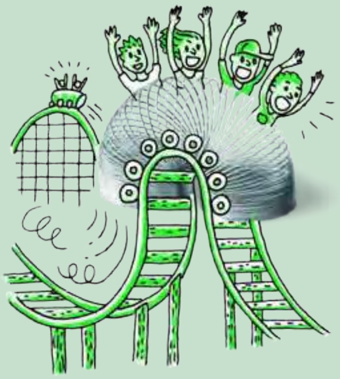
- What is puberty and what does it mean when we "reach puberty"?
- Why do we all go through puberty at different times and rates?
- What changes take place inside our bodies during puberty?
- What do our reproductive organs look like when they are mature?
- How does reproduction occur?
- What is menstruation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

At this stage in your life, your body is probably going through all sorts of changes as it grows, develops and matures. In this chapter we will learn more about these changes and why they occur.

3.1 Purpose and puberty

The purpose of reproduction

You have previously learnt that reproduction is one of the seven life processes, and like all organisms, humans need to reproduce to ensure the survival of the species.



ACTIVITY: Reflecting on population growth

Have a look at the website link provided in the visit box about our "Breathing Earth". This will give you an idea about how our population is growing.

In 2011 the world's population grew to 7 billion people, one billion more since 1999. Medical advances and increases in agricultural production (food) allow more and more people to live longer lives.

In ancient times, countries such as India, Rome and Greece, saw a large population as a source of power. The Romans even made laws about how many babies a couple could have and punished those who did not follow the rules. Yet Confucius (551-478 BC) thought that too many people was a problem, as there wouldn't be enough food to feed everyone, leading to war and famine and various other problems. Today in China this philosophy still applies and couples are only allowed one baby and are heavily taxed if they have more than one.

South Africa's population grew by 15,5%, or almost 7-million people, in the space of 10 years to reach a total of 51.7-million in 2011. This is according to the country's latest national census which took place in 2011. The last census took place 10 years previously in 2001.

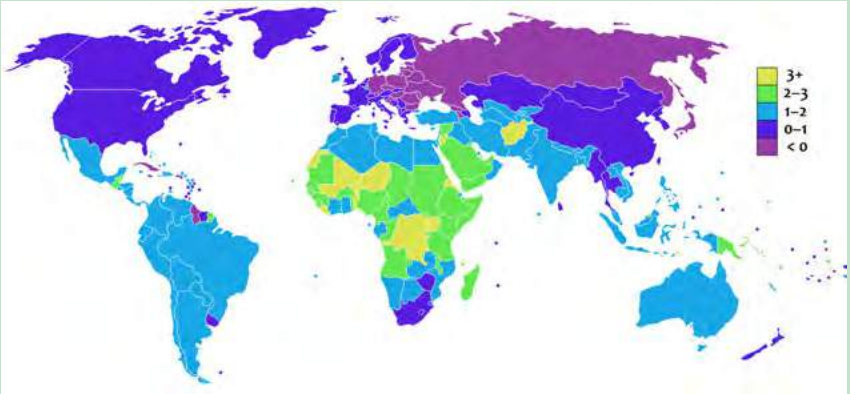
QUESTIONS:

1. List any possible reasons why you think South Africa would want to have a large population.

2. What are some advantages and disadvantages to the country in which the number of children per couple is limited so that the population growth is limited?

3. Predict what possible long-term problems might arise if the population in South Africa continues to grow at the fast rate at which it is currently growing.

4. Have a look at the following diagram which shows the percentage growth a country's population in a year. The different colours give an indication of the growth rate, as shown in the key. For example, countries which are colour coded yellow, have an annual growth rate of 3%. This means their population increase by 3% each year. Answer the questions which follow.



Percentage growth rate of each country.

NEW WORDS

- birth control
- conception
- fertilisation
- implantation
- population growth rate
- puberty
- sexual intercourse
- sperm

VISIT

Video on our world population growth.
bit.ly/16DDIpB

A simulation to show population growth
bit.ly/19kSnvE

1. Which continent would you say has the largest percentage growth rate each year? Justify your answer.

2. Many countries in Europe are coloured light purple in the diagram. What does this mean?

VISIT

The science of overpopulation (video).

bit.ly/13Q6VPn

3. Various population control methods are put in place around the world - contraceptives to stop women from falling pregnant, abortion clinics, large tax incentives to convince people not to want more children, and others. What is your opinion about population control methods and do you think they should be allowed in modern society?

What is the purpose of puberty?

NEW WORDS

- hormone
- menstrual cycle
- oestrogen
- penis
- testes
- testosterone
- uterus

The human body is geared towards reproduction to ensure the survival of the species. Men have to produce sperm and ensure that they come into contact with a female egg cell. Women have to produce (and store) egg cells that can be fertilised by a male sperm cell.

Children's bodies and sexual organs are not mature and cannot yet perform the reproductive function. Puberty is therefore the time when a child's body develops and changes. The sexual organs mature to enable the body to produce sex cells. These sex cells are called **gametes**.

How does puberty just "start"?

Puberty is the stage in the life cycle of humans when we become capable of sexual reproduction. Girls and boys do not, generally, go through puberty at exactly the same time. So how does puberty "start"?

Many of the complex actions that take place in our bodies are controlled by chemical messengers called hormones. Hormones are produced by different glands in our bodies. The pituitary gland is an important gland which controls most of the body's hormones and hormonal activities. It is about the size of a pea and located at the base of the brain.

Puberty is brought on when the pituitary gland releases specific hormones into the bloodstream. These hormones then travel to the immature sex organs and signal the hormones in these to be released.

In girls, the ovaries are stimulated by hormones released by the pituitary gland to release the hormone **oestrogen**. In males, the testes are stimulated to release the hormone **testosterone**. These hormones initiate all the bodily changes that you experience during puberty.

VISIT

Visit this interactive site to explore the changes that occur during puberty

bit.ly/1cpBnFI

What changes during puberty?

The main purpose of puberty is for the sexual organs to mature. However, the hormones which are released from the reproductive organs also start a number of other changes in the human body. We call these **secondary sexual characteristics**.

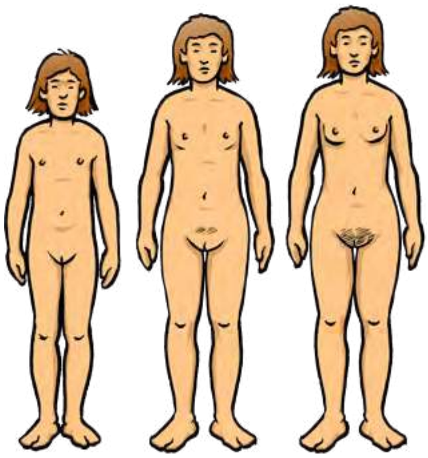
Puberty brings about the following secondary changes in females:

- **Breasts** start to develop that may be used for breastfeeding a baby after childbirth.
- **Pubic hair** starts to grow at the onset of puberty. Underarm hair also starts to grow.
- **Menstruation** occurs in girls in a monthly cycle once they reach puberty.
- **Body shape** also changes due to the rising levels of oestrogen in the body.
- **Body odour and acne** develop as more oil is secreted and the smell of sweat in the body changes.

VISIT

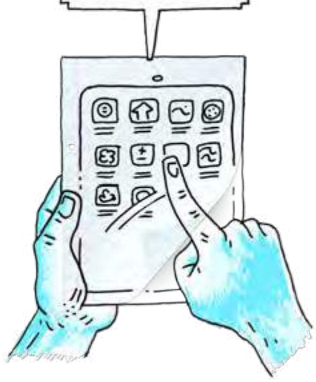
This animation shows the position of the pituitary gland (the pink gland)

bit.ly/15qfVXa



TAKE NOTE

Testes is plural and testis is singular.

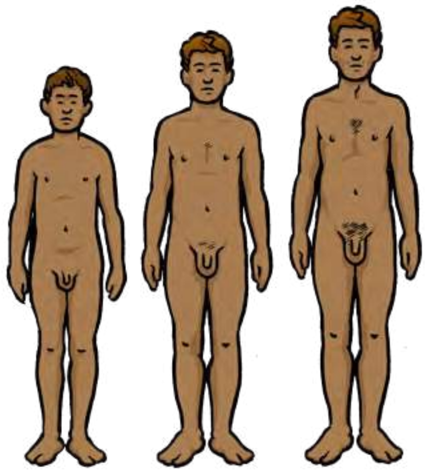


At the start of puberty boys are, on average, 2 cm shorter than girls, yet adult men are approximately 13 cm taller than adult women. Puberty brings about the following secondary changes in males' bodies:

- **Testicle and penis size** increases.
- **Hair** starts to grow on the pubic areas, the limbs, chest and the face.
- **Voice** becomes deeper as the larynx (voice box in your throat) grows.
- **Body shape** changes occur as the skeletal muscle and bones increase in size and shape.
- **Body odour and acne** start to develop, as with females.

NEW WORDS

- ejaculate
- erection
- foreskin
- scrotum
- semen
- vagina
- sperm duct (vas deferens)



Let's take a look at the reproductive organs.

3.2 Reproductive organs

Let's take a closer look at the male and female reproductive organs to see how they are structured and what functions they perform.

ACTIVITY: Identify the role of the male and female bodies in reproduction

In the space below, explain what you think the role of the male and female bodies are in reproduction.

1. The male body has to ...

___

___

___

2. The female body has to...

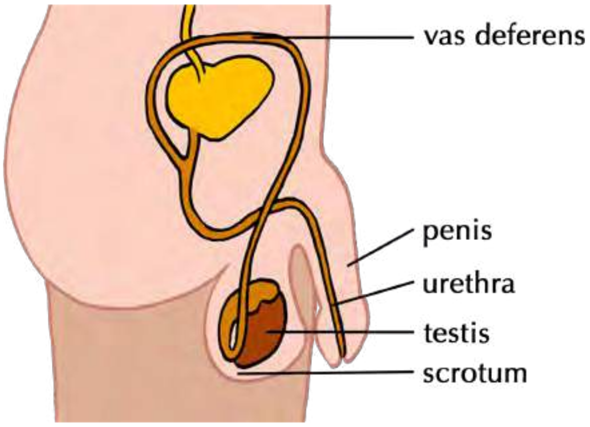
___

___

___

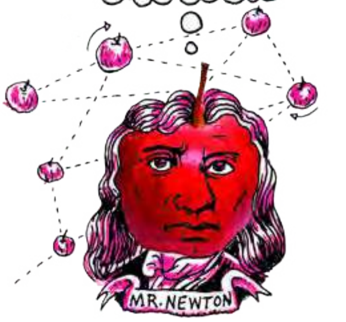
Male reproductive organs

The male reproductive organs include:



DID YOU KNOW?

Semen contains sperm cells, dissolved nutrients and enzymes that nourish and protect the sperm inside the woman's body. Every millilitre of semen can contain up to 100 million sperm cells!



1. Testes and scrotum

Males are born with their two testes hanging outside their bodies. The testes in young boys do not produce sperm. During puberty the two testes release testosterone which then triggers the production of sperm.

The two testes are each contained in a pouch of skin called the scrotum. The scrotum ensures that the testes are kept at a constant temperature of 35°C which is the temperature at which sperm is produced.

2. Sperm duct (vas deferens)

Different tubes (ducts) carry the semen from the testes to the penis. The sperm duct carries the sperm from the testes to the urethra in the penis.

3. The penis

The penis is the external sex organ. The head is often covered by a loose fold of skin called the foreskin. The penis needs to be erect (stiff and hard) to be able to go into the vagina to deliver the sperm to the cervix during ejaculation.

4. Urethra

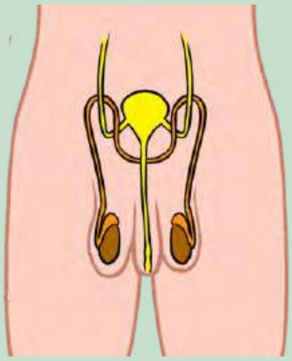
The semen moves through the urethra to the outside during ejaculation. The urine passes through the urethra during urination, but the semen and urine do not move through the urethra at the same time.

TAKE NOTE

Some cultures have the foreskin removed, called circumcision. This is done when the boy is a baby or at puberty.

ACTIVITY: Identify structure and function

1. Study the diagram of the male reproductive system. Label each part using its correct scientific name.
2. In the table, identify the function(s) of the male reproductive organs mentioned.
3. In the last column, suggest how you think the structure of the organ is adapted to perform the function most effectively.



Reproductive Organ	Function	Adaptation
Penis		
Testes and scrotum		

NEW WORDS

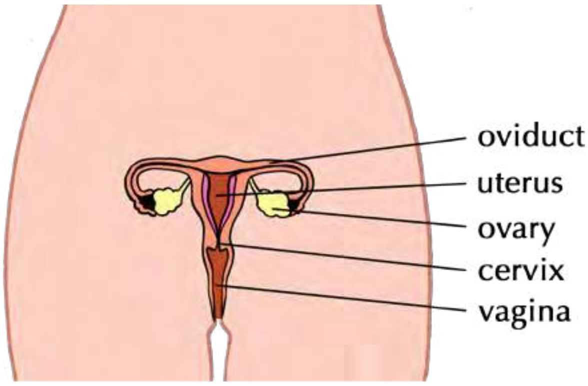
- cervix
- Fallopian tube (oviduct)
- ovary
- ovulation
- womb

Female reproductive organs

The female reproductive organs include:

DID YOU KNOW?

Women are born with thousands of immature egg cells in each ovary, but very few ever reach maturity.



1. Vagina

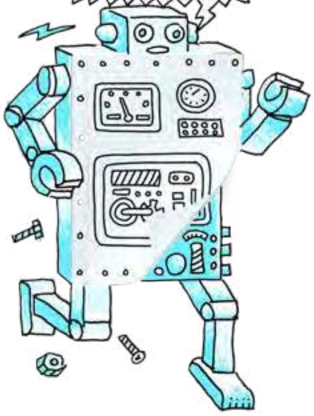
The vagina is a tube that connects the uterus with the outside of the body. During intercourse the vagina acts as a canal for the penis to fit into to deliver sperm. Once a month, during menstruation, the menstrual blood leaves the body through the vagina. It is also the birth canal during childbirth when it stretches to allow the baby to pass through.

2. Uterus

The uterus is hollow with extremely strong muscular walls that can carry and protect a baby. Two oviducts (Fallopian tubes) at the top of the uterus, connect it to the ovaries. The bottom neck of the uterus is called the cervix, which is tightly closed to protect the inside of the uterus.

TAKE NOTE

The plural of ovum is ova.



3. Ovaries

There are two ovaries on either side of the uterus. They produce oestrogen and contain the ova. Each month the ovaries take turns to produce a mature ovum. This is called **ovulation**.

4. Oviducts (Fallopian tubes)

The uterus and ovaries are connected through a pair of muscular tubes called the oviducts or Fallopian tubes. The mature ovum travels into these tubes to the uterus. Fertilisation occurs in the oviduct.

ACTIVITY: Comparing the reproductive organs

1. Explain how the structures of the vagina, cervix and uterus are specially adapted to fulfil their functions.

___

___

___

___

2. Provide at least 2 reasons why the uterus needs to have strong muscular walls.

___

___

___

___

VISIT

Learn more about the female reproductive system at this site:

bit.ly/1cWaGpM

3. Compare the position and functions of the ovaries with that of the testes. Create a table to show these differences.

NEW WORDS

- contraception
- contraction
- embryo
- gestation (pregnancy)
- labour
- menopause
- surrogacy
- umbilical cord
- zygote

3.3 Stages of reproduction

VISIT

Learn how to create an ovulation calendar to keep track of a menstrual cycle.
bit.ly/19WfMCU

Learn more about the menstrual cycle:
bit.ly/14k7tc2

We have already mentioned most of the processes that take place during reproduction. These processes occur in stages. Let's first have a look at the female reproductive cycle.

The reproductive cycle

The female reproductive cycle repeats every 28-30 days to release an egg cell to be fertilised if sperm are present. This cycle will repeat for many years from puberty to **menopause** (when the reproductive cycle comes to an end).

The processes that occur will differ depending on whether the ovum is fertilised or not. After ovulation, if fertilisation does not occur, the reproductive organs 'reset' through menstruation to start the process again.

Ovulation

Once a month, one of the ovaries releases one mature ovum into the oviduct.. This process is called ovulation. At the same time the uterus wall thickens and develops extra blood vessels. This is in preparation for the *possible* implantation of a fertilised egg.

Menstruation

When there is no fertilised egg cell (**zygote**) to implant in the uterus, the thick layer of blood and tissue is no longer needed. It is passed out through the vagina during menstruation. The entire process is called the menstrual cycle and it normally repeats every 28-30 days.

Fertilisation

During sexual intercourse the erect male penis enters the female vagina. This is called **copulation**.

The male penis deposits sperm into the female vagina through **ejaculation**. There can be millions of sperm cells in one ejaculation, but only one will be able to penetrate the outer membrane of the ovum.

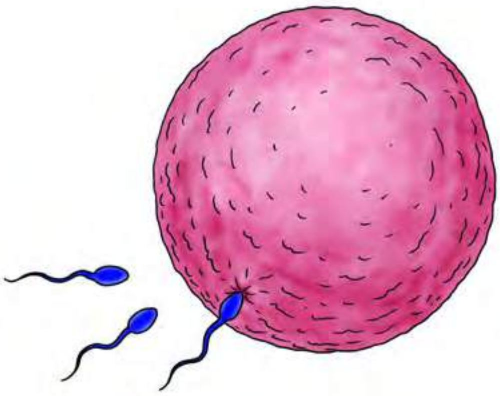
After ejaculation into the vagina, the sperm swim into the cervix and through the uterus to the oviducts. Once inside the oviducts, the sperm swim to meet the mature egg that was released from the ovaries and is now travelling towards the uterus.

One sperm cell burrows into the surface of the ovum. Only the sperm's head enters, the tail stays outside. As soon as one has penetrated the outer layer, the surface of the ovum changes and no more sperm will be allowed to enter.

This process is called **fertilisation** and it takes place in the outer part of the oviduct, and not in the uterus or vagina.

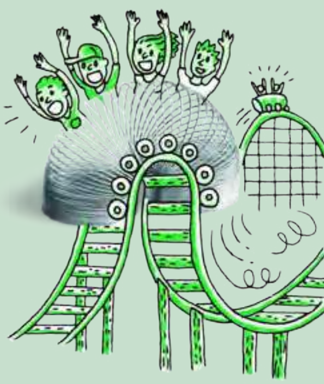
TAKE NOTE

There are times in the menstruation cycle near to ovulation when there is a high chance of becoming pregnant. All girls need to be aware of where they are in their own menstrual cycle as each cycle differs slightly.



Once the sperm on the right has entered the outer layer of the ovum, no more sperm will be able to penetrate.

ACTIVITY: Comparing fertilisation and menstruation



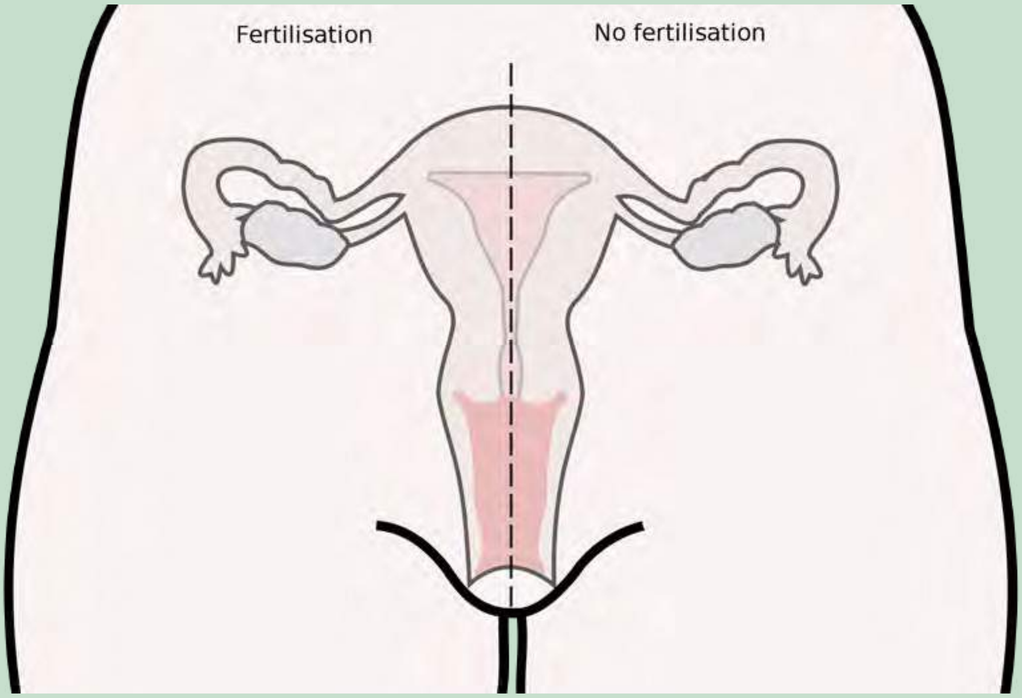
INSTRUCTIONS:

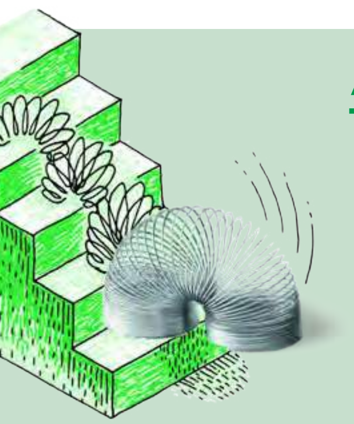
1. Use the following diagram to compare what happens when an egg is fertilised compared to when it is not fertilised. You can even use coloured pens if you have.
2. Use labels and arrows to illustrate on the left hand side what happens to the ovum if it is fertilised by a sperm cell.
3. Use arrows and labels to illustrate on the right hand side what happens if the ovum is not fertilised and the woman subsequently menstruates.

VISIT

Video on fertilisation and early development.

bit.ly/11WbMNR





ACTIVITY: Flow diagram of the pathway of sperm

INSTRUCTIONS:

1. Use a flow chart to track the progress of a sperm cell from the testes in the male body to the ovum in the female body.
2. Use the space below to draw your flow diagram. Remember to draw arrows.
3. Use the following terms in your flow chart, in the correct order.

a) Cervix
b) Uterus
c) Urethra
d) Penis
e) Testes
f) Sperm duct
g) Oviduct/Fallopian Tube
h) Vagina

Pregnancy and birth

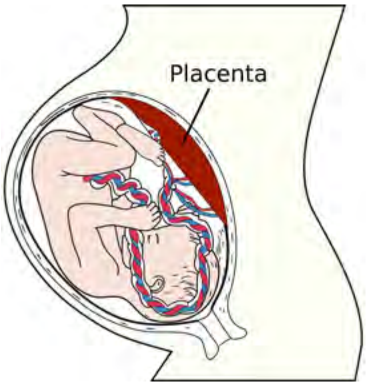
Pregnancy begins the moment the female egg cell is fertilised by the male sperm cell. This is then called a **zygote**.

The zygote will then start to divide and grow as it moves down the oviduct. It will then implant in the uterus lining, where it will continue to grow. The fertilised egg is now called an **embryo** and undergoes cell division over and over again. This forms a cluster of cells with the different cells differentiating to become the specialised cells, tissues and organs that make up the human body.

An 8-cell human embryo on day 3 after fertilisation.

Where the embryo implants into the spongy, blood-vessel rich lining of the uterus, some of the cluster of cells that formed after fertilisation form the placenta. The placenta is partly formed by the mother and partly by the embryo. The embryo develops an umbilical cord to attach itself to the placenta. The embryo can receive food and oxygen and remove its wastes through the umbilical cord and placenta.

VISIT
Video on fertilisation and early pregnancy.
bit.ly/19WfV9m



The foetus is attached to the placenta by the umbilical cord.

A newborn baby.

In humans, pregnancy is about 40 weeks (9 months). We call this the **gestation period**. Towards the end of the pregnancy, the uterus starts to contract. This pushes the head of the foetus into the vagina (birth canal). After the head has appeared the rest of the body comes out quite quickly. The last to come out is the placenta.

ACTIVITY: Debate Surrogacy

Many couples, for various reasons, are unable to fall pregnant. A surrogate mother can be impregnated with the couple's fertilised embryos and can therefore carry the couple's baby to full term. South African law only allows certain individuals to do this, it is not just available to anybody.

INSTRUCTIONS:

1. Work in groups of 6.
2. Debate the issue of surrogacy in your group. Base your debate on the ethical concerns below or any others you may think of.
3. Appoint a spokesperson for the group.
4. Each of the groups' spokesperson must then share their groups points of view with the class.
5. Debate these issues in the class.

There are many ethical issues concerning surrogacy:

- In many cases, the surrogate mother is paid to grow the baby inside her body. Often it is women who are poor that agree to be surrogate mothers and it is suggested that people who pay them to carry their babies are exploiting them. Should women be paid to be pregnant and deliver babies?
- In certain religions, surrogacy (including the donation of sperm and ova) is seen as "highly immoral" because it involves the intrusion of a third person on a couple's relationship. Should religious institutions be allowed to prevent surrogacy in this way?

1. Use the following lines to write down some notes on any other points your group discusses:

DID YOU KNOW?

Hearing is one of the first senses to develop in a foetus. So it is thought that unborn babies can hear and are affected by sounds whilst in the womb.

Influences on the unborn baby

During pregnancy, what the mother eats, drinks and takes into her body has been shown to directly affect the unborn child. Other substances like smoking, alcohol and drugs have a negative influence on an unborn baby.

The placenta transports nutrients and oxygen to the foetus, and removes metabolic waste products and carbon dioxide. However, it cannot differentiate between nutrients and harmful products, such as nicotine, alcohol or drugs. If the mother uses these substances during pregnancy, they will most likely pass through the placenta to the foetus causing great harm to the unborn child.

Pregnant mothers who drink alcohol during pregnancy may cause irreversible birth defects in their unborn babies. This is called Foetal Alcohol Syndrome.

VISIT

The University of Stellenbosch has a website on FAS

bit.ly/16DEdQk

Prevention of pregnancy and contraceptives

Anyone who is sexually active and who wants to prevent an unwanted or unplanned pregnancy can take certain precautions.

There are a range of different contraceptives that can be used to prevent pregnancy. There are four different types of contraceptives:

1. **barrier** - physically prevent sperm from reaching uterus
2. **hormonal** -prevent ovulation and fertilisation in the female using hormones
3. **intra-uterine devices**- prevent the embryo implanting
4. **sterilisation** - by surgery in men and women which is permanent and not reversible

ACTIVITY: Describing different contraceptives

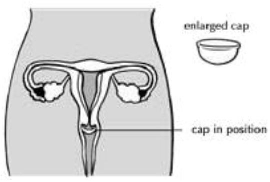
INSTRUCTIONS:

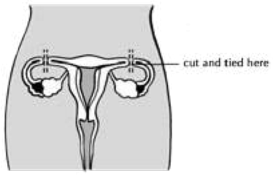
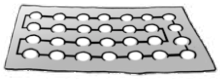
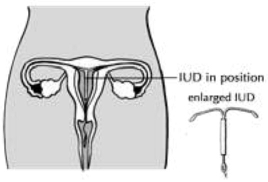
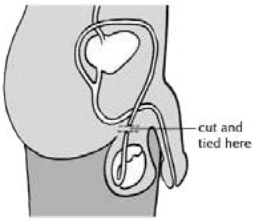
1. In the following table, several different types of contraceptives have been listed, along with a picture and description.
2. You need to read the information, look at the images and classify the types of contraceptive as one of the following:

   a) barrier
   b) hormonal
   c) intra-uterine device
   d) sterilisation

TAKE NOTE

'Contra-' means against, so 'contra-ception' means against conception.

Contraceptive	**Description**	**Classification**
Male condoms 	These thin sheaths of rubber are placed over the erect penis before inserting it into the vagina. When the male ejaculates the sperm and seminal fluid is caught in the condom and cannot enter the cervix.	
Diaphragm 	The diaphragm is a small rubber cap that is placed at the entrance to the uterus before sexual intercourse to create a seal and prevent sperm from entering the uterus.	

Tubal ligation in women 	A surgical procedure in women in which the the oviducts are cut and tied which prevents mature eggs from reaching the uterus for fertilisation.	
Oral contraceptive pill 	Often referred to as "the Pill", it is taken every day by mouth. It contains a combination of female hormones which prevents ovulation each month.	
Female intra-uterine device (IUD) 	A small 'T'-shaped device is inserted into the uterus and prevent fertilisation. It is a long-acting, reversible contraception as the device may be removed again. It is not suitable for women who have not yet had a baby and must be inserted by a doctor.	
Vasectomy 	A surgical procedure in males in which the vas deferens is cut and tied. Sperm are therefore prevented from becoming part of the ejaculate.	

Sexual intercourse with many different partners is very risky behaviour as there are many diseases that are transmitted through the fluids involved in the sexual act. We call these **Sexually Transmitted Diseases** (STDs). There are many different STDs, for example; HIV/AIDS, Herpes virus, Syphilis, Gonorrhoea and genital warts.

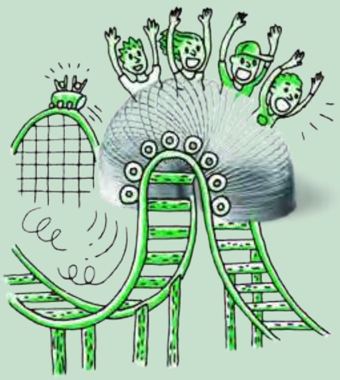
Being faithful to one partner limits your chances of contracting STDs. If you know that your partner has an STD he or she can either get medical treatment for this and/or you can take the necessary precautions to prevent contracting the disease. One of the most popular precautions to prevent the transmission of STDs is for the male partner to wear a condom. However, condoms can break and this can expose you to an STD, so you still have to be careful.

Choices regarding unwanted pregnancies

Many women who become pregnant might feel that they do not want or cannot care sufficiently for their unborn baby. Some may feel that they do not have the money to support another baby if they already have other children. When teenage girls become pregnant, many might feel that they would still like to complete their schooling and could not also raise a child. Other women might not want the baby as it might possibly be a result of rape or incest. Many women have many different reasons why they do not want to be pregnant or raise a child.

There are of course various choices that they can make in such a situation.

- **Adoption** - where the baby is given to another family who want to adopt him or her.
- **Leaving the baby in a place of safety** while remaining anonymous. The baby will then be put forward for adoption.
- **Parenting** - keeping the baby with the support of the extended family.
- **Abortion** - terminating the pregnancy by removing the embryo from the mother's uterus.



ACTIVITY: Forum discussion

Hold a forum discussion regarding the choices women have when they do not want to be pregnant or raise a child. Before the discussion, do research and interviews with your parents or caregivers, with health professionals or ask your Life Orientation teacher.

How to hold a forum discussion:

In a forum discussion, experts are asked to sit on a panel and give their opinion about a particular topic. There are specific roles in a forum discussion:

- **Moderator**: This person keeps the discussion focused and on track.
- **Participants**: The experts. This will be you, the learners, after you have conducted your research.

1. Work in groups of 6.
2. Choose a moderator.
3. Discuss the different choices that women have regarding unwanted pregnancies using the information you obtained from the interviews you conducted.

Rules for a forum discussion:

1. The speakers need to take turns to give their opinions.
2. Treat everyone with dignity and respect. Speak politely.
3. Use the correct scientific terminology.

Record your findings:

Use the space below to record the findings from the forum discussion explaining what choices women have when faced with an unwanted pregnancy.

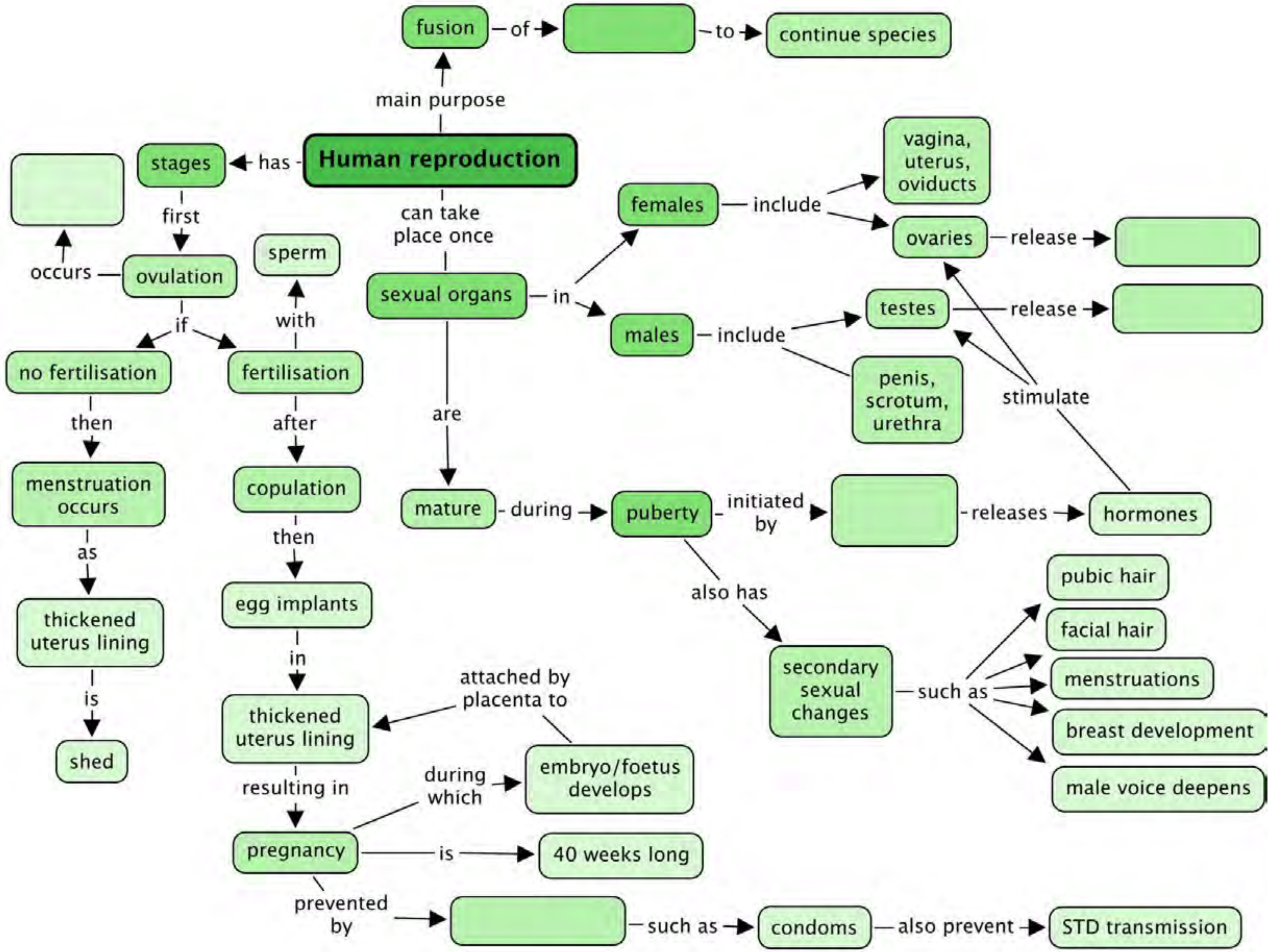
SUMMARY:

Key Concepts

- The main aim of human reproduction is to produce babies to continue the species.
- In human reproduction, two gametes (the sperm and egg cell) fuse during conception to form a zygote, that will eventually become a new baby.
- Puberty is the stage in the human life cycle when the sexual organs mature and prepare for reproduction.
- The pituitary gland below the brain releases hormones that stimulate the testes and ovaries to release hormones that will start the production of sperm in the male and the maturation of ova (egg cells) in the female.
  - In males, the hormone testosterone stimulates the testes to produce sperm.
  - In females, the hormone oestrogen stimulates the ovaries to produce mature ova.
- Testosterone and oestrogen cause different secondary changes in the body.
  - Females begin to menstruate, grow breasts and grow pubic and underarm hair, and may experience acne.
  - Males grow hair on the pubic area, on the face, chest and underarms, develop a deep voice and may develop acne.
- The male reproductive organs are: penis, sperm duct (vas deferens), testes, scrotum and urethra. Sperm is produced in the testes.
- The female reproductive organs are: vagina, cervix, uterus, oviducts (Fallopian tubes) and the ovaries. Ova are produced in the ovaries.
- Stages in the reproductive cycle include: ovulation→ copulation→ fertilisation → embryo implants in uterus → results in pregnancy → gestation lasts 40 weeks → childbirth
- Pregnancy can be prevented by using contraceptives. Condoms prevent the sperm from reaching the ovum and also prevent the spread of STDs.
- Pregnant women have various options if they do not want to keep their babies. Very early in the pregnancy they can undergo an abortion. They may also give the baby up for adoption.

Concept Map

This concept map shows all that we have learned about reproduction in humans. Complete it by filling in the blank spaces. You might find this quite tricky, but you need to learn to "read" a concept map by constructing sentences. For example, "**Human reproduction** can take place once **sexual organs** are **mature**. They mature during **puberty** which is initiated by .... The .... releases **hormones** which stimulate the **ovaries** and **testes**." What is this gland which initiates puberty and releases hormones, and which hormones do the ovaries and testes release? Fill this in below.



Human reproduction
main purpose
fusion
of
to
continue species
has
stages
first
ovulation
occurs
if
no fertilisation
then
menstruation occurs
as
thickened uterus lining
is
shed
fertilisation
with
sperm
after
copulation
then
egg implants
in
thickened uterus lining
attached by placenta to
embryo/foetus develops
resulting in
pregnancy
during which
is
40 weeks long
prevented by
such as
condoms
also prevent
STD transmission
can take place once
sexual organs
in
females
include
vagina, uterus, oviducts
ovaries
release
males
include
testes
release
penis, scrotum, urethra
stimulate
are
mature
during
puberty
initiated by
releases
hormones
also has
secondary sexual changes
such as
pubic hair
facial hair
menstruations
breast development
male voice deepens

REVISION:

1. Explain the changes that occur to the male and female body during puberty. [10 marks]

2. Describe the hormonal control of the start of puberty. Name the organs involved and the hormones. [5 marks]

3. At what stage of the reproductive cycle can one say that a woman is pregnant? [1 mark]

4. There is a urban legend or myth that says that a girl cannot fall pregnant the first time she has sexual intercourse. Think carefully about everything you have learnt about conception and fertilisation, and discuss whether this myth is true or false. [2 marks]

5. Explain why you think it is important for someone who considers becoming sexually active to know how reproduction occurs in humans. [1 mark]

6. Imagine someone who has many sexual partners asks you for advice on which contraceptive to use. What advice would you give them? [3 marks]

7. Some people have religious reasons for not using contraceptives. Decide whether you agree with them or not and why. Write a short letter to the editor of local newspaper expressing your concerns about contraceptives from this specific point of view. [6 marks]

8. Do you think schools should teach learners about different contraceptives? Why do you say so? [3 marks]

9. During pregnancy the pregnant mother needs to take care of herself in order to provide a healthy and safe environment for the unborn child. Your local clinic has asked you to produce a brochure that they can display in their waiting room for first-time mothers. Write a detailed list of instructions for a pregnant woman explaining what she needs to do to keep herself and her unborn baby healthy. You can chose how you want to do this - perhaps a list of "Do's" and "Dont's", or else provide some headings under which you can list some instructions such as "Diet" , "Lifestyle", etc. [6 marks]

Total [37 marks]

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

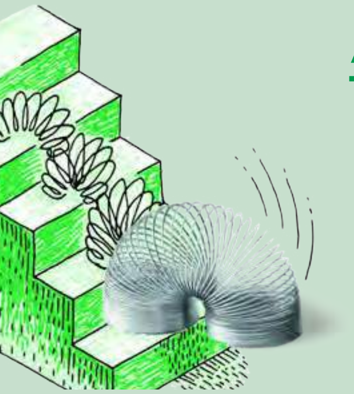
4 Circulatory and respiratory systems

KEY QUESTIONS:

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

If we do not get oxygen for a few minutes, humans get permanent brain damage and may die. Cell respiration needs a constant oxygen supply to provide us with enough energy, so we constantly need to breath and keep blood circulation going to deliver this oxygen and remove the carbon dioxide.

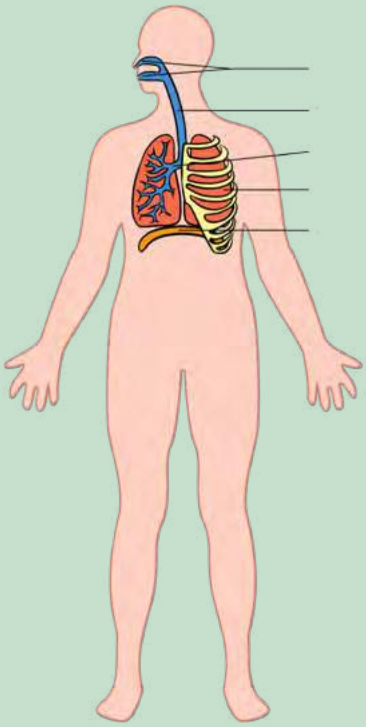
The respiratory and circulatory systems need to work together. Let's briefly revise the main components involved.



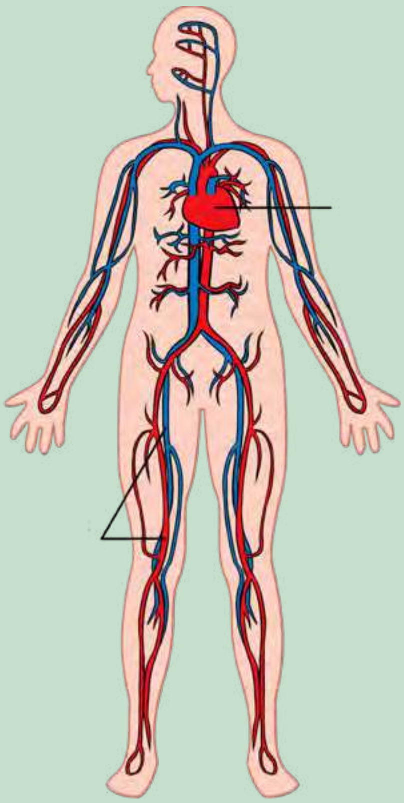
ACTIVITY: Main components in the circulatory and respiratory systems

INSTRUCTIONS:

1. Study the diagrams below.
2. Label the different components that form part of the respiratory and circulatory system.



The respiratory system.



The circulatory system.

NEW WORDS

- blood
- blood vessels
- bronchi
- bronchioles
- diaphragm
- diffuse
- exhale
- (heart) chamber
- heart
- inhale
- lungs
- pharynx
- pulse
- respiration
- trachea

We will now look at these two systems under the following processes:

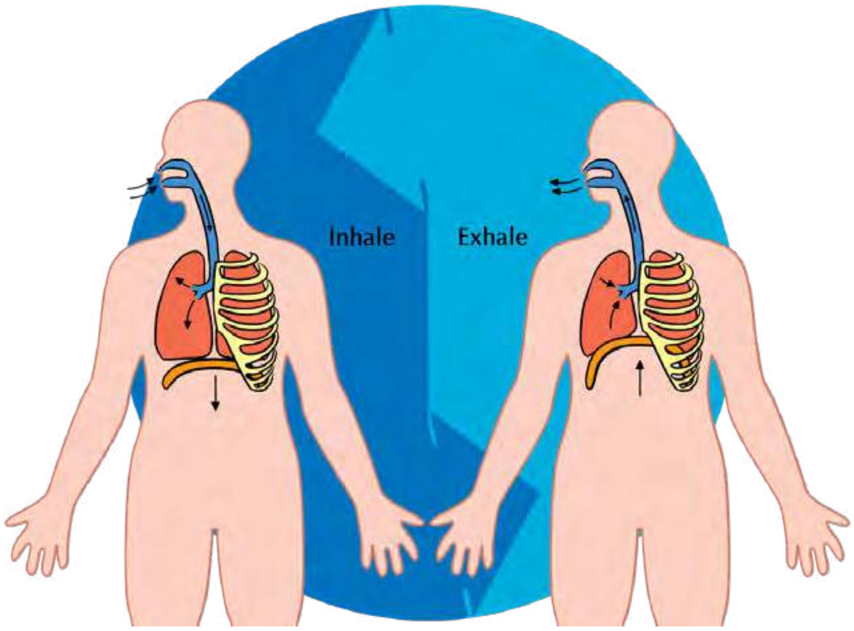
- breathing
- gaseous exchange
- circulation and respiration

4.1 Breathing

We already learnt in Chapter 2 that breathing consists of two processes:

1. inhalation
2. exhalation

When we inhale we take in air with a high concentration of oxygen and when we exhale we breathe out air that has more carbon dioxide in it. These processes take place in a continuous cycle.



During **inhalation** the following takes place:

- The rib cage moves upwards and outwards.
- The diaphragm contracts and flattens causing it to move downwards.
- This causes the chest volume to increase and the pressure decreases.
- As a result the lungs are also pulled to become bigger.
- This allows the air to be pulled into the extra space inside the lungs.

During **exhalation** the following takes place:

- The rib cage moves downwards and inwards.
- The diaphragm also relaxes, causing it to become more dome-shaped
- This causes the chest volume to decrease and the pressure increases.
- As a result the lungs are squeezed smaller
- This forces the air out of the lungs.

ACTIVITY: Summarise breathing using a flow chart

A flow chart allows us to write short summaries of processes that take place. When you study for a test or exam you can picture the flow chart in your head, which often helps to trigger memories of what you learnt.

Use a flowchart to show how breathing (inhalation and exhalation) takes place. You may chose your own design for the flow chart but it needs to show that inhalation and exhalation occur in a cycle.

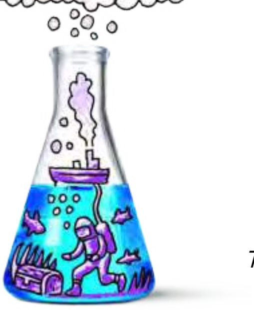
TAKE NOTE

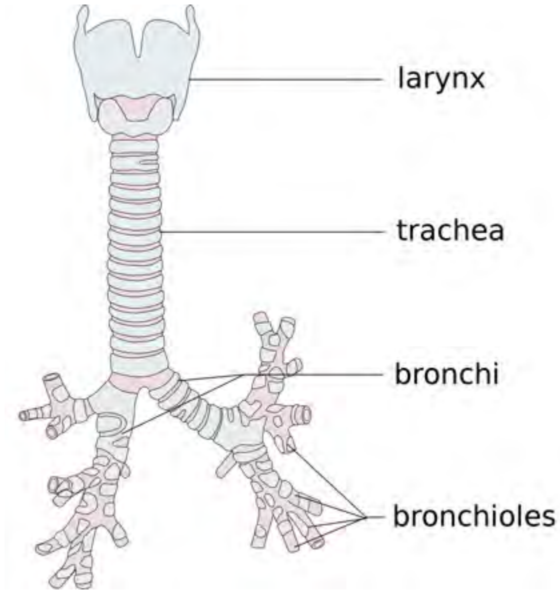
The two tubes that branch from the trachea are called bronchi (plural) or a bronchus (singular).

During inhalation, air travels to the two bronchi - tubes that lead to each lung. The bronchi are themselves branched (divided) into thousands of tiny bronchioles. During exhalation, the reverse takes place as air leaves the lungs and body.

NEW WORDS

- alveoli
- capillaries
- cartilage
- diffusion
- haemoglobin
- red blood cells





This image shows how the larynx joins the trachea which branches into the bronchi within the lungs.

What happens to the air within the lungs?

VISIT

A video on gaseous exchange.

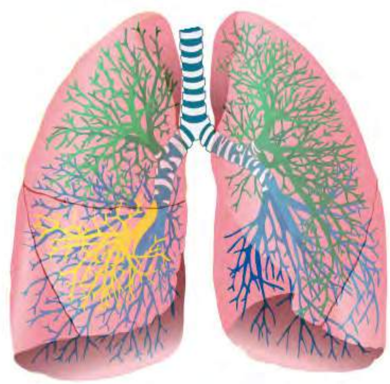
bit.ly/13Znipl

4.2 Gaseous exchange in the lungs

Gaseous exchange takes place in the lungs and in the cells of the body. The structure of the lung is adapted to fulfil the function of gaseous exchange.

Structure of the lung

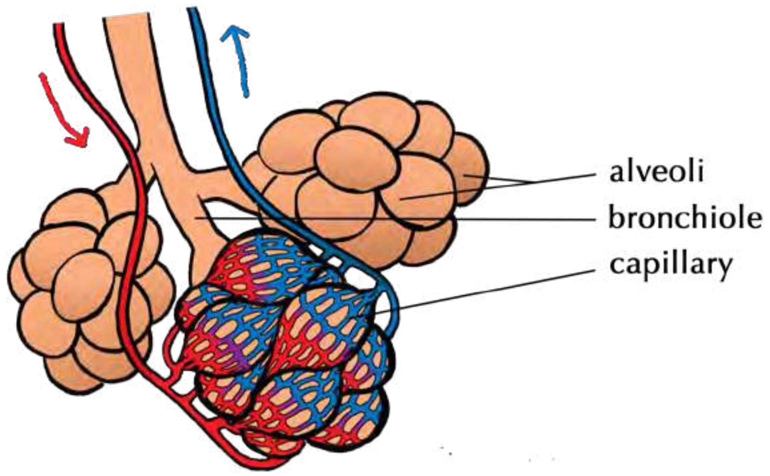
Although the lungs inflate during inhalation and deflate during exhalation, they are not hollow. The lungs in a healthy individual are soft, pink and *spongy*.

External structure of the lungs	Internal structure of the lungs
	

TAKE NOTE

The colours of the different bronchioles in the diagram indicate air travelling to different parts of the lungs.

The alveoli look like small grape-like structures made up of many individual air sacs. An big network of capillaries surrounds each alveolus. Have a look at the following image showing this.



An alveolus is one air sac but a group together (plural) is called alveoli.

VISIT

Watch a video that shows how gases are exchanged at the alveoli
bit.ly/14Fdil2 and
bit.ly/11WcfzA

ACTIVITY: Lung dissection

If you are not able to do this in class, you can watch some of the videos showing a lung dissection.

MATERIALS:

- lung
- tray
- scalpel
- dissecting scissors
- rubber tubing (for example the Bunsen burner tubing) or hose pipe
- ruler
- beaker of water
- water and soap for washing hands
- disinfectant

Health and safety tips:

1. The lungs may carry some bacteria. It is not necessary to wear gloves, as we do not wear gloves when preparing meat in a kitchen, but you must wash your hands thoroughly.
2. Clean all equipment and your work surface with disinfectant after the dissection.
3. Be careful when handling sharp equipment, such as the scalpel.
4. Decide how you are going to dispose of the lungs.

VISIT

Watch this video that shows the structure of the lungs
bit.ly/17gByw6

INSTRUCTIONS:

Part 1: Preparation:

1. Place the lung on the tray on your workbench.
2. Make sure all your dissecting instruments have been disinfected and are sharp. Lay them out next to your tray.
3. Make sure you have access to a first aid kit if necessary.

Part 2: External structure

1. Take note of the external structure of the lung. Look at the general shape, colour and texture.
2. If you have access to a scale, measure the mass of the lung.
3. Use your ruler to measure the length of the lung.
4. Identify the following parts of the lung
   a) The **trachea** (wind pipe) which is the main tube bringing air into and out of the lungs
   b) The **hard rings** in the trachea. What do you think these rings are for?

5. The **bronchi**. There are two bronchi that branch off from the trachea - one to each lung.
6. See if you can identify the first bronchioles branching off from the bronchi.
7. Are there any **blood vessels** visible that are attached to your lung? If so, feel these vessels and describe what you feel.
8. Use the rubber tubing or straw or hose pipe and insert this into the tube leading into the lung and hold the trachea tightly closed around the pipe. Blow on the end of this tube to see if you can inflate the lung. Do not breathe the air back into your own lungs!

Part 3: Internal structure

1. Using the scalpel and dissecting scissors, cut down into the lung.
2. Observe the inner tissue of the lung and think how you would describe it. Discuss this with your group.
3. Cut out a piece of the lung tissue and feel for tiny bronchioles (they feel like little hard lumps in the soft lung tissue). Place this piece of lung tissue into a beaker of water. Observe the piece of lung tissue. Does it float or sink?

QUESTIONS:

1. Write a description of the look, feel and colour of the lung you observed. If you were able to measure the mass, write it down, and include the length of the lung in centimeters.

2. What structures made the trachea stay open, but still able to bend?

3. When you cut the lung open, was it like a hollow balloon or bag, or was it spongy inside? What else did you observe when you cut the lung open and observed the inside?

4. When you placed a piece of the lung tissue into water, why do you think it floated?

5. When you blew air into the lung, what did it look and feel like? Did you have to squeeze the lung to force the air out again?

6. In a human, what is responsible for pushing the air out of the lungs?

VISIT

Watch an interesting clip about the amazing molecule haemoglobin which transports oxygen around the body!

bit.ly/160vSHr

The process by which gaseous exchange occurs is called **diffusion**.

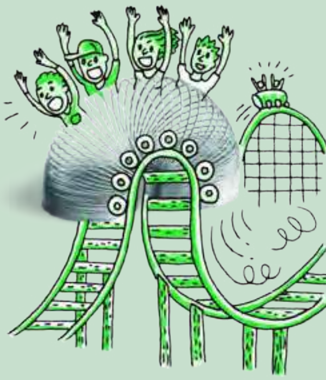
How does diffusion work?

The movement of particles from an area where there is a high concentration to where there is a low concentration is called **diffusion**.

In the lung, each alveolus is surrounded by a network of capillaries. The two gases which diffuse between the alveoli and the blood in the capillaries are oxygen and carbon dioxide.

- oxygen diffuses into the cells of the alveolus and then into the blood in capillaries
- carbon dioxide diffuses out of the blood and into the cells of the alveolus, then into the air

ACTIVITY: Drawing gaseous exchange in the alveoli



INSTRUCTIONS:

1. Draw a diagram to show alveoli surrounded by a capillary.
2. On this diagram, name the gases and indicate the direction in which the gases diffuse.
3. Indicate whether the blood is oxygenated or deoxygenated in the capillaries that travel towards and away from the alveolus.

1. Give your diagram a heading.

NEW WORDS

- arteries
- atrium
- blood pressure
- veins
- ventricles

4.3 Circulation and respiration

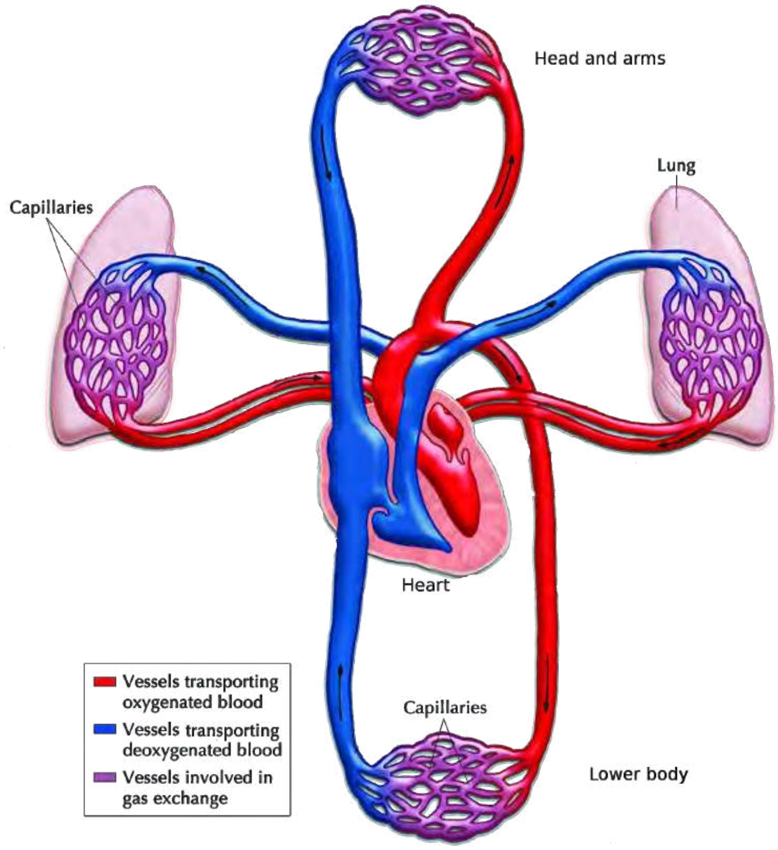
Blood is continually circulated to support cell respiration. Let's have a look at how this takes place.

Blood circulation from the lungs to the heart

The heart pumps the blood around your body by rhythmic, repeated contractions. This is felt as your **heart beat**.

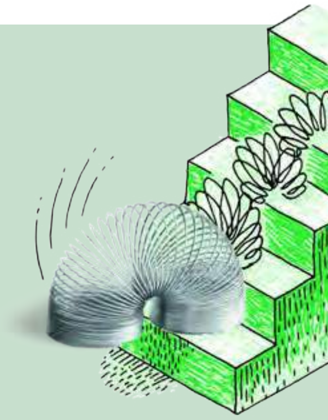
The oxygenated blood flows from the lungs to the left side of the heart. The left side then contracts to pump the blood out of the heart and into the aorta. The aorta is the main artery leaving the heart.

Have a look at the adjacent diagram which shows how the blood flows from the lungs to the heart and then to the rest of the body.



Let's take a closer look at the structure of this vital organ in the circulatory system.

ACTIVITY: Heart dissection



MATERIALS:

- heart (sheep or pig)
- tray
- scalpel
- dissecting scissors
- rubber tubing (for example the Bunsen burner tubing) or straw
- ruler
- beaker of water
- water and soap for washing hands
- disinfectant

Health and safety tips

As with the lung dissection, the same health and safety tips apply to the heart dissection.

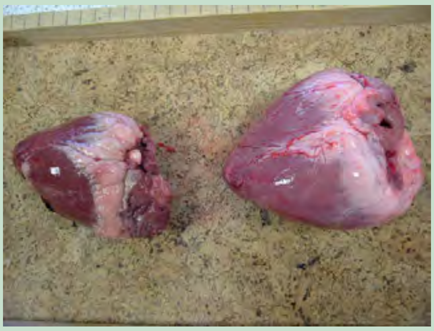
INSTRUCTIONS:

Part 1: Preparation:

1. Place the heart on the tray on your workbench.
2. Make sure all your dissecting instruments have been disinfected and are sharp. Lay them out next to your tray.
3. Make sure you have access to a first aid kit if necessary.

Part 2: External structure

1. Take note of the external structure of the heart. Look at the general shape, colour and texture.



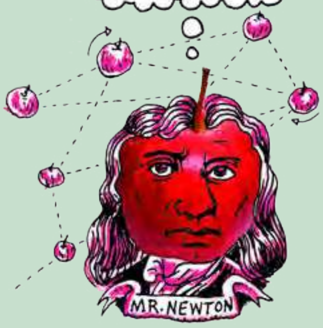
Two animal hearts on a tray.

2. If you have access to a scale, measure the mass of the heart.
3. Use your ruler to measure the length of the heart.
4. Identify the following parts of the heart:
   a) There are blood vessels entering and leaving the heart (**arteries and veins**). Arteries have much thicker, more rubbery walls than veins which have thin walls. See if you can identify the difference.

b) Place your fingers inside the blood vessels to feel their texture and strength. Look inside the main arteries and veins as well and describe what you see to your group. Place your one finger down the aorta and see if you can feel any structures. The following photo shows the aorta opening.

DID YOU KNOW?

The average human heart, beating at 72 beats per minute, will beat approximately 2.5 billion times during an average 66 year lifespan.



Can you see the large opening of the aorta?

5. Examine the **surface** of the heart for blood vessels. Why do you think the surface of the heart also has blood vessels attached to it?

Take note of the surface of the heart and the blood vessels attached to it.

VISIT

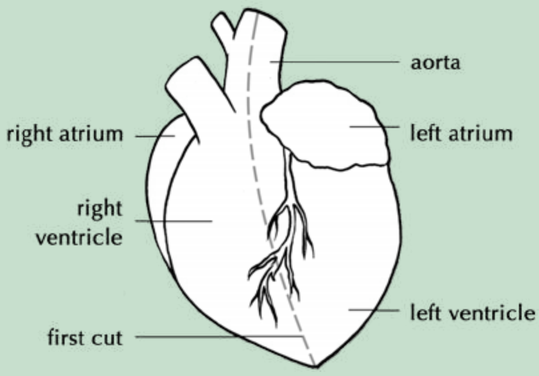
Watch this video to see how blood is pumped through the four chambers of the heart

bit.ly/16DEtyM

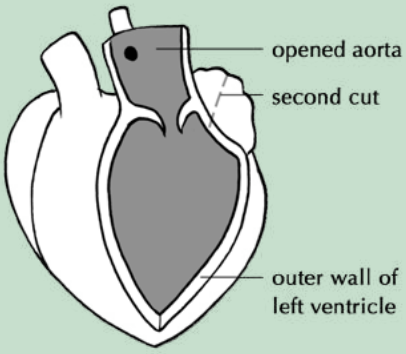
6. Locate the **atria** and **ventricles**.
7. Locate which is the right and which is the left hand side of the heart.

Part 3: Internal structure

1. We are now going to cut into the heart to view the internal structure. Use the following diagrams to help you orientate the heart before cutting.
2. Make a cut down the aorta and then through the left ventricle to the tip of the heart. A tip is to first cut through the aorta using scissors, and then to cut through the left ventricle using the scalpel.



3. Once you have made the cut, pull the ventricle walls apart so that you can view the inside. Can you see the structures at the base of the aorta that you felt in Part 1 (step b)? What do you think these structures do?
4. Look at the following diagram to make the second cut upwards into the left atrium.



5. Using your ruler, measure the thickness of the left atrium wall and the left ventricle wall. Write these measurements down.
6. You can now cut open the right side of the heart in the same way. Measure the thickness of the right ventricle wall. The following diagram provides a detailed overview of the internal structure of the heart. We have not discussed all of these structures and you are not required to know all of these. However, for this dissection, use this diagram to see how many of these parts you can identify in your dissected heart. If you are able to locate them in the actual heart, draw a ring around the label in the following diagram.

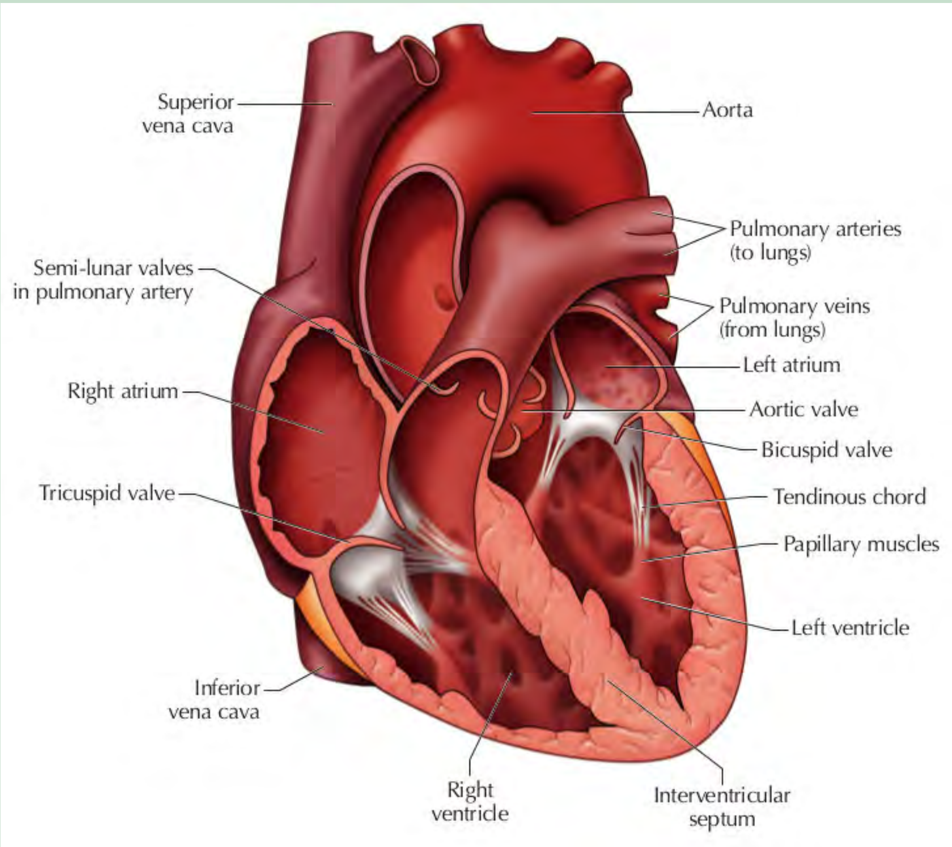


Diagram of the internal structure of the heart.

QUESTIONS:

1. Write a description of the look, feel and colour of the heart you observed. If you were able to measure the mass, write this down, and include the length of the heart in centimeters.

___

___

___

2. Write down the thickness that you measured for the left ventricle and atrium walls. Why do you think there is a difference in the thickness of these walls? Hint: Think back to where the atria have to pump the blood and where the ventricles have to pump blood.

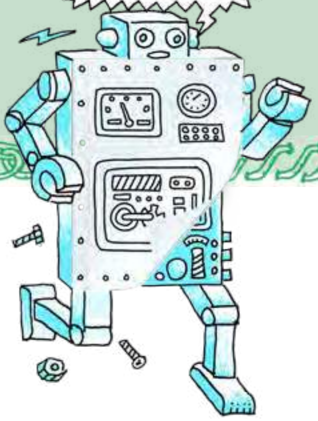
___

___

___

TAKE NOTE

Remember that arteries carry blood AWAY from the heart and veins carry blood towards the heart.



3. Write down the thickness that you measured for the right ventricle wall. Mention possible reasons for the difference in thickness between the left and right ventricle walls. Once again, think about where each ventricle is pumping blood to.

___

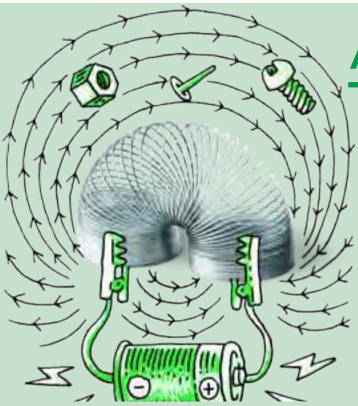
___

___

Once the blood is pumped out of the heart, it enters the circulatory system in the body.

Blood circulation from the heart to the rest of the body

Once blood leaves the heart in the aorta, this main artery branches into smaller arteries which form a network throughout the body.



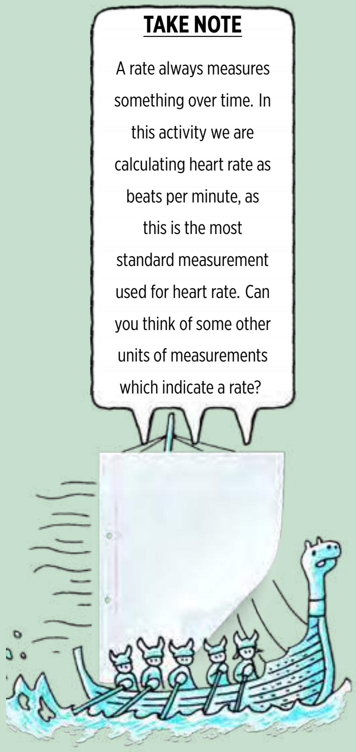
ACTIVITY: Feel your blood rushing through your body!

INSTRUCTIONS:

1. Put your index (pointer) and middle fingers against your neck in the hollow between your trachea (windpipe) and the large neck muscles. Use your finger tips as these are more sensitive. You should feel the throbbing of your blood.

Measuring heart rate in the wrist.

2. Can you find your pulse in your wrist? Place your middle and index fingers just below the creases in the skin of your wrist - on the side of your thumb. Press lightly until you feel the pulse which means the blood is pushing under your skin.
3. You can also try and find your pulse behind your knee, on the inside of your elbow or near the ankle joint.
4. Each throb of your pulse is when your heart pumps the blood from the left side of your heart into the arteries of your body, causing the pressure in the arteries to rise.



QUESTIONS

1. Count how many times your heart beats in one minute. Alternatively, count your heart beats for 30 seconds while a friend or your teacher times you, and write the number on the line below.

---

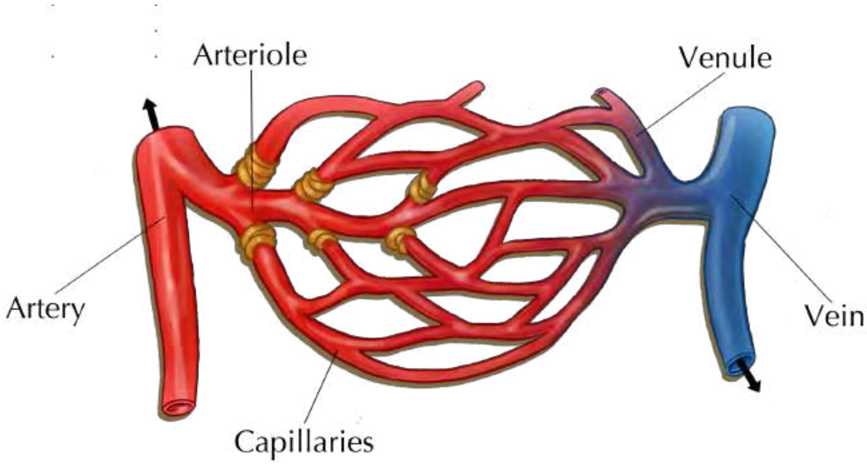
2. Now, calculate your heart rate in beats per minute and write your answer on the line below.

Arteries then subdivide to form capillaries. Capillaries are in close contact with the body cells. Capillaries are much smaller than arteries. They form a fine network throughout the body's cells to make sure that all cells get a supply of blood and oxygen.

The capillaries leaving the cells with deoxygenated blood then combine to form form veins. Veins from the body carry deoxygenated blood back to the heart.

TAKE NOTE

An exception to the rule of arteries carrying *oxygenated* blood, are the pulmonary arteries which carry deoxygenated blood away from the heart to the lungs to become oxygenated.



Arteries

- Arteries transport blood **away** from the heart.
- Arteries transport oxygenated blood (except for the pulmonary arteries).
- Arteries need to have strong muscular walls because they carry blood away from the heart under high pressure.

DID YOU KNOW?

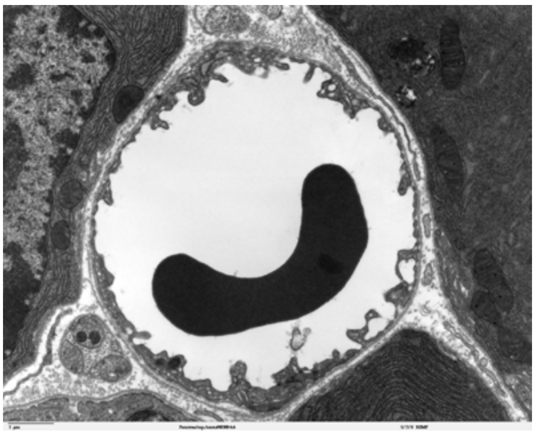
If you put TEN capillaries next to each other, together they would only be as thick as ONE human hair!

Veins

- Veins transport blood **towards** the heart.
- Veins transport deoxygenated blood (except for the pulmonary veins).
- The blood is flowing back to the heart and therefore the blood pressure in the veins is much lower.

Capillaries

- Capillaries form webs or networks around each cell to ensure that all cells receive nutrients and oxygen.
- Capillaries are much smaller than veins and arteries.



This transmission electron micrograph shows a cross section through a capillary. The semicircular black structure within the capillary is a red blood cell. This shows how small capillaries are. They are only just wider than a red blood cell.

ACTIVITY: Tabulating differences between the blood vessels

INSTRUCTIONS:

1. Compare arteries, veins and capillaries.
2. Use the following table in which to do this comparison.

Blood vessel type	**Artery**	**Vein**	**Capillary**
Image			
Function			
Type of blood			
Exceptions			

TAKE NOTE

Page back to Chapter 1 of Life and Living to refresh your memory about the structure of mitochondria.

Respiration within the cells

Within the cells, the mitochondria use oxygen to respire. This is called cellular respiration.

- The mitochondria combine oxygen with food particles, such as glucose.
- Energy from the food particles is released and can be used by the cell to perform various processes.
- During cellular respiration, carbon dioxide is released as a by-product.

The carbon dioxide diffuses from the cells back into the blood in the capillaries. This blood therefore becomes deoxygenated as oxygen has been removed and carbon dioxide is added.

VISIT

An amazing summary video on respiration.

bit.ly/1bmhKdF

Blood circulation from the body back to the heart and lungs

The deoxygenated blood in the body then returns to the right side of the heart through the veins in the circulatory system.

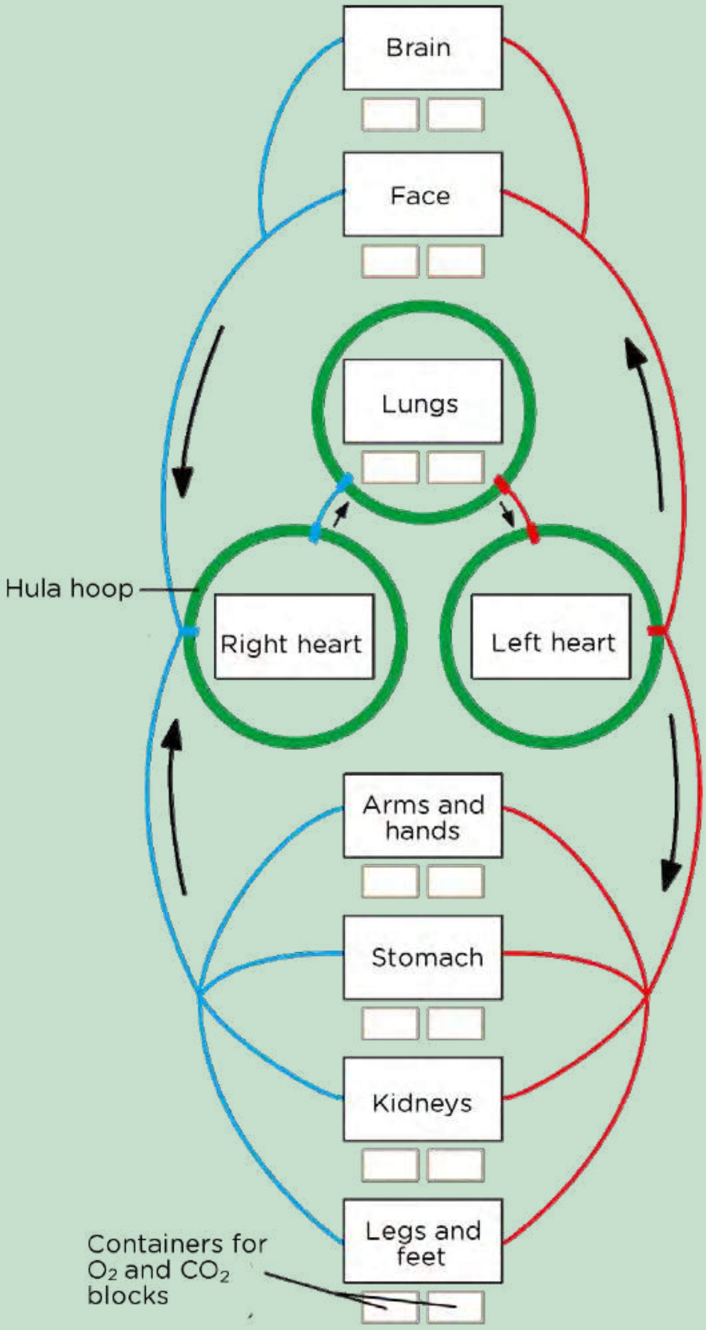
The right side of the heart pumps the deoxygenated blood to the lungs through the pulmonary arteries.

ACTIVITY: A circulation simulation!

We are going to create a simulation of our circulation!

INSTRUCTIONS:

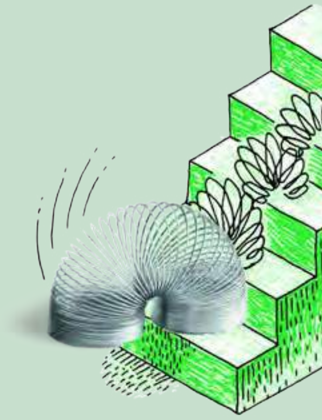
1. Imagine that you are a red blood cell and you will be carrying oxygen around the body.
2. Your teacher will help your class to lay out the huge body in an open space using A4 sheets with labels and hula hoops as in the following diagram.
3. There are two colours of paper blocks at each organ or body part and in the lungs. One colour will represent oxygen (preferably red) and the other colour will represent carbon dioxide (preferably blue).
4. Start off by standing in the lungs and pick up oxygen. You now represent oxygenated blood.
5. Walk to the left side of the heart.
6. The heart now pumps you out to the body in the circulatory system. Leave the left heart hula hoop and walk to the organ or body part you are going to supply with oxygen.
7. When you reach the body part, drop off your oxygen block into the container and now pick up a coloured block representing carbon dioxide. You now represent deoxygenated blood.
8. Walk to the right side of the heart.
9. From here, the heart pumps you to the lungs. Walk to the lungs.
10. At the lungs, gaseous exchange takes place and you drop off the carbon dioxide you were carrying and pick up oxygen again.
11. You can now repeat the cycle and walk to a different body part.



Heart rate

Your resting heart rate is often used as an indicator of how fit you are or whether there are possible health concerns that you should pay attention to.

ACTIVITY: Homework activity to measure your resting heart rate



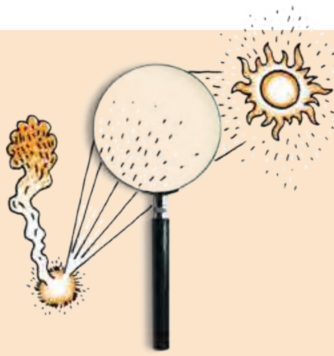
INSTRUCTIONS:

1. Take your resting heart rate first thing when you wake up in the morning. Record how many times per minute your heart beats.
2. Repeat this over 3 days to get an average - this is more reliable than a once-off reading.
3. Record your resting heart rates in the table.

	Heart rate (beats per minute)
Day 1	
Day 2	
Day 3	
Average	

We have now had a look at our heart rate when we are resting. But what happens when we do some kind of physical activity? Will your heart rate increase or decrease? Do you think you could use your heart rate as a measure of how fit you are? Let's investigate!

INVESTIGATION: Measuring and comparing heart rates before and after exercise



INSTRUCTIONS:

Measure the heart rate of at least 10 learners in your class after they have done 2 minutes of skipping or running on the spot. Discuss in your group how you are going to do this and write down your method. Record your measurements and use a graph to display your findings. Make deductions about your class' fitness levels based on their heart rates after completing the graphs and discuss the benefits of exercise for the circulatory and respiratory system (also known as the cardiovascular system).

AIM:

1. What is the aim of your investigation?

HYPOTHESIS:

1. What is your hypothesis for your investigation?

VARIABLES:

In any scientific investigation, it is crucial to identify the variables at the start.

- When you do an investigation you are going to change or vary one factor to answer your question. This is called the **independent variable**.
- The factor that you are measuring or observing is the **dependent variable**.
- Normally, you will have a third variable, the **control variable**. These are the factors that you want to keep the same (unvaried) during your test so they cannot affect your results.

1. What are the variables involved in this investigation?

MATERIALS:

Write a list of the materials you will need for this investigation.

Possible materials to be listed are:

- stopwatch
- skipping rope (if learners are to skip, otherwise they may just run on the spot)
- recording sheet and pen

METHOD:

1. Write down the method below. The steps must be numbered.

RESULTS:

1. Design a table that will record the heart rate of the 10 learners when at rest and after 2 minutes of physical activity (skipping or jogging on the spot). Remember to give your table a heading.

ANALYSIS:

In order to analyse your results, it is helpful to plot a graph as this helps you to see the relationship between the dependent and independent variables and to make comparisons. Below is a description of different types of graphs and when they are used.

- **Line graph:** A line graph is used if the data you have is numerical and changes continuously, often over time. A line graph is useful for visualising a trend in the data over time.
- **Bar graph:** A bar graph is used to compare different categories or groups, normally when the categories are words. There are spaces between the bars in a bar graph.
- A *double* bar graph can compare two sets of data. In a double bar graph, two of the bars touch and are shown in different colours, and are separated by a space from the next two bars.
- **Histogram**: A histogram is used when the data for the independent variable is numerical and can be grouped into categories which are continuous. The bars in a histogram touch each other.
- **Pie graphs:** Pie graphs (or sector diagrams) are used to show the relative proportions or percentages of the categories when they make up a whole.

1. Which type of graph will you use to represent the data in this investigation? Give a reason for your answer.

___

___

___

2. How will you differentiate on your graph between the two sets of measurements for each learner (ie. heart rate before and after exercise)?

___

___

___

Tips for drawing your graph:

- Start by giving your graph a title, something that shows which dependent and independent variables you were studying.
- Use the appropriate axes for each variable: x-axis = independent variable (along the bottom of the graph) and y-axis = dependent variable (along the side).
- Label your x-axis and y-axis.
- Use an appropriate scale and use the space that you have been given to draw the graph wisely.

Draw your graph on the graph paper provided.

1. Which learner in your group had the smallest increase in heart rate from before to after physical activity?

2. Which learner in your group had the largest increase in heart rate from before to after physical activity?

3. Rank the learners in your group from the smallest increase to the largest increase.

4. What deductions can you make about the fitness level of the learners in your group based on their heart rates before and after the physical activity? When you make deductions, ask yourself these questions:
   a) What do you see is happening?
   b) What do you notice that is different?
   c) What does this imply?

DISCUSSION AND EVALUATION:

An important part of an investigation is to discuss your results and observations and evaluate them. At this point you get to talk about your results and explain them.

You also point out any shortcomings of the investigation. What could you have done to improve the investigation? You can also point out any unexpected results in your investigation and try to explain these using your science background. You should do some background research into the benefits of exercise for the cardiovascular system and write some points in your discussion.

CONCLUSION:

Write a conclusion for your investigation. In a conclusion, you need to refer back to your hypothesis to see whether your results support or reject the hypothesis.

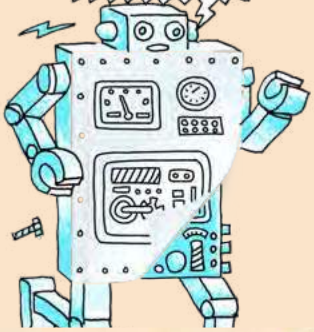
REFERENCES:

If you researched any additional information to support your discussion, you need to reference these sources in the following way:

- **Books:** Surname of author, Name of book, Year published, Name of publisher, Page numbers you used.
- **Internet:** Give the full URL for the website.
- **Person:** Personal communication with "Name, Surname, Occupation."

TAKE NOTE

Simply listing Google or Wikipedia as your source is not recognised as a reference for your work.



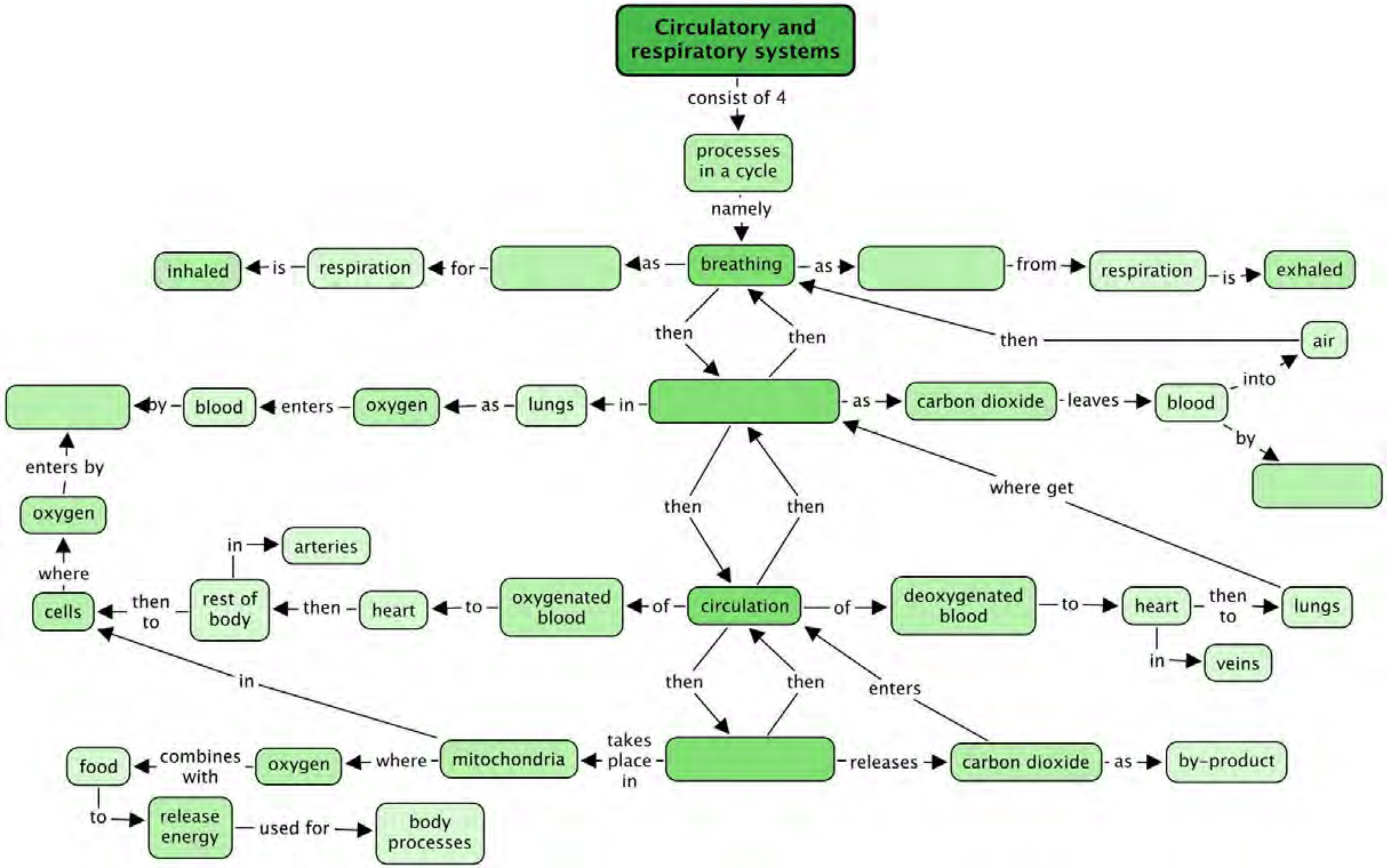
SUMMARY:

Key Concepts

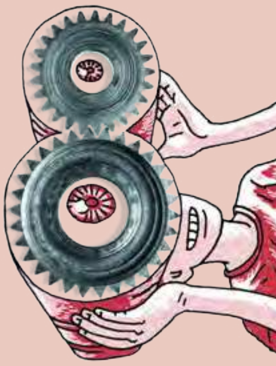
- Oxygen is inhaled in a process called breathing.
- In the lungs, gaseous exchange occurs by diffusion.
- Oxygenated blood is transported in pulmonary veins from the lungs to the left side of the heart.
- The oxygenated blood is pumped through the aorta and arteries to the different parts of the body.
- Arteries divide into capillary networks between the cells, where oxygen and food diffuse from blood to cells.
- The cells carry out cell respiration, forming carbon dioxide, which diffuses back to the capillaries.
- Capillaries flow into veins that carry the deoxygenated blood to the right side of the heart.
- At the heart the deoxygenated blood is transported to the lungs by the pulmonary artery where gaseous exchange takes place once more.
- The carbon dioxide from cellular respiration diffuses out of the blood into the lungs and is exhaled.

Concept Map

From what we have learnt in this chapter, we can say that the circulatory and respiratory systems consist of 4 processes which occur in a cycle. Two of these processes are named in the concept map, and there are spaces to write the other two. During breathing, what is the gas which is inhaled for respiration, and which is the gas which is exhaled from respiration? Fill these in too. What is the name for the process by which these gases move across the cell membranes?


Circulatory and respiratory systems
consist of 4
processes in a cycle
namely
breathing
as
for
respiration
is
inhaled
as
from
respiration
is
exhaled
then
then
then
air
in
lungs
as
oxygen
enters
blood
by
enters by
oxygen
where
cells
as
carbon dioxide
leaves
blood
into
by
where get
then
then
circulation
of
oxygenated blood
to
heart
then
rest of body
in
arteries
then to
of
deoxygenated blood
to
heart
in
veins
then to
lungs
then
then
enters
takes place in
mitochondria
in
where
oxygen
combines with
food
to
release energy
used for
body processes
releases
carbon dioxide
as
by-product

REVISION:



1. Draw a flow diagram to show how the different components of the respiratory and circulatory systems function in a cycle. [6 marks]

2. Complete these sentences. Write just the word on the line below. [13 marks]
   a) Oxygen diffuses into the blood from the air in the __________.

   b) The blood vessels that carry blood away from the heart are called __________.

   c) Tiny blood vessels called __________ come into close contact with __________.

   d) Carbon dioxide __________ out of the cells into the __________.

   e) __________ carry the __________ blood to the heart from where it is sent to the __________ to be oxygenated.

   f) The chemical reaction that takes place in the __________ of the cell when oxygen and glucose combine to release __________ is called __________.

3. Complete this table to describe what happens in the chest during breathing. [6 marks]

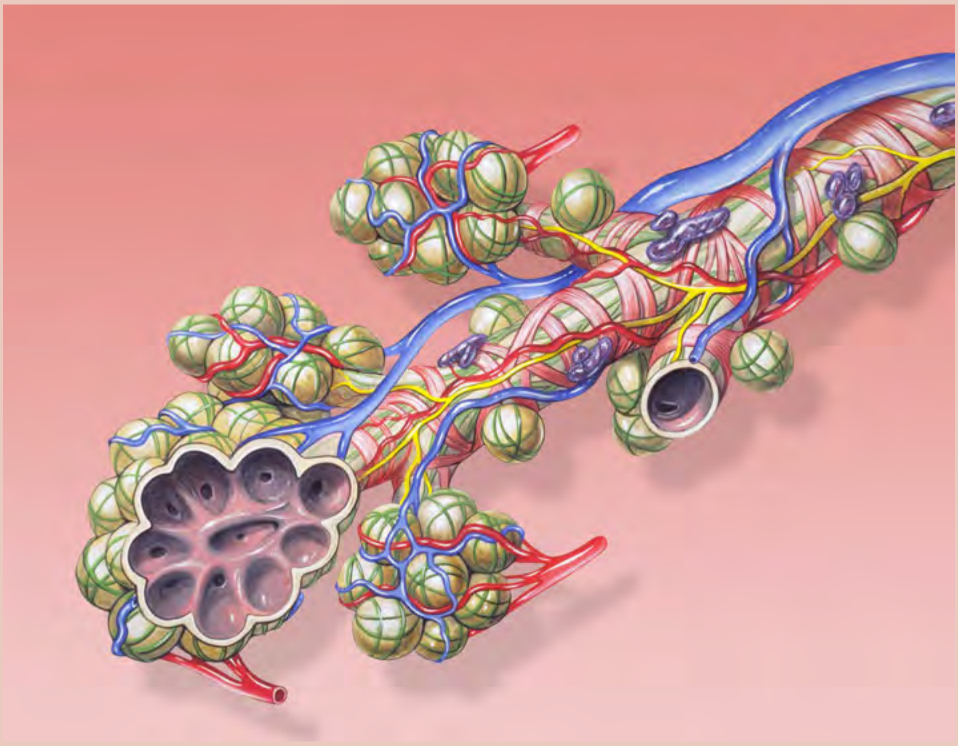
	Inhaling	**Exhaling**
Chest volume		
Pressure on lungs		
Air movement		

4. Match the word on the left to its correct meaning on the right. Write only the letter next to the word to indicate the correct meaning. Use each letter only once. [13 marks]

	breathing	a	arteries, veins and capillaries
	diaphragm	b	the type of tissue that keeps keeps the trachea open
	alveoli	c	small grape-like bunches at the ends of the bronchiole
	trachea	d	the movement of particles through a permeable membrane from a high to a low concentration
	heart	e	the tube that carries air to and from the mouth to the bronchi
	veins	f	blood vessels that transport blood away from the heart
	respiration	h	blood vessels that carry blood towards the heart
	cartilage	i	tubes leading from the trachea into the lungs
	bronchi	j	the process takes place in mitochondria to release energy for the cell to use

	capillaries	k	the organ responsible for pumping blood throughout the body
	types of blood vessels	l	inhaling and exhaling
	diffusion	m	these blood vessels surround alveoli to allow for gaseous exchange
	arteries	n	a large dome shaped muscle across the bottom of the rib cage

5. The following image is an artist's drawing of one of the structures you learnt about in this chapter. What does it represent? Give three reasons for your answer. [3 marks]



6. Describe how capillaries are suited to their function of allowing gaseous exchange within the lungs and at the cellular level in the body. [3 marks]

Total [44 marks]

Are these just cogs? Be curious! What else could they be?

5 Digestive system

KEY QUESTIONS:

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

In this chapter we are going to look more closely at the food we eat to see why certain foods are considered healthy and others unhealthy. We will then investigate how the food from our plates gets to our cells and why our digestive system is so well adapted for its job.

5.1 A healthy diet

Our human bodies are very active. Our bodies need a huge variety of different nutrients and substances in order to perform all these processes. We obtain these nutrients from the food we eat. The human body needs a balanced, healthy diet to keep functioning property.

ACTIVITY: Comparing healthy and unhealthy foods

INSTRUCTIONS:

1. Work with a partner.
2. We often know if a food is healthy or unhealthy. List at least 10 healthy and 10 unhealthy foods in the following table.

Healthy food	Unhealthy food

When you are done share your food list with the class and record the class' ideas of healthy and unhealthy foods on a large sheet of paper or on the board. Display this in the class.

Study the list of healthy and unhealthy food.

1. What common characteristics can you identify in the food that the class listed as healthy?

____

____

____

2. What common characteristics can you identify in the food that the class listed as unhealthy?

____

____

____

NEW WORDS

- balanced diet
- carbohydrates
- dehydration
- diet
- enzymes
- fats
- fibre
- glucose
- iodine solution
- minerals
- nutrients
- protein
- starch
- sugars
- vitamins

VISIT

A simulation about eating and exercise

bit.ly/19buenM

Let's take a closer look at what makes up a healthy diet.

The seven building blocks of a healthy diet

The foods that we eat can be divided into different groups:

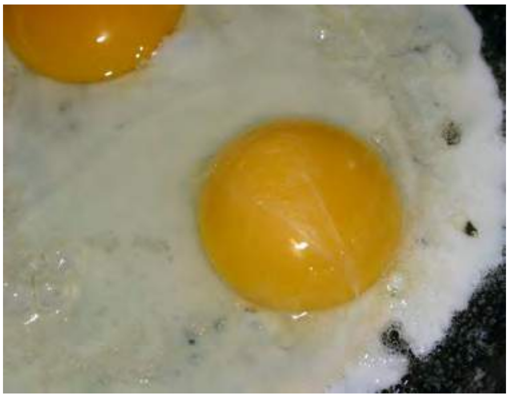
- proteins
- carbohydrates
- fats and oils
- vitamins
- minerals
- fibre (non-digestible carbohydrates)
- water

A healthy diet consists of foods from all of these groups.

Proteins

Proteins are our bodies' building blocks. They build and repair body cells and tissues. Foods rich in protein are: fish, meat, poultry, eggs, cheese and other food from animal sources. There are also many sources of protein from plants. For example: products made from soya beans, peas and beans, nuts and seeds.

Meat.



Eggs.

Almond nuts.

Cheese.

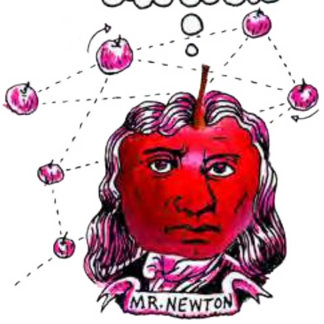
Carbohydrates

Carbohydrates are the main supply of energy for our bodies. They break down in our digestive system to form glucose (which is a sugar). Examples of foods that contain carbohydrates are: whole grain bread, potatoes, pasta, rice, fruit, vegetables, maize and legumes.

Unfortunately many people eat too many carbohydrates, especially processed carbohydrates like sweets and biscuits, chips, pastries, soft drinks and sweetened fruit juices.

DID YOU KNOW?

Often, fruit juice is not the healthiest choice of drink as some fruit juices contain the same amount or more sugar than the average soft drink. The best choice is water!



Whole wheat bread.

Potatoes.

Rice.

Mealies (corn) contain a lot of carbohydrates.

Fats and oils

Fats and oils are important for many body processes:

- Fat protects and insulates your organs
- They help maintaining healthy hair and nails.
- Some vitamins can only be absorbed and transported when attached to fat molecules.
- Fats and oils also provide the body with energy.

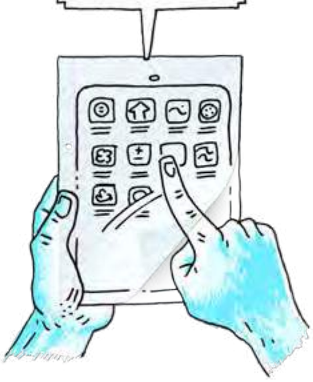
However, some fats are better than others and having too much of any type is not a good idea.

Olive oil and canola oil are both healthy oils.

Sardines are high in healthy fats.

TAKE NOTE

Many people take large amounts of supplements to ensure they get enough vitamins and minerals. However it is rather wasteful as the body excretes any excess vitamins and minerals and only stores a few vitamins like Vitamin A, D, E and K.



Vitamins

Our sources of vitamins are from fruit...

...and vegetables.

Vitamins help with the different chemical reactions in our bodies:

- **vitamin A** helps strengthen our immune system and is good for eyesight in the dark
- **B vitamins** help us process energy from food
- **vitamin C** helps to keep your skin and gums healthy and improves the immune system
- **vitamin D** helps to build strong bones and teeth

Our main sources of vitamins are from fruit and vegetables. The following diagram summarises some of these sources for various vitamins.

Food sources of different vitamins.

Minerals

Our bodies cannot produce minerals and we therefore need to include these in our diets. Some of the minerals we should include in our diets are:

- **calcium** which is essential for strong bones and teeth.
- **iron** which is needed for healthy blood.
- **magnesium** which is used for building strong bones, teeth and muscles.
- **sodium** which is also needed for muscle and nerve function, and more importantly it helps regulate the amount of water in the blood.

There are a variety of sources of minerals. For example, high levels of calcium are found in dairy products, meat is a high source of iron, and magnesium is found in lots of foods such as bananas, nuts, green leafy vegetables and milk. The most common source of sodium is in sodium chloride, which is table salt.

Fibre

Fibre found in the skins of fruit and vegetables, and in wholegrain cereals, cannot be digested. It therefore travels through the alimentary canal. We need fibre in our diet as it helps us to have regular bowel movements and avoid constipation. .

Beans are a good source of fibre.

High fibre breakfast cereal.

Water

Our bodies are made up of more than 50 percent water. Water is necessary to help our blood carry nutrients and waste around the body and to help the chemical reactions that occur in our cells. Water forms most of sweat, saliva and tears.

You need to drink water daily.

ACTIVITY: Comparing meals

INSTRUCTIONS:

1. Below are photographs of different meals for breakfast, lunch and dinner.
2. One of the meals is healthier than the other.
3. Choose which is the healthier option and explain why.

1. **Breakfast:**

Option 1: Fruit loops	Option 2: Fruit salad
	

____

____

____

2. **Lunch:**

Option 1: Hamburger	Option 2: Omelette with salad
	

____

____

____

3. **Supper:**

Option 1: Chicken pieces	Option 2: Beef, peas and rice
	

Different cultures and religions follow different diets. Some cultures will only eat certain types of food and will avoid other combinations. Some religions might restrict their followers to only certain foods while others have no real dietary laws. Within South Africa, we have a very diverse population with people from many cultures, backgrounds and religions. This makes our country a truly unique, diverse and interesting place in which to live!

Testing food

There are various chemical tests which are used to easily identify the type of food molecules present in different foods.

Once such test is the **starch test**. We can also test for the presences of fats and oils using the **emulsion test**.

INVESTIGATION: Which foods contain starch and fats and oils?

In this investigation, learners will be provided with the background information and basic instructions. They will have to design the investigation themselves and then write up their findings in an experimental report.

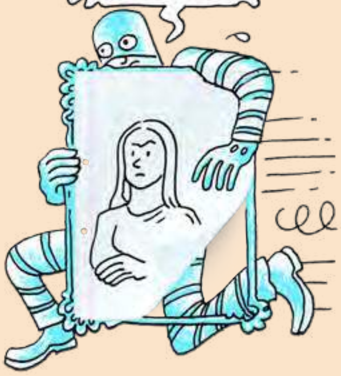
Before the lesson starts, set up each workbench with the materials and apparatus the learners will require to do the food tests.

The materials required are (per learner or group):

- various food items to test for starch: for example, pieces of bread, apple, tomato, boiled egg, cheese, cucumber, potato, yoghurt, ham (some substances must contain starch and some not)
- various food items to test for fats and oil: for example, the above food items can be used, and in addition, you could also provide peanut butter and butter
- petri dish per group or learner for the starch test
- bottle of iodine solution and dropper
- several test tubes for the fat emulsion test
- water
- glass rod (or any other suitable round hard item) for crushing food substances for fat emulsion test
- bottle of ethanol
- forceps

TAKE NOTE

In lower grades you might recall doing the starch test on plants to see which leaves store starch from the glucose produced in photosynthesis.



INSTRUCTIONS:

1. You need to conduct an investigation to test whether the food substances you have been provided with contain starch or fats and oils or both.
2. A summary of each test is given below. You will need to design your investigation and conduct it.
3. Before starting, think about how you will record your results and write out your proposed method.

Starch iodine test:

Iodine solution is an orange-brown colour. When iodine is added to a substance which has starch in it, the iodine reacts with the starch to produce a blue-black colour. The blue-black colour indicates the presence of starch.

Fat emulsion test:

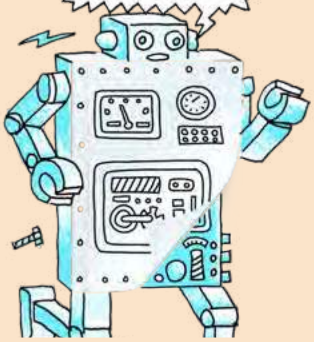
To conduct the test, crush a piece of the food (or liquid) in a small amount of ethanol. Pour some of the mixture onto paper. Once the ethanol has evaporated, oil stains on the paper will indicate the presence of fats or oils in the food.

AIM:

1. What is the aim of your investigation?

TAKE NOTE

If you are allergic to iodine rather observe this experiment and do not participate.



HYPOTHESIS:

1. What is your hypothesis for this investigation?

MATERIALS AND APPARATUS:

List the materials and apparatus you used in this investigation.

METHOD:

Write down the method which you followed in this investigation.

RESULTS AND OBSERVATIONS:

Use the following space to record your results and observations from this investigation.

DISCUSSION:

Discuss and evaluate your results and findings and the importance of food tests.

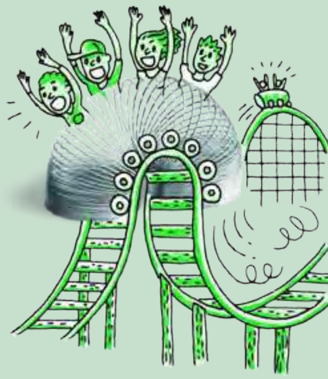
CONCLUSION:

What do you conclude from this investigation?

Health problems relating to diet

In Chapter 2 this term, we looked at some of the health issues relating to the digestive system, such as ulcers, diarrhoea and eating disorders. There are also health issues which arise directly due to your diet. The following activity will introduce you to some of these health concerns.

ACTIVITY: How does your diet affect your health in the short and long term?



INSTRUCTIONS:

1. Below is a table with descriptions of several health issues relating to a poor diet.
2. You need to read the descriptions and use your knowledge of the food groups to then classify what the diet of the person is deficient in, or else has a surplus of in their diet.
3. For some conditions, there may be a variety of causes, but this activity is focusing on the causes related to diet.

Name of health issue	Description	What does this person have a deficiency or surplus of in their diet?
Osteoporosis	Osteoporosis is a disease, most common in older women, where the bones become fragile and are more likely to break. Usually the bones lose density and become porous.	
Anaemia	Anaemia is a condition of the blood when there are not enough healthy red blood cells. A patient feels tired and weak as the tissues and organs in the body are not able to get enough oxygen so respiration slows down.	
Marasmus	This is a severe form of malnutrition due to starvation. The person becomes extremely thin (emaciated).	

Name of health issue	Description	What does this person have a deficiency or surplus of in their diet?
Constipation	A person has constipation when they have a bowel movement less than 3 times per week. The person may have hard stools and difficulty and pain when passing stools.	

NEW WORDS

- digestion
- dissolve
- enzymes
- faeces
- gastric
- peristalsis

5.2 Digestion and the alimentary canal

What is digestion?

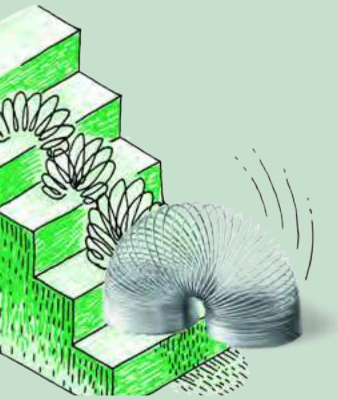
Digestion involves a variety of complex processes that turn the food that you eat into tiny molecules that can then be absorbed and transported to the cells of the body.

There are two types of digestion:

1. **Mechanical digestion** occurs when food is physically broken down through chewing, churning and mashing. Mechanical digestion takes place in your mouth and in your stomach.
2. **Chemical digestion** takes place when different digestive **enzyme s**break down the bits of food into smaller molecules. Enzymes are special proteins that speed up certain chemical reactions in the body. Chemical digestion starts in the mouth where enzymes in your saliva start to break down starch. Chemical digestion also takes place in the stomach and small intestine.

The alimentary canal

We already studied the alimentary canal in Chapter 2 so we'll start by reviewing what we learnt there.



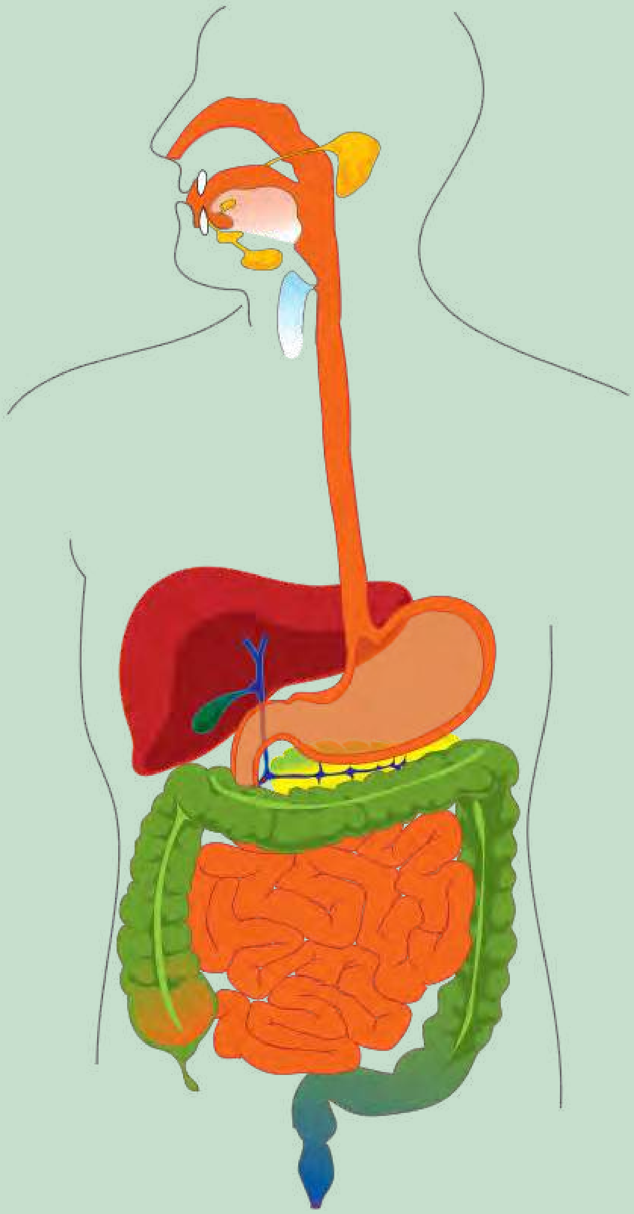
ACTIVITY: The different organs in the digestive system

INSTRUCTIONS:

1. Label the following diagram.
2. The labels have been provided for you. There are some which you might not have come across yet, as they are not the main components in the digestive system, but still play important roles.

Labels to include:

- large intestine
- anus
- oesophagus
- rectum
- stomach
- mouth
- small intestine
- liver
- gallbladder
- pancreas



DID YOU KNOW?

Dr William Beaumont (1785 - 1853) discovered how food is digested in the stomach. He dropped food, attached to silk threads, into the stomach of a patient who had a gunshot wound to the stomach that would not close, and examined what happened.

Let us make a model of the alimentary canal that can demonstrate mechanical and chemical digestion in the different parts, and also learn about how the different parts are structurally adapted to suit their function.

ACTIVITY: A digestion simulation

MATERIALS:

Each group will need the following:

- large dish to work over, or black bags and newspaper
- crackers, white bread or viennas
- mixing bowl
- scissors, pestle and potato masher
- water bottle that can squirt water through a small hole
- the inner tube of a kitchen paper towel roll or toilet paper roll
- a clear plastic Ziplock bag
- 30 - 40 ml of lemon juice, vinegar or a fizzy drink
- full length stocking with the toe section cut open - it helps if one leg is put inside the other to form a double layer
- bicarbonate of soda dissolved in water in syringes (10ml)
- large bowl

VISIT
Take a virtual tour through the alimentary canal
bit.ly/15qh8Oh

INSTRUCTIONS:

1. Work in groups and construct a model to demonstrate the different processes that food goes through in the different parts of the alimentary canal.
2. Make careful observations and describe in detail what happens at each stage.
3. Work over a large bowl or tray or sheets of newspaper and black bag to contain the mess which might be produced during this activity.

Stage 1 - The mouth

The function of the mouth is to ingest food and to start to digest the food. The mouth is specifically adapted for its function as follows:

- The lips keep the food in the mouth while chewing.
- Food is bitten off with the front teeth.
- Food is cut, torn and mashed into smaller parts by the different teeth in the mouth - this is mechanical digestion.
- The tongue moves the food around the mouth while it is being chewed. It also prepares the food for swallowing.
- Salivary glands secrete saliva. Saliva coats the food in the mouth making it easier to swallow. Saliva also contains enzymes which start to chemically digest.

1. Using the mixing bowl to represent the mouth and the scissors, pestle and potato masher to represent and simulate the digestion of your food type that occurs in the mouth.
2. Squirt some water onto the mixture as you are 'digesting' the food.
3. Describe what is happening to the food at this point.

4. Compare the model to the actual process in your mouth and what each part and action you are performing in the simulation represents.

Stage 2 - The oesophagus

The pharynx (the throat) moves food from the mouth to the oesophagus. The oesophagus transports food from the pharynx to the stomach.

- A flap in the pharynx covers the trachea (windpipe) to prevent food from accidentally going into the trachea and causing the person to choke.
- The oesophagus is a muscular tube that moves the food by contracting in sections and relaxing in other sections. This is called peristalsis.
- A special circular muscle shuts the entrance of the stomach. It prevents the contents of the stomach from pushing back into the oesophagus which may lead to vomiting.

1. Roll the ball of food you created in the mouth down the cardboard tube and into the clear Ziplock bag.
2. Describe what is happening to the food at this point.

3. Compare the model to the actual process in your oesophagus. Can you think of a better way of simulating the action of moving the food from the mouth to the stomach?

Stage 3 - The stomach

The stomach is specifically adapted for its function as follows:

- The stomach has strong muscles which help churn the food to break it up further. This also mixes the pieces of food with the digestive gastric juices.
- Since the stomach has to store food and liquid, it has many folds and ridges in the wall that help to expand the stomach further.
- The lining of the stomach is replaced to prevent the stomach from digesting itself.
- The stomach secretes gastric juices when food is present. This helps the functioning of the enzymes in the chemical digestion of proteins.
- Cells in the stomach lining are adapted to absorb water.
- The lower end of the stomach has muscles which can control the emptying of the stomach contents.

1. The Ziplock bag represents the stomach. After the food has entered the stomach, pour one of the digestive juices (lemon juice, vinegar or Coca Cola) into the bag over the ball of food.
2. In your body, a special circular muscle closes and seals the stomach and digestive juices from the oesophagus. Seal the Ziplock as if you were sealing the actual upper end of the stomach.
3. Squeeze the bag to show the churning of food in the stomach.
4. Describe what is happening to the food at this point.

____

____

5. Compare the model to the actual process in your stomach.

____

____

Stage 4 - The small intestine

In the small intestine, the digestion of proteins, carbohydrates and fats is completed and the end-products of these digestion processes are absorbed. The small intestine is specifically adapted for its function as follows:

- Since most of the digestion and absorption process takes place in the small intestines, it is especially long and folded to create an even bigger absorption area.
- The inner layer of the small intestine is lined with small finger like structures called villi which aid absorption and increases the area for absorption.
- The small intestine has a large network of capillaries surrounding it to transport the absorbed food away.
- The muscles of the small intestine control the direction in which the food flows through peristalsis.

1. The stocking that you have been provided with represents the small intestine. Cut a small corner off the bottom of the Ziplock bag and insert this end into the stocking.
2. Work over a large dish or black plastic bags for this part. While one learner is holding the stocking, the other learner should squeeze the food mixture into the stocking.
3. Use the syringes with the dissolved bicarbonate of soda and squirt the bicarbonate of soda into the food as it enters the stocking.
4. Simulate the action that takes place in the small intestine to move the food mixture through.
5. Describe what is happening to the food at this point.

6. Compare the model to the actual process in your small intestine.

Stage 5 - The large intestine

The large intestine absorbs water and mineral salts, to make some vitamins, and to decay the undigested food materials to form faeces. The large intestine is specifically adapted for its function as follows:

- Undigested waste remains in the large intestine for up to 24 hours in order to maximise the absorption of water from this region.
- The muscles in the large intestine are able to turn the waste material into faeces preparing it for egestion.
- When it is time to egest waste, the muscles in the large intestine create strong peristaltic movements to force the faeces out of the body via the rectum and anus.
- Circular muscles in the anus control the emptying of the waste materials.

VISIT
Watch a video with some fascinating facts about the digestive system
bit.ly/1cWbA5D

1. Was this a worthwhile activity for you? Explain what you learnt from this activity and whether you think it was a worthwhile activity or not, giving reasons for your opinion.

In exams and tests you will be asked how a specific structure is adapted to its function. Remember when you see such a question to break it down into four separate steps:

1. **Outline**: Give a brief explanation of the the main point you will discuss, i.e. structure, function and specific adaption(s).
2. **Structure**: Here you need to specify what the structure looks like.
3. **Function**: What does it need to do? What role does it play or purpose does it fulfil?
4. **Adaptation**: This is where you put together structure and function - it has X, so it can do Y. For example, it is thin, so gases diffuse through it quickly.

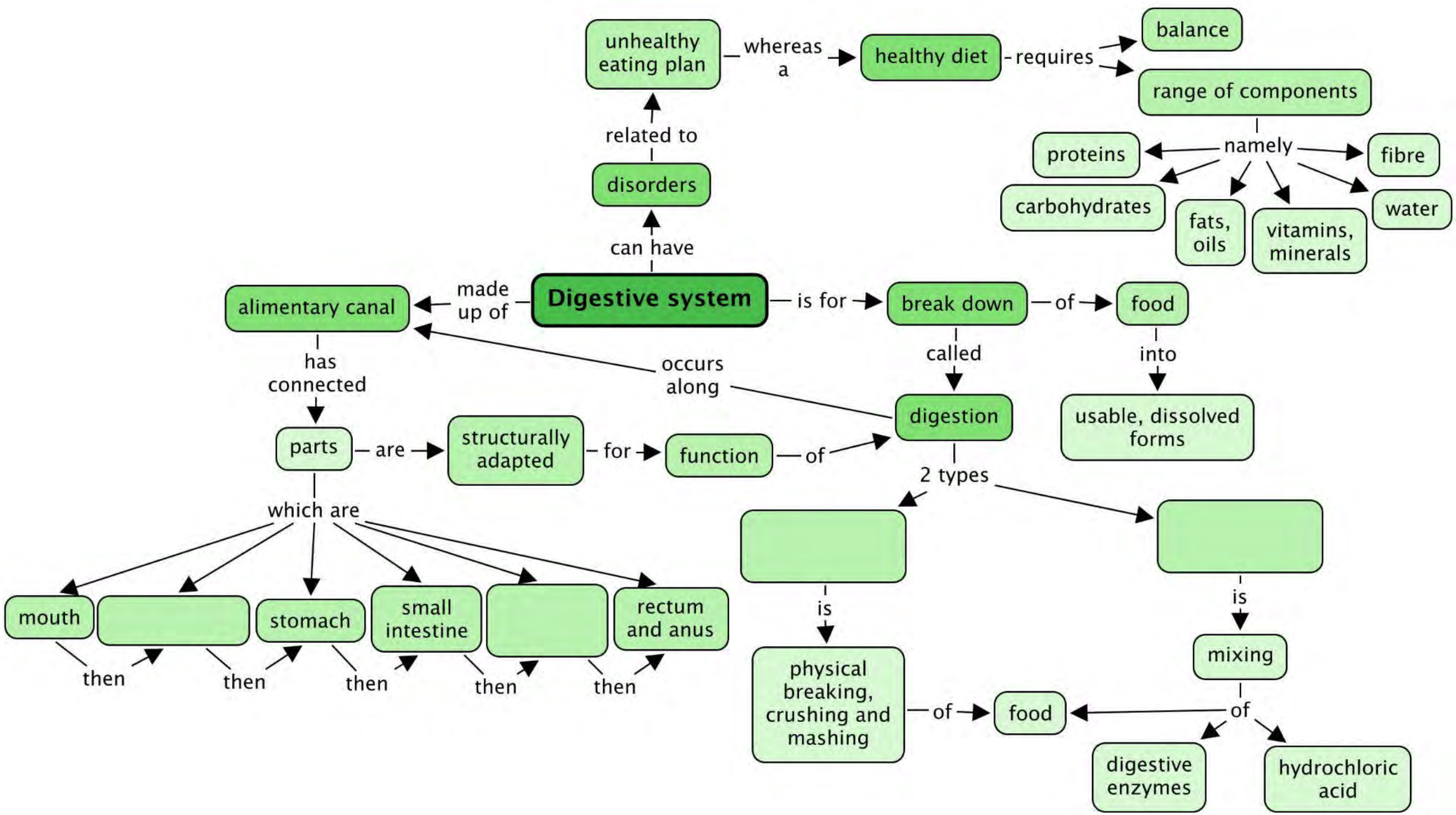
SUMMARY:

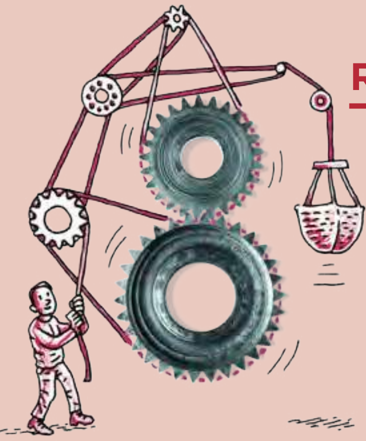
Key Concepts

- There are seven buildings blocks in a healthy diet: proteins, carbohydrates, fats and oils, vitamins, minerals, fibre and water.
- A healthy diet includes the correct proportions of the seven building blocks.
- Problems in our digestive system can be related to an inappropriate diet that does not give our bodies the correct nutrients.
- Our alimentary canal is composed of the mouth, oesophagus, stomach, small intestine, large intestine, rectum and anus.
- Digestion is the breaking down of food into usable, dissolvable forms that can be absorbed.
- There are two types of digestion: mechanical (or physical) and chemical digestion.
- Each structure in the alimentary canal is specifically adapted to suit its purpose.

Concept Map

The alimentary canal is made of several parts linked together - two of these parts are missing in the concept map. We also looked at two types of digestion in this chapter. What are these? When filling them in on the concept map, you need to decide which space to put them in by looking at the concepts which come after to describe each type.


unhealthy eating plan
whereas a
healthy diet
requires
balance
range of components
namely
proteins
carbohydrates
fats, oils
vitamins, minerals
fibre
water
related to
disorders
can have
Digestive system
made up of
alimentary canal
is for
break down
of
food
into
usable, dissolved forms
called
digestion
occurs along
has connected
parts
are
structurally adapted
for
function
of
which are
mouth
stomach
small intestine
rectum and anus
then
then
then
then
then
2 types
is
physical breaking, crushing and mashing
of
food
is
mixing
of
digestive enzymes
hydrochloric acid



REVISION:

1. Describe what you understand the term 'healthy diet' means. [2 marks]

2. For each of the following food items, classify what nutrients you can get from them (i.e. protein, carbohydrates, vitamins, etc). Some food items provide more than one class of nutrient. [10 marks]

Food item	Nutrients	Food item	Nutrients
 Fried chips		 Strawberries	
 Chicken pieces		 Bran biscuits	
 Butternut		 Yoghurt	
 Assorted nuts		 Split peas and lentils	
 Green beans		 Margarine	

3. Which of the foods in Question 2 contain starch? How can you test if they contain starch? [9 marks]

4. Why is it important to limit your intake of take-aways? [3 marks]

5. Give at least 2 reasons why we should eat raw fruit and vegetables. [2 marks]

6. Some food may take up to 24 to 36 hours to digest and be fully absorbed. Why do you think this process takes so long and why is this a good thing? [2 marks]

Total [28 marks]

GLOSSARY

absorption:	food molecules pass into the bloodstream
alimentary canal:	the tube that runs from your mouth to your anus where food is digested, nutrients are absorbed and solid waste is egested
alveoli:	clusters of tiny air sacs in the lung that together provide a very large surface area
antibiotic:	a medicine that kills bacteria
anus:	the opening at the lower alimentary canal through which waste is eliminated from the body
arteries:	blood vessels that carry blood away from the heart
atrium:	the upper left and right chambers of the heart
auditory:	of or relating to the sense of hearing
balanced diet:	a way of eating that includes adequate amounts of the necessary nutrients required for healthy growth and activity in their correct proportions
birth control:	the limitation or control of the number of children that a couple or a woman want to conceive by the planned use of contraceptive techniques
bladder:	the membranous, balloon-like sac in our bodies in which urine is collected for excretion
blood pressure:	the pressure of the blood in the circulatory system against the walls of the blood vessels
blood:	the red liquid in the blood vessels of the body that transports nutrients and oxygen to cells and removes waste and carbon dioxide from the cells
blood vessels:	tube-like structures that carry blood to and from tissues and organs
bowing:	bending
brain:	the organ in the skull made of soft nervous tissue that coordinates activities, senses and intelligence
breathing:	taking air into the body through the mouth, trachea, bronchi and lungs and releasing carbon dioxide-rich air from the lungs, trachea and mouth
brittle:	hard but easily broken or shattered
bronchioles:	smaller, branched air passages in the lungs
bronchi:	the two large air tubes going into each lung from the trachea
capillary:	the smallest branching blood vessels that that form a network between cells and join arteries to veins; diffusion between blood and cells occurs here
carbohydrates:	nutrients from plants, such as sugar and starch, that serve as a major source of energy in animals' diets
carbon dioxide:	a colourless, odourless gas that is released from the chemical breakdown of food during cellular respiration

cartilage:	firm, whitish, flexible connective tissue found in joints, outer ear, larynx, nose and in rings around the trachea
cell membrane:	the selectively permeable membrane that surrounds the cytoplasm of a cell
cell:	the structural and functional unit of all living organisms; the smallest living part of plants and animals
cellular respiration:	process whereby organic substances (from food) combine with oxygen in order to release energy; carbon dioxide and water are by-products
cellulose:	a special type of carbohydrate made up of many glucose molecules that that are packed very tightly together, so it doesn't dissolve in water; provides support in plants
cell wall:	tough, usually flexible layer that surrounds a plant's cell membrane; supports and protects the plant cell
cervix:	the neck of the uterus
chemical digestion:	breaking food into molecules that can dissolve in the blood and be transported to the cells using chemical agents (enzymes)
chloroplast:	a cell organelle found in plants that contains chlorophyll and can therefore photosynthesise
cilia:	small hair-like extensions in specialised cells in the lining of the nose and all breathing tubes that trap and remove dust and germs from the body
closed blood system:	blood never leaves blood vessels
collagen:	a strong, flexible protein in connective tissue that cannot stretch
conception:	moment of fertilization when the male sperm and the female ovum fuse together and a new individual is formed
conduct:	to carry impulses from one neuron the next
contraception:	any method that prevents pregnancy
contraction:	the shortening (tensing) of a muscle; term used to refer to the forceful tensing of the uterus muscles during childbirth
contract:	to get smaller or shorter
cover slip:	a small glass square which is placed over the specimen on a slide to view under a microscope
cytoplasm:	the gel-like material found within a plant or animal cell that is enclosed by the cell membrane but excluding the cell nucleus
degenerative:	a worsening in function over time
dehydration:	when the body loses too much water
deoxygenate:	to remove oxygen
deprived:	not given enough of something
diaphragm:	the dome-shaped muscle that separates the thorax from the abdomen; it plays a major role in breathing

diet:	what a person (or an animal) regularly eats or drinks
differentiation:	process by which a less specialised cell type becomes more structurally specialised to perform certain functions
diffuse:	move from an area of high concentration to an area of low concentration through a permeable membrane
diffusion:	the movement of a substance from an area of high concentration to a region of low concentration
digest:	break into pieces that are small enough to dissolve in the bloodstream and be absorbed into the cytoplasm
digestion:	breaking up food into small soluble parts that can be absorbed
dissolve:	when a solid breaks down into smaller and smaller particles until it mixes completely with a liquid (goes into solution)
DNA:	DeoxyriboNucleic Acid; molecule that stores information on how to make proteins and what characteristics the organism inherited from its parents
egestion:	passing out solid, undigested waste
ejaculation/ ejaculate:	the release of sperm from the penis
embryo:	a very young, developing baby
emulsion:	a mixture of two liquids that normally do not mix together, such as oil and water
enzymes:	special proteins that help reactions to take place in the body of the organism
erection:	the enlarged state or condition of tissues around the penis
eukaryote:	an organism that has genetic material inside a nucleus
excrete:	to remove metabolic waste products and carbon dioxide from the body
excretion:	removing harmful wastes that were made in the body and need to be removed from the body
exhale:	letting air rich in carbon dioxide out of the body through the mouth or nose, breathing out
faeces:	the waste from your body formed from undigested food in the intestines and passed out through the anus
Fallopian tube (oviduct):	a tube extending from the ovary to the uterus to transport a mature ovum
fats:	a nutrient that is very high in energy and doesn't mix with water and is found in oils and greasy foods
fertilization:	when a sperm fuses with an egg
fibre:	the cell walls of plant material that we eat that cannot be digested by humans
flaccid:	soft and hanging loosely

foreskin:	a layer of skin that covers and protects the head of the penis
fracture:	crack or break
frame structure:	a structure made by connecting beams and columns
gamete cells:	another name for 'sex cells' that fuse during fertilization
gaseous exchange:	the process in the lungs when oxygen enters the bloodstream and carbon dioxide is removed; at cellular level when oxygen is removed from the bloodstream and enters the cells and carbon dioxide is removed from cells and enters the bloodstream
gastric:	of or relating to the stomach
gestation (pregnancy):	the period (9 months) of development in the uterus from conception to birth
glucose:	a simple sugar molecule that is produced during photosynthesis and is the main source of energy for living organisms
haemoglobin:	a red iron-rich protein responsible for transporting oxygen in the blood
heart chamber:	any of the four spaces of the mammalian heart
heart:	the organ responsible for pumping blood throughout the body
hereditary:	characteristics that are transmitted from the parent to the offspring
hormone:	the body's chemical messengers that travel in the bloodstream to tissues and organs to affect many different reactions in the body
implantation:	the attachment of the fertilized egg into the wall of the uterus of the mother
impulse:	an electrical signal travelling along a nerve cell
infection:	when bacteria or viruses invade and multiply in the body's tissues and cells causing disease and illness
ingestion:	taking food into the mouth and body
inhale:	taking air rich in oxygen into the body through the mouth or nose, breathing in
inherited:	genetic characteristics received from the parent
integrate:	to make into a whole by bringing all the parts together; unify
iodine solution:	a brownish-orangy liquid that is used as an antiseptic and dye; it changes colour in the presence of starch
jaundice:	yellowing of the eyes and skins common in liver conditions
joint:	the place where two or more bones meet
kidney:	organ in the abdomen that filters the blood and produces urine
labour:	the process or effort of childbirth; the time during which this takes place

ligament:	a short band of tough, flexible, fibrous connective tissue that connects two bones or cartilage, or holds together a joint
locomotion:	movement or the ability to move from one place to another
lungs:	the organs used for breathing and gaseous exchange
medium:	a solution in which cells or organelles are suspended and in which reactions take place
membrane:	a thin flexible sheet or skin that acts as a boundary around a cell or cell organelle
menopause:	the changes that occur in an an older female (around age 50) body when she is no longer able to reproduce
menstrual cycle:	a recurring series of bodily changes in women that occurs roughly every 28 days in which the lining of the uterus thickens in preparation for the possible implantation of a fertilized egg; when that doesn't happen the lining of the uterus breaks down and is discharged as menstrual blood
metabolic:	relating to the chemical processes and changes that happen within the cells of plants and animals
metabolic waste products:	any unwanted substance produced by the various body processes
metabolize:	any build-up or break-down process in the body
microscope:	an optical instrument used for viewing very small objects not often visible to the naked eye
microscopic:	so small that it can only be seen under a microscope
mineral salts:	chemical elements in food needed for growth and development, like, sodium, potassium, calcium, iron, phosphorous etc.
minerals:	the elements (like iron, sulfur and clacium) that are essential to animals and plants
mitochondria:	a cell organelle that uses oxygen and food molecules to release energy for the cell
mucus:	a slimy substance secreted by the mucous membranes and glands (in the nose for instance) for lubrication and protection
multicellular organisms:	organisms that have many cells
muscle:	a type of tissue in the body that can contract to produce movement
nerve:	a whitish bundle of neuron fibres that transmits impulses between the nerve centres in the brain and spinal cord and various parts of the body
network:	a structure that interconnects many different parts
neuron:	a specialized nerve cell that transmits nerve impulses
nuclear membrane:	a double-layered membrane that separates the content of the nucleus from the cytoplasm

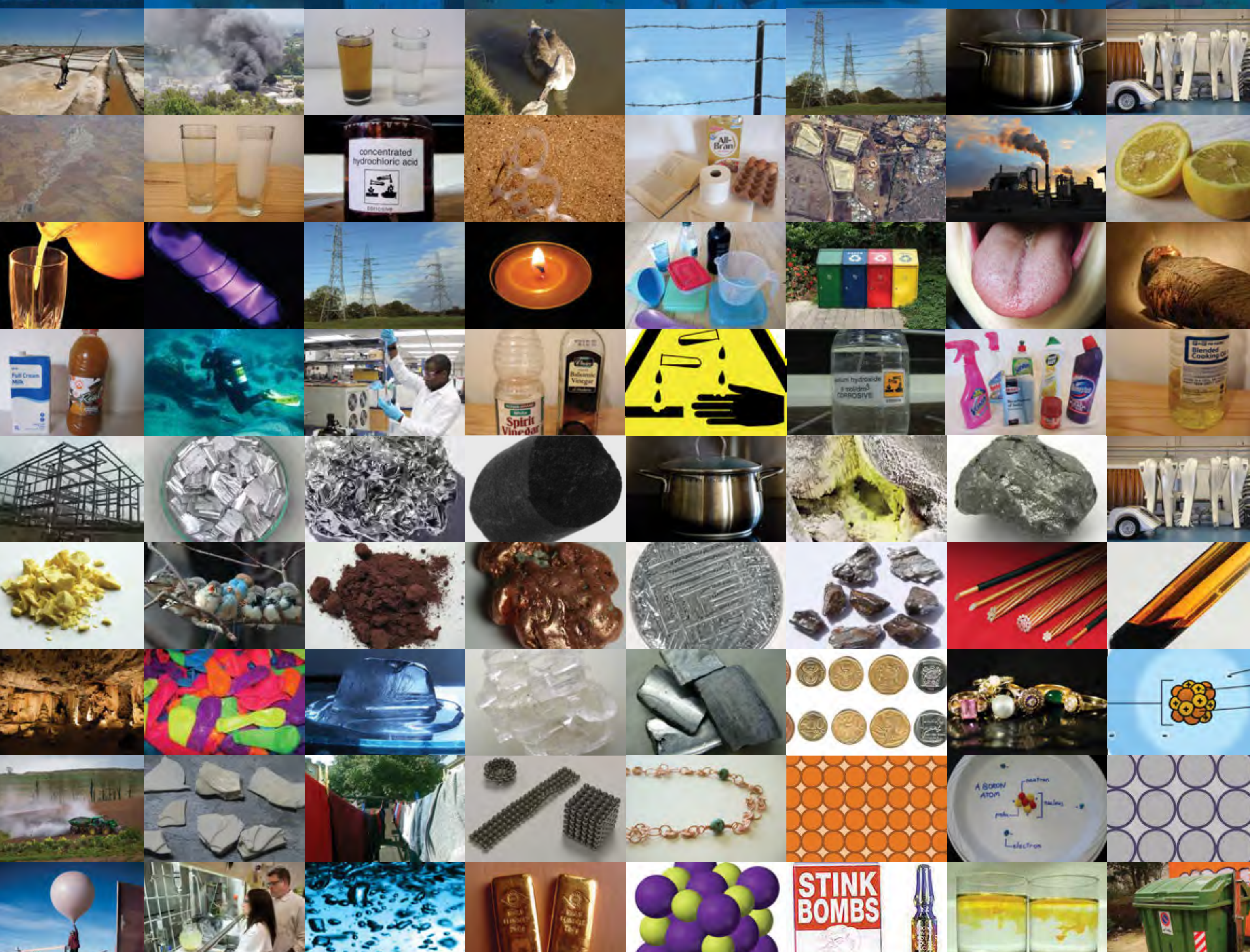
nucleolus:	small dense round structure in the nucleus of a cell
nucleus:	structure with a membrane around it that contains the cell's hereditary information and controls the cell's growth and reproduction
nutrients:	components of food that provide the body with energy or supply the building blocks for growth and repair
oestrogen:	the female sex hormone that causes the development of many of the female secondary sex characteristics
optic:	of or relating to the eye or vision
organelle(s):	specialised structures inside the cytoplasm of the cell that perform functions for the cell
organism:	an individual animal, plant or single-celled life form
ovary:	the organ that produces the female ova (egg cells), as well as the female hormones oestrogen and progesterone
ovulation:	the process whereby a mature ovum or egg cell gets released from the ovaries
ovum:	the female egg cell produced in the ovaries of a woman
oxygen:	a colourless, odourless reactive gas is used in cell respiration of all organisms
oxygenate:	to supply with oxygen
penis:	one of the male sex organs
peristalsis:	the wave-like contraction and relaxation of the walls of the alimentary canal that helps move food forward
pharynx:	throat
population growth rate:	growth of a population over time seen as the change in the number of individuals (of any species) in a population per unit of time
prokaryote:	a type of organism that does not have a separate nucleus but has its hereditary material in the cytoplasm
protein:	group of biological molecules that provide structure and enable chemical reactions
puberty:	the time between childhood and adulthood when the sex organs mature with accompanying changes in the body that prepare the person's body for reproduction
pulse:	the rhythmical throbbing of the arteries as blood is pumped through them by the heart
red blood cells:	specialised cells in the bloodstream that contain haemoglobin and therefore can carry oxygen
reproduction:	any process by which organisms produce offspring
respiration:	the chemical process in cells that releases energy from food molecules by using oxygen and forming carbon dioxide as a waste product
rupture:	break or burst open

saliva:	the watery substance in the mouth that covers chewed food, moistens the mouth
scrotum:	the external sac of skin that encloses the testes in males
selectively permeable:	a feature and a function of the cell membrane that allows it to regulate the substances that enter and leave the cell
self-propulsion:	having the ability to move itself
semen:	the fluid that is produced in the male reproductive organs, containing sperm and other chemicals suspended in a liquid medium
sexual intercourse:	how the male sperm is introduced into a woman's body when the penis is placed inside the vagina
slide:	a small glass plate on which we mount specimens to examine under a microscope
small intestine:	the part of the alimentary canal between the stomach and large intestine where most of the digestion and absorption of nutrients takes place
specialised:	able to perform a particular function
species:	the most basic biological classification of organisms; organisms that are capable of mating with one another to produce FERTILE offspring
specimen:	a sample or small part of a larger organism that we want to examine or analyse; it can also mean an object or organism that was selected and presented as part of a collection or series
sperm duct (vas deferens):	the tube that connects the testes to the ejaculation duct
sperm:	the male sex cell produced by the testes
starch:	a large storage molecule in plants that is made from many glucose molecules joined together
stem	cell: a special undifferentiated cell that can become any of the other cell types
stimulus:	any change that is detected inside or outside the body, to which we need to react
stomach:	the wider part after the oesophagus where food is stored for a short while; proteins are digested here
sugars:	group of sweet-tasting simple carbohydrates that are made by plants during photosynthesis
surrogacy:	when a person or animal acts as a substitute for another third person; when a woman carries and delivers a child for another couple or person
synthesis:	the process by which organic molecules are made inside organisms
temperature:	how much heat is present in an object, substance or body; the degree of internal heat of someone's body
tendons:	an inelastic cord of strong fibres made of collagen tissue that attaches a muscle to a bone
testes:	male glands that produce sperm cells and male hormones

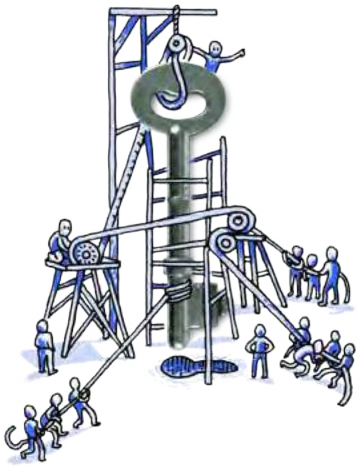
testosterone:	the male sex hormone that causes physical changes during puberty and controls the production of sperm
toxic:	poisonous
trachea:	(windpipe) the tube that carries air from the mouth and nose to the bronchial tubes in the lungs
transmit:	send out a message
transport:	move from one part of the body to another
turgid:	swollen or bulging outwards
ulcer:	an open sore in the alimentary canal
umbilical cord:	the cord or tube-like structure that connects the foetus at the abdomen with the placenta of the mother and transports nourishment and oxygen to the foetus and removes waste
unicellular:	consisting of a single cell
urea:	a metabolic waste product that is formed when protein is broken down in the liver
ureter:	the duct (tube) that joins the kidney and bladder and allows urine to pass from the kidney to the bladder
urethra:	the thin tube that allows urine to flow from the bladder to the outside
urinate:	to excrete or pass urine out of the body
uterus:	the hollow muscular organ in the pelvic area of female mammals in which the fertilized egg implants and develops (also known as the*womb*)
vacuoles:	a fluid-filled bag in the cytoplasm of most plant cells
vagina:	an elastic muscular tube or canal that connects the neck of the uterus (cervix) with the external opening
variation:	a change or slight difference
veins:	blood vessels that carry blood back to the heart
ventricles:	the lower left and right chambers of the heart
vision:	the ability to see
vitamins:	organic substances essential to normal growth and development in the body and found naturally in plant and animal products
wet mount:	when you mount a specimen on a slide using a drop of liquid
womb:	another non-technical term for uterus
zygote:	the result of two gametes that fuse; a fertilised ovum


concentrated
hydrochloric acid
Spirit
Vinegar
STINK
BOMBS
10.33
A
B
C
HYDROCHLORIC
ACID

MATTER AND MATERIALS



1 Compounds



KEY QUESTIONS:

- What is a compound?
- How is a compound different from an element?
- How is a mixture of elements different from a compound?
- What does the position of an element on the Periodic Table tell us about its properties?
- Where do we find metals, non-metals and semi-metals on the Periodic Table?
- What are the vertical columns of the Periodic Table called?
- What are the horizontal rows of the Periodic Table called?
- What do elements belonging to the same 'group' of the Periodic Table have in common?
- What additional information about an element can we find on the Periodic Table?
- What does the formula of a compound tell us about it?

NEW WORDS

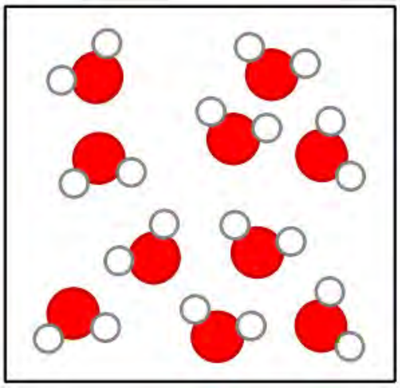
- compound
- crystal lattice
- element
- diatomic
- molecule

1.1 Elements and compounds

Can you remember learning about compounds in Gr. 8 Matter and Materials? We will start this chapter by summarising and revising some of the main ideas about **elements** and **compounds** from Gr. 7 and 8. This should help us to link the new ideas in this chapter to what we already know.

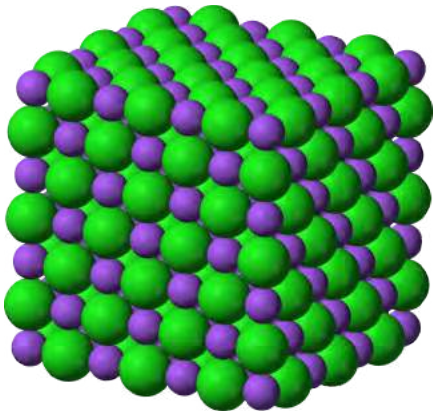
The particles that make up compounds

The particles of a compound always consist of two or more atoms. In Physical Sciences Gr. 10 you will learn that these atoms combine in different ways. In some cases they can form **molecules**. You may remember that 'molecule' is the word scientists use for a cluster of atoms that stick together in a specific way. Other compounds consist of atoms which are arranged in a regular pattern called a **crystal lattice**.



Water molecules.

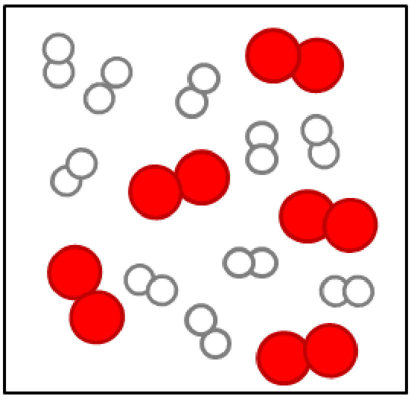
The molecules of a compound always consist of two or more different kinds of atoms, like the molecules of water in the following diagram.



A sodium chloride crystal lattice consisting of sodium (purple) and chloride (green) atoms in a fixed ratio.

Compounds that form crystal lattices consist of many atoms, but they always combine in a fixed ratio. For example, in sodium chloride (table salt), there is one chlorine atom for every sodium atom in the crystal. The smallest 'unit' that is repeated in the crystal consists of one Na and one Cl. The formula NaCl represents one 'formula unit' of NaCl.

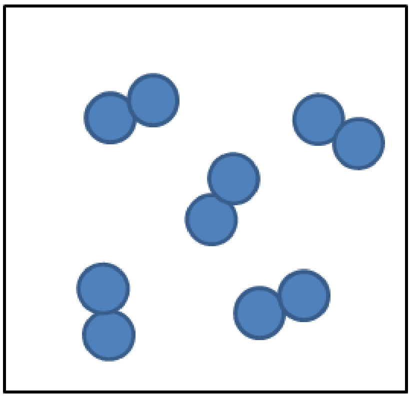
From the diagram of the water molecules and the sodium chloride lattice above, we can see that a compound is not simply a mixture of elements. A mixture of the elements hydrogen and oxygen would look like this:



A mixture of hydrogen and oxygen molecules.

Why are the hydrogen and oxygen atoms paired in the diagram above? Before we answer that question, here is an important reminder: Elements are made up of just one kind of atom.

Some elements exist as diatomic molecules, like the ones in the diagram on the right below and the hydrogen and oxygen molecules in the 'mixture' diagram above. The most important examples of diatomic molecules are H_2, N_2, O_2, F_2, Cl_2, Br_2, and I_2. **Diatomic** means 'consisting of *two atoms*'.

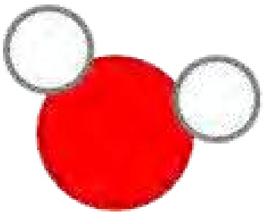


Some elements exist as diatomic molecules.

Can you see that the water molecules in the diagram above are all identical? That brings us to the next point about compounds.

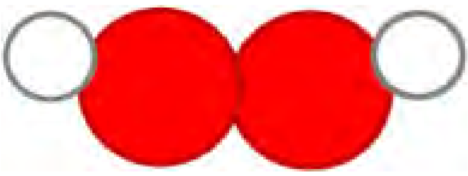
The atoms in molecules and lattices are combined in a fixed ratio

In water, for example, one oxygen atom (O) has combined with two hydrogen atoms (H). All water molecules are exactly the same in this respect.

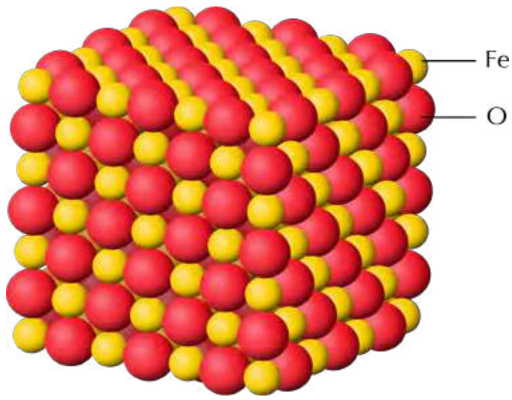


All water molecules consist of one O atom and two H atoms and this gives water its specific properties.

Any other combination of hydrogen and oxygen atoms would NOT be water. For example, hydrogen peroxide consists of the same elements as water (hydrogen and oxygen) but the ratio is different: two oxygen atoms have combined with two hydrogen atoms.



The hydrogen peroxide molecule consists of two O atoms and two H atoms. This gives hydrogen peroxide different properties to water.



In the crystal lattice of black iron oxide, there is one iron (Fe) atom for every oxygen (O) atom.

The next important point about compounds is the following.

Each compound has a unique name and formula

Water can be represented by the formula H_2O. The formula tells us that two hydrogen atoms (H) are combined with one oxygen atom (O) in a molecule of water.

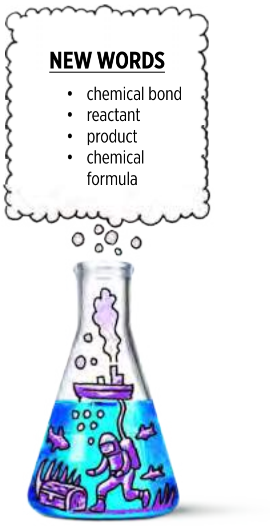
What is the formula of hydrogen peroxide? Can you remember the name of the compound with the formula CO_2? Remember to take notes as you discuss things in class!

What formula represents one 'formula unit' of the type of iron oxide in the previous diagram?

The atoms in a compound are held together by chemical bonds

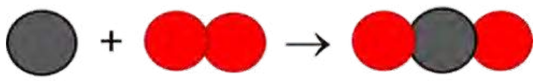
What holds the clusters of atoms that we call molecules together? When atoms combine to form molecules, they do so because they experience an attractive force between them. The forces that hold atoms together are called **chemical bonds**.

Next, we need to be reminded where compounds come from.



Compounds form during chemical reactions

In all chemical reactions, the atoms in molecules rearrange themselves to form new molecules. This is how compounds form: the atoms in one set of compounds separate as bonds break between them, and they get rearranged into new groups as new bonds form. When this happens, we say a chemical reaction has occurred. Look at the following illustration.



In the example above, the elements to the left of the arrow are called the **reactants**. They have rearranged to form a new compound. This is called the **product** and it is shown to the right of the arrow.

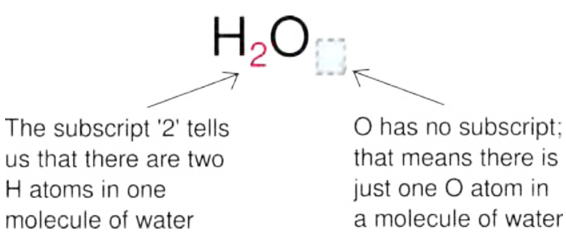
Can you describe what happened to the atoms and the bonds in this reaction? Discuss which bond broke, which ones formed, and how the atoms were rearranged during the reaction.

The final aspect of compounds that we learnt in Gr. 8 is that each compound can be represented by a unique chemical formula:

A compound has a chemical formula

Compare the formula for water with the diagram of the water molecule you saw earlier. Can you make the connection?

The **chemical formula** of a compound is the same for all the molecules of that compound. When we read the formula, the subscripts tell us how many atoms of a particular element is in one molecule of that compound:



When we write H_2O, we actually mean H_2O_1. According to convention, we do not use 1 as subscript in formulae and so the first formula is the correct one. What it means is that there are 2 hydrogens to every 1 oxygen. This is also a ratio and can be written as 2:1. We will practise writing formulae in the next activity.

ACTIVITY: Writing formulae and revision

INSTRUCTIONS:

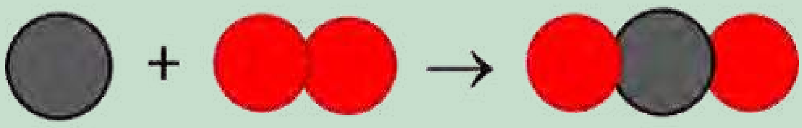
1. In the following table, the names of some pure substances are given in the left-hand column. The middle column tells us what one molecule of each compound is made of.
2. You must use this information to write the formula of each compound in the final column, on the right.
3. The first row has been filled in for you, so that you have an example:
4. Column 1 contains the name: water
5. Column 2: one molecule of water contains two H atoms and one O atom.
6. Column 3: From the information in column two we can write the formula: H_2O

Name of substance	What it is made of?	Chemical formula
water	2 H atoms and 1 O atom	H_2O
carbon dioxide	1 C atom and 2 O atoms	
ammonia	1 N atom and 3 H atoms	
methane	1 C atom and 4 H atoms	

QUESTIONS:

1. What holds the atoms together in a compound?

2. The following diagram shows how carbon and oxygen react to form carbon dioxide.



What are the reactants and what is the product in this reaction? Write these names onto the diagram.

3. Why is oxygen represented as two circles together?

4. Magnesium oxide has the formula MgO. what does this ratio tell us about the atoms in the compound?

Now that we have refreshed our memories, we are going to return to the table that scientists use to organise their knowledge about the elements. Can you remember what it is called?

1.2 The Periodic Table

NEW WORDS

- Periodic Table
- symbol (or element symbol)
- atomic number
- unique

We first encountered the Periodic Table in Gr. 7. Here is a summary of what we already know:

1. All the elements that are known, can be arranged on a table called the Periodic Table.
2. 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.
3. 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.
4. An element's position on the Periodic Table tells us whether it is a metal, a non-metal or a semi-metal.
   a) metals are found on the left hand side of the table;
   b) non-metals are found on the far right hand side of the table; and
   c) semi-metals are found in the region between the metals and non-metals.
5. An element can be identified in 3 different ways:
   a) each element has a unique name;
   b) each element has a unique chemical symbol; and
   c) each element has a unique atomic number.
6. Metals are usually shiny, ductile, and malleable. Most are solids at room temperature and have high melting and boiling points.
7. 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.
8. The semi-metals are all solids at room temperature. They usually have a combination of metallic and non-metallic properties.

We learnt about the origins of the Periodic Table in Gr. 7. Let's also revise what we learnt then, so that we have a firm foundation for our new learning.

The Periodic Table is basically a chart that scientists use to list the known elements. The table consists of individual tiles for each of the elements. What information can we find on the Periodic Table? That is what the next section is all about.

TAKE NOTE

There is a large version of the Periodic Table printed on the inside cover of your workbooks for you to easily refer to.

What information can we find on the Periodic Table?

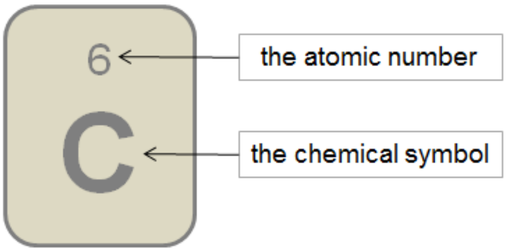
The information that most commonly appears on each tile of the Periodic Table is the following:

- The chemical symbol; and
- The atomic number

The diagram alongside shows an example of one of the tiles on the Periodic Table. Can you identify the element it represents? How many protons does it have in its atoms?

____

____



An example of one of the tiles on the Periodic Table

There are different versions of the Periodic Table, which can each contain different information about the elements. Can you identify what information is provided about the elements in the following table?

____

Periodic Table of the Elements

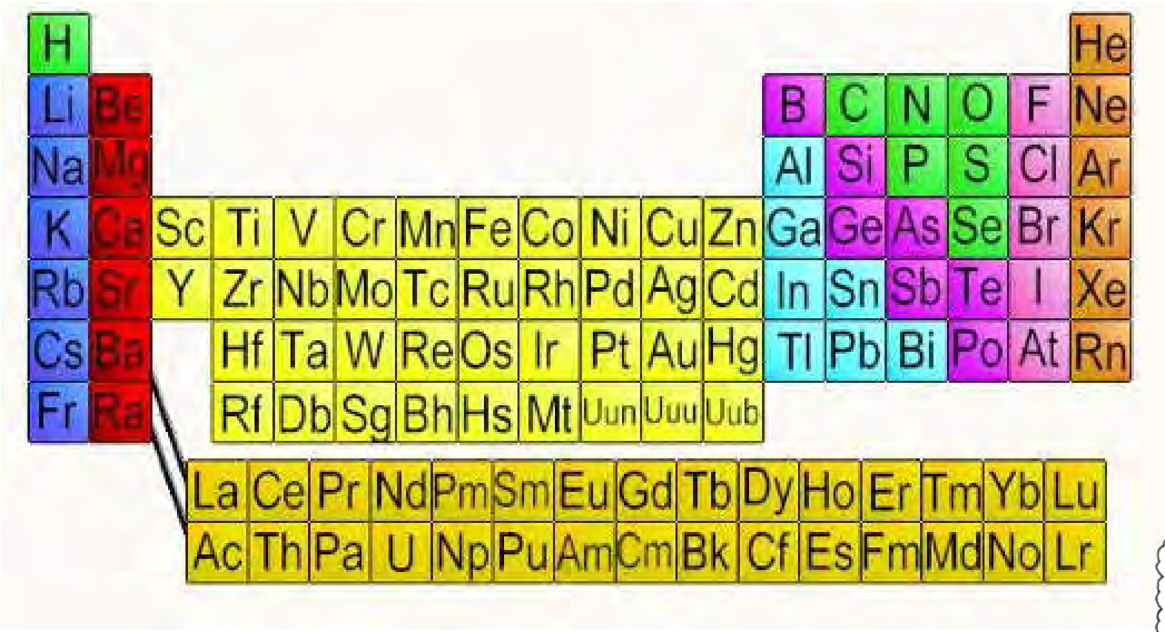
No Element

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

The following Periodic Table only shows the symbols for the elements.



VISIT

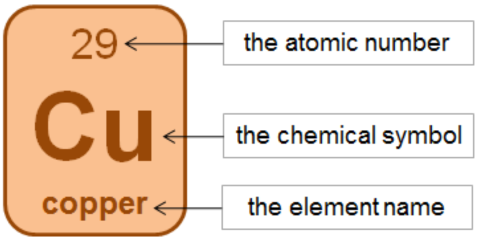
An interactive site on the Periodic Table. Click on each element to view lots of interesting information about it

bit.ly/14nnga0

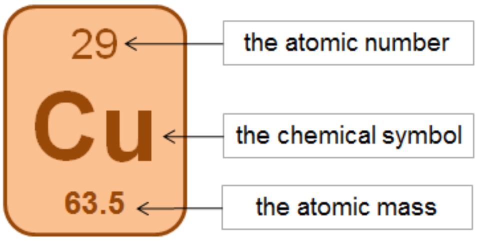
Other versions of the Periodic Table may contain additional information, such as:

- The element name; and/or
- The atomic mass, usually indicted at the bottom of each tile for an element.

The diagrams below show examples of how this information is sometimes presented.



This tile shows information about the element copper



This tile also shows information about the element copper. Instead of the element name, the atomic mass of copper is given.

NEW WORDS

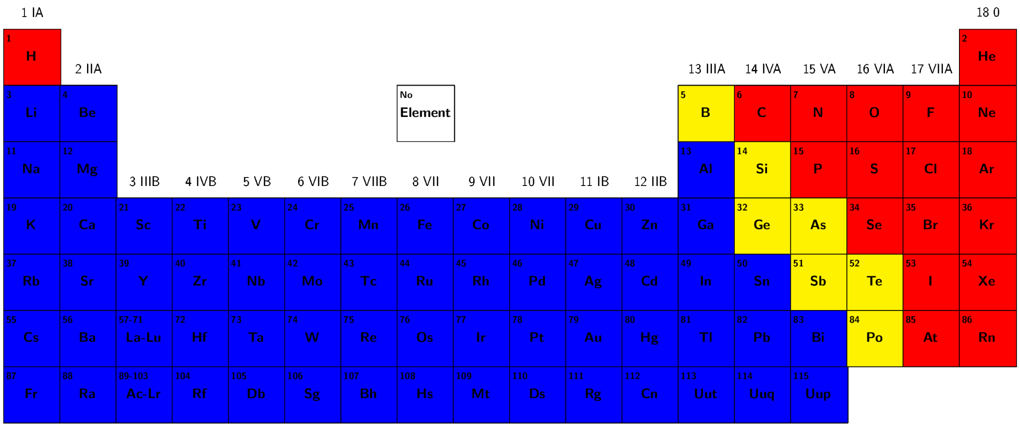
- metal
- non-metal
- semi-metal
- group
- period
- electrons
- neutrons
- protons

How are the elements arranged on the Periodic Table?

We have learnt that the elements on the Periodic Table are arranged in a very specific way.

The elements are arranged in order of increasing atomic number. The element with the smallest atomic number is hydrogen (H: atomic number = 1) is in the top lefthand corner of the table. The elements with the largest atomic number are found at the bottom of the table.

The elements are also arranged in regions and these regions are often presented in different colours. The following Periodic Table shows us where the metals, non-metals and semi-metals can be found.



TAKE NOTE

The semi-metals are also sometimes referred to as the metalloids.

We can summarise:

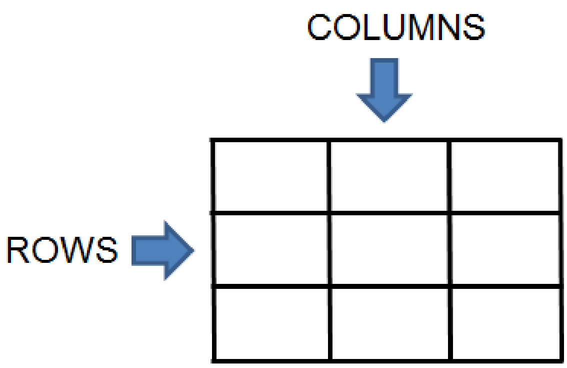
- The **metals** are found on the left of the Periodic Table, reaching across almost the entire table, except the top right hand corner. In the table above, the metals are blue.
- The **non-metals** are found in a relatively small, triangular region at the top right hand side of the table. In the table above, the non-metals are red.
- A few elements that have metallic and non-metallic properties (called the **semi-metals**) separate the metals from the non-metals. They occur in a diagonal strip on the right hand side of the table. In the table above, the semi-metals are yellow.

Now that we have revised what we already learnt in previous grades, let's learn some new characteristics of the Periodic Table.

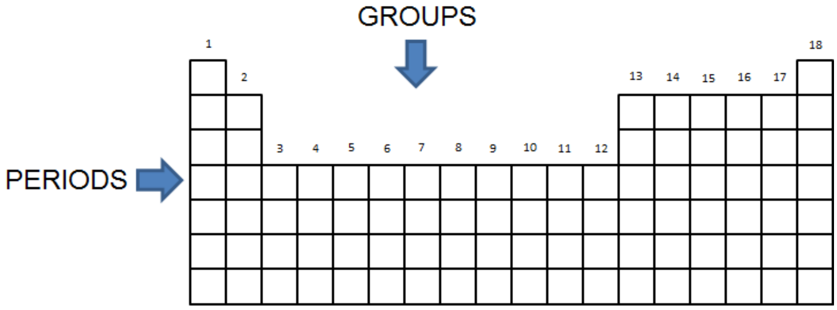
All tables have rows and columns. Can you remember the difference between vertical and horizontal? Draw short lines to show the difference between 'vertical' and 'horizontal' in the following table.

Vertical	Horizontal

Vertical runs 'up and down', and horizontal runs 'from side to side'. In a conventional table the columns run vertically, and the rows run horizontally.



There are special words to describe the columns and rows of the Periodic Table. The following diagram shows what the column and rows are called.



Groups: The vertical columns of the Periodic Table are called groups. The groups on the Periodic Table are numbered in such a way that Group 1 is on the left. How many groups are there?

The groups are numbered from 1 to 18. On older tables, the groups are numbered in a more complicated way. The colourful Periodic Table from Gr. 7 (shown earlier) is an example of the numbering style that you may find in older textbooks and other science resources.

Periods: The horizontal rows of the Periodic Table are called periods. The first period is at the top of the table. What is the first element in the third period?

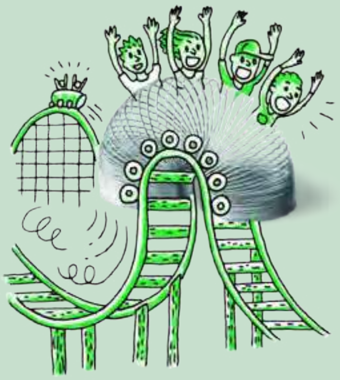
Which element is in Group 14 and in the second period? Write its symbol and its name.

Names and chemical symbols

In Gr. 7 we learnt that each element has a unique name. We also learnt that each element has a unique symbol. There is a list of 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.

As scientists, we are expected to know the names and symbols of all the most important elements. You will not be expected to learn all of them off by heart just yet, but at the end of this chapter you must know the names and chemical symbols of the first 20 elements on the table. To make them a little easier to remember, they have been placed in a table below.



ACTIVITY: Elements on the Periodic Table

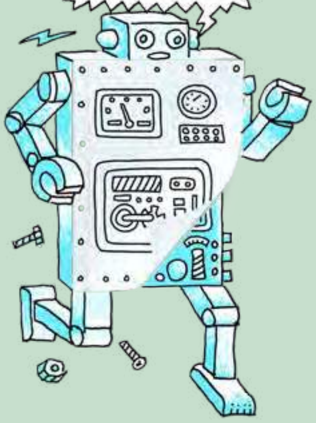
INSTRUCTIONS:

1. Use your Periodic Table to complete the following table.
2. Write the chemical symbol and element name for each of the first 20 elements, identified by their atomic numbers.

Atomic number	Chemical symbol	Element name
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

TAKE NOTE

You need to know the names and symbols of the first 20 elements on the Periodic Table, as well as iron, copper and zinc.



3. There are three important industrial metals of which you need to know the names and formulae. Their atomic numbers have been written in the table below. Complete the table by filling in the chemical symbols and element names.

Atomic number	Chemical symbol	Element name
26		
29		
30		

QUESTIONS:

1. What does the atomic number tell us about the atoms of an element?

2. How many protons are there in oxygen atoms?

3. In most oxygen atoms, how many neutrons are there?

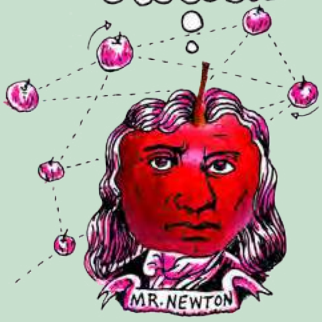
4. In a neutral oxygen atom, how many electrons will there be?

5. What is the charge on protons and electrons?

6. How are the protons, neutrons and electrons (the sub-atomic particles) arranged in an atom?

DID YOU KNOW?

Even though the electrons in an atom move so fast that it is not possible to describe their actual 'positions', scientists have been able to figure out patterns in the arrangement of the electrons. These patterns repeat after every 18th element.



7. Draw a model of an oxygen atom in the space provided. Label your diagram.

You may wonder why the Periodic Table has exactly 18 groups and not 14 or 10 or any other number. That is a very good question! The actual explanation is quite complex, and has to do with how the electrons inside the atom are distributed. You will learn about this in greater detail if you take Physical Sciences in Gr. 10.

Properties of elements in the same group

Elements from the same group often have similar physical and chemical properties. For now, it is enough to know that the electrons in the atoms of an element determine the chemical properties of that element. And since the 'electron patterns' repeat after every 18th element, there are 18 groups. Since the elements in a group have similar 'electron patterns', they will behave similarly in chemical reactions.

The metals of Group 1 are called the **alkali metals**. Can you write the name and chemical symbol of the lightest member of the group? You can disregard hydrogen, which is really a non-metal, but is placed with the alkali metals on the Periodic Table because it has a similar electron pattern.

Lithium metal is stored in oil and floats in the bottle. Why do you think this is?

Lithium, and all the other alkali metals, are soft dull-grey metals. The look very similar and have similar **physical** properties. These elements all react in a very peculiar way with water.

For example, when a small piece of lithium is dropped in water, it will immediately start to react with the water. Here is the chemical equation for the reaction:

$$\mathbf{2\ Li + 2\ H_2O \rightarrow 2\ LiOH + H_2}$$

The piece of lithium metal will dance around on the surface of the water, because the reaction produces hydrogen gas (H_2), which causes tiny bubbles to stream from under the lithium. Heat is also given off and sometimes the hydrogen gas will start to burn on top of the water. The other product that forms is lithium hydroxide. Can you find its formula in the chemical equation above?

Write the word equation underneath the chemical equation above.

What are the reactants and the products in the above chemical reactions?

Now, the interesting thing is that all the other alkali metals behave in a similar way. Sodium is more reactive than lithium, so it not only bobs around on the surface of the water, but immediately bursts into flame. The chemical reaction is almost identical, though:

$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$

When large amounts of sodium come into contact with water, there is an explosion, such as in this photo where water was poured on 1,5 kg of sodium.

Can you see how similar it is to the reaction between lithium and water?

Potassium is even more reactive than sodium, so it explodes when it hits the surface of the water:

$2\ K + 2\ H_2O \rightarrow 2\ KOH + H_2$

What you should notice is that these elements, all from the same group, react in the same way when they come into contact with water. That is what is meant when we say that elements from the same group have similar **chemical** properties.

A small piece of potassium metal explodes as it reacts with water.

NEW WORDS

- IUPAC
- IUPAC system
- systematic name
- suffix
- prefix

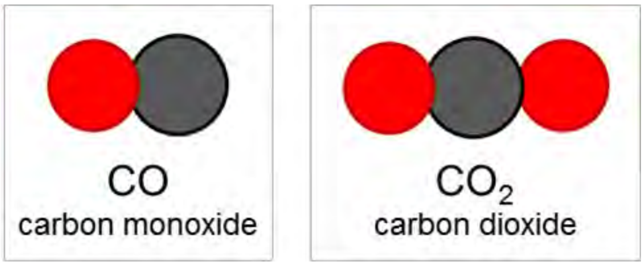
1.3 Names of compounds

Perhaps there are two or more people in your class with the same name? Then you will know how confusing it can be when two people have the same name!

We have learnt that each element has a unique name. This is important, so that we do not end up confusing elements with each other.

Each compound has a unique name

It is just as important for each compound to have a unique name. The following example will help you see why:



The two compounds CO and CO_2 consist of the same two elements, carbon and oxygen. If we named them both 'carbon oxide' (since they are both made of carbon and oxygen), we could easily confuse them. Under certain circumstances that could create problems, because CO is much more poisonous to humans and animals than CO_2. So it is easy to see why each compound needs a unique name.

When we write the chemical formulae for compounds, they are always a combination of the symbols of the elements in the compound. For example, when we see the formula NaCl, we know that this compound consists of Na and Cl.

When we name compounds, the names of the elements in the compound are combined and sometimes changed slightly, to make a name for the compound.

When we hear the name *sodium chloride*, for instance, it is quite obvious that the compound being described must consist of *sodium* and *chlorine*. But, why is it *chloride* and not *chlorine*? Well, as you will see shortly, when we join up the names of the elements, the one that is named last is changed.

TAKE NOTE

A 'suffix' is something placed at the **end** of a word. A 'prefix' is something placed at the **beginning** of a word.

All the above may sound very complicated and for this reason a system has been developed for naming compounds. The system was developed by the **International Union of Pure and Applied Chemistry (IUPAC)**. The system is designed in such a way that the name of a compound describes the elements it contains and how they are combined.

The IUPAC system for naming compounds is very complex, but we do not need to learn all its rules. At this point we only need to learn how to name compounds consisting of two elements.

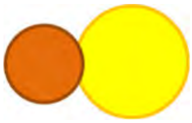
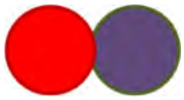
At this level we have to distinguish between two types of compounds, because the type of compound determines how it should be named.

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

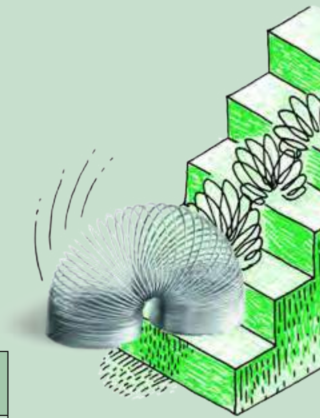
For compounds of this type, the rule is simple. The metal comes first and the non-metal second. The name of the non-metal changes slightly: the suffix *-ide* replaces the ending of the name.

All compounds of this type form crystal lattices rather than molecules. What do we call the repeating 'units' in a crystal lattice?

____

Formula	Consists of	Name	Picture of one formula unit of the compound
NaCl	Sodium and chlorine	Sodium chloride	
FeS	Iron and sulfur	Iron sulfide	
MgO	Magnesium and oxygen	Magnesium oxide	
LiF	Lithium and fluorine	Lithium fluoride	

ACTIVITY: Naming compounds of metals and non-metals



INSTRUCTIONS:

1. Refer to the Periodic Table and complete the following table.
2. You need to identify the elements which make up the compound and give the name of the compound.

Formula	Which elements does it consist of?	Name
Li_2O		
KCl		
CuO		
NaBr		

Type 2: Compounds that contain only non-metals

This type of compound is slightly more complicated to name. There are three rules that you have to follow. They are as follows:

Rule 1:

The name of the element further to the left on the Periodic Table comes first, followed by the name of the element further to the right on the table. The name of the second element changes slightly: the suffix *-ide* replaces the ending of the name.

For example:

- oxygen becomes ox*ide*
- fluorine becomes fluor*ide*
- chlorine become chlor*ide*
- nitrogen becomes nitr*ide*

TAKE NOTE

The prefix mono- is usually left out from the beginning of the first word of the name. For instance CO is carbon monoxide, not*mono*carbon monoxide.

Rule 2:

When two or more compounds have different numbers of the same elements (like CO and CO_2 in our example above), we must add prefixes to avoid confusion.

The first four prefixes are listed in the table below:

Number of atoms	Prefix
1	mono-
2	di-
3	tri-
4	tetra-
5	penta-

Here are some examples of how this rule should be applied:

Compounds of carbon and oxygen:

- CO - carbon monoxide (notice that it is not mono-oxide, but monoxide)
- CO_2 - carbon dioxide

Compounds of nitrogen and oxygen:

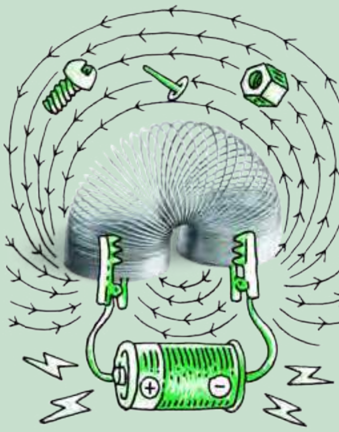
- NO_2 - nitrogen dioxide
- N_2O_4 - dinitrogen tetroxide (did you notice how tetraoxide becomes tetroxide?)

Compounds of sulfur and oxygen:

- SO_2 - sulfur dioxide
- SO_3 - sulfur trioxide

We are going to practice what we have learnt so far in the next two short activities. First, we will write names from formulae.

ACTIVITY: Writing names from the formulae of compounds



MATERIALS:

- play dough, beans or beads

INSTRUCTIONS:

1. How would you name the following compounds? Write the name next to each formula in the table below.
2. Build one molecule of each compound with play dough, beans or beads. If you are not sure how to arrange the atoms, here is an important tip: the atom that comes first in the name (it will usually also be the first atom in the formula) must be placed at the centre of the molecule. All the other atoms must be placed around it. They will be bonded to the atom at the centre, but not to each other.
3. Draw a picture of your molecule in the final column of the table.

Formula of the compound	Name of the compound	Picture of one molecule of the compound
CO_2		
H_2O		
PF_3		

Formula of the compound	Name of the compound	Picture of one molecule of the compound
SF_4		
CCl_4		

Next, we will write formulae from the names of some compounds.

ACTIVITY: Writing formulae from the names of compounds

MATERIALS:

- play dough

INSTRUCTIONS:

1. What formulae would you give the following compounds? Write the formula next to each name in the table below.
2. Build a model of each compound with play dough.
3. Draw a picture of one molecule of each compound in the final column of the table.

Formula of the compound	Name of the compound	Picture of one molecule of the compound
	hydrogen fluoride	

Formula of the compound	Name of the compound	Picture of one molecule of the compound
	dihydrogen sulfide	
	sulfur trioxide	
	carbon monoxide	

VISIT

Build some compound molecules with this simulation!

bit.ly/14CQ4PO

TAKE NOTE

Now we have learnt an important new skill, namely to write and interpret the names and formulae of compounds.

There is one additional rule - an easy one to remember!

Rule 3:

Many compounds are not usually referred to by their systematic names. Instead, they have **common names** that are more widely known. For example, we use the name *water* for H_2O, *ammonia* for NH_3, and *methane* for CH_4.

In this chapter we reviewed all the information about compounds and about the Periodic Table, that we have learnt in previous years. We added some new information to both of these topics.

SUMMARY:

Key Concepts

Elements

- All the atoms in an element are of the same kind. This means that an element cannot be changed into other elements by any physical or chemical process.
- Elements can be built up of individual atoms, or as bonded pairs of atoms called diatomic molecules.
- When elements combine, they form compounds.

Compounds

- In a compound, atoms of two or more different kinds are chemically bonded in some fixed ratio.
- The atoms that make up a molecule are held together by special attractions called chemical bonds.
- Compounds can be formed and broken down in chemical reactions.
- A chemical reaction in which a compound is broken down into simpler compounds and even elements is called a decomposition reaction.
- Compounds cannot be separated by physical processes, but they can be separated into their elements (or simpler compounds) by chemical processes.

The Periodic Table

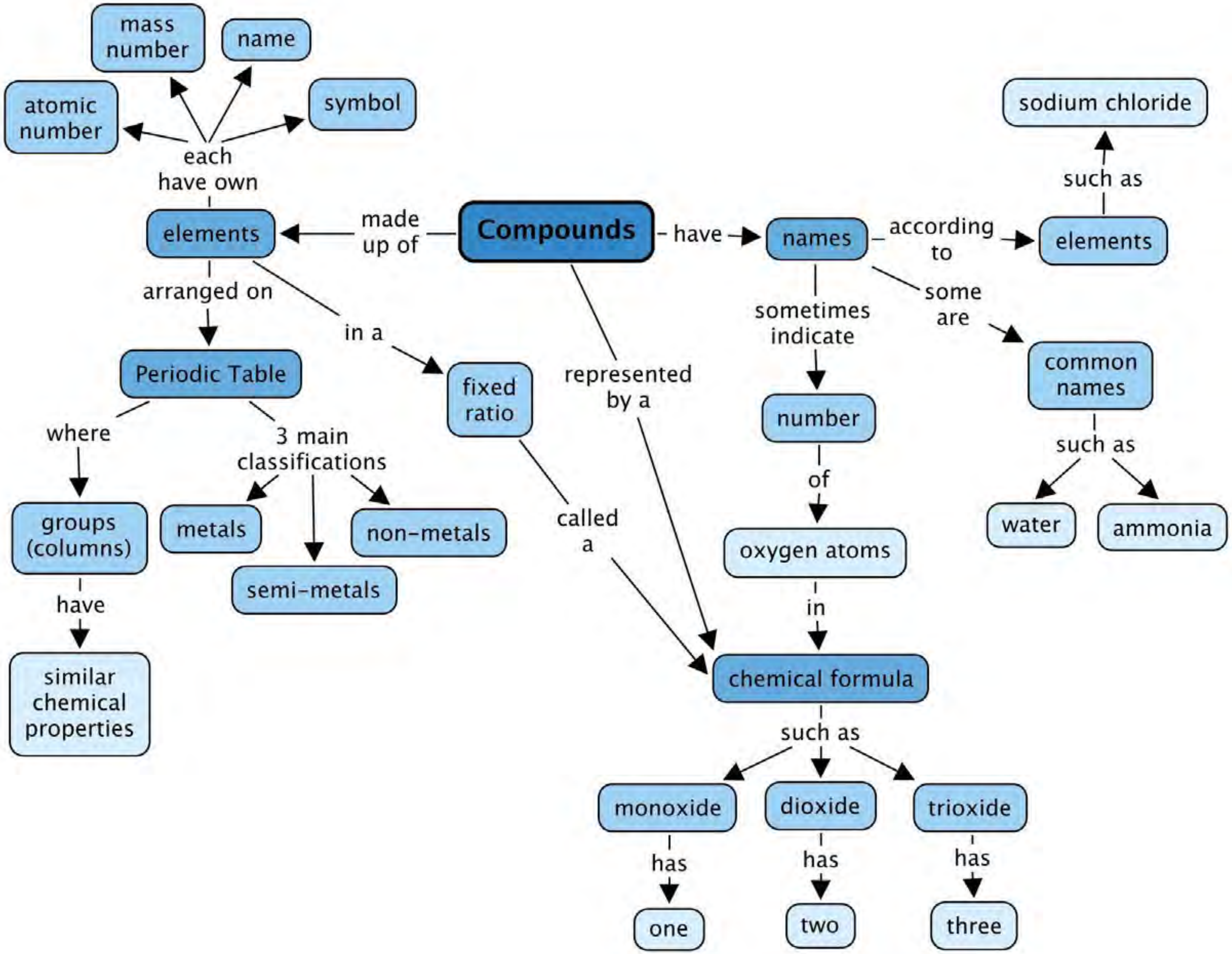
- Each element has a fixed position on the Periodic Table. The elements are arranged in order of increasing atomic number, with the lightest element (hydrogen: H) in the top left hand corner.
- An element's position on the Periodic Table tells us whether it is a metal, a non-metal or a semi-metal.
  - 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.
- The vertical columns of the Periodic Table are called groups. The Periodic Table has 18 groups.
- The horizontal rows of the Periodic Table are called periods. There are 7 periods.
- Elements belonging to the same 'group' of the Periodic Table exhibit the same chemical behaviour, and will often have similar properties.
- Many different versions of the Periodic Table exist. Typically, the element symbol, the atomic number and the atomic mass of each element are given on the table.

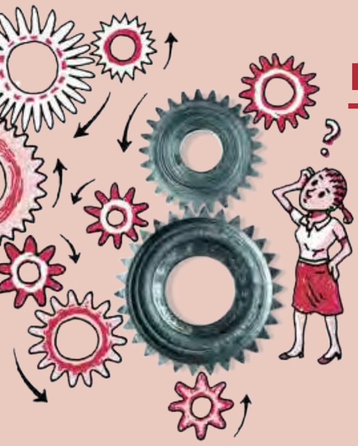
Names and formulae

- Each compound has a unique name and formula.
- The formula of a compound tells us which elements are in the compound and how many atoms of each element have combined to form one molecule of that compound.
- There are rules for naming compounds that take into account how many atoms of each type are in one molecule of the compound.

Concept Map

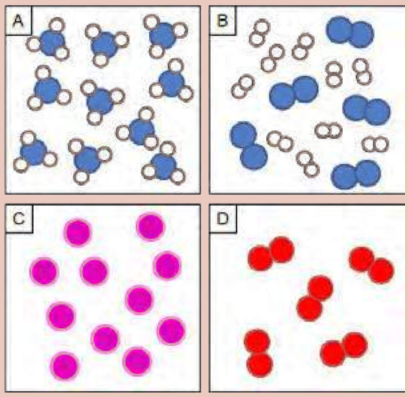
Study the concept map below summarising what we learnt in this chapter about compounds.


Compounds
made up of
elements
each have own
atomic number
mass number
name
symbol
arranged on
Periodic Table
where
groups (columns)
have
similar chemical properties
3 main classifications
metals
semi-metals
non-metals
in a
fixed ratio
called a
represented by a
chemical formula
have
names
according to
elements
such as
sodium chloride
some are
common names
such as
water
ammonia
sometimes indicate
number
of
oxygen atoms
in
such as
monoxide
has
one
dioxide
has
two
trioxide
has
three



REVISION:

1. Each of the four blocks below (labelled A to E) contain some matter. You must answer the following questions using the diagrams in the blocks. Each question may have more than one answer! [12 marks]



a) Which block represents the particles of an element?

b) Which block represents the particles in a compound?

c) Which block represents the particles in a mixture?

d) Which block represents diatomic particles?

e) If the blue atoms are N and the white atoms are H, write the formula for the molecules in block A.

f) If the blue atoms are N and the white atoms are H, write the formula for the molecules in block B.

g) Which blocks contain molecules?

h) Which block contains single atoms?

2. How would you name the following compounds?
   a) Write the name next to each formula in the table below.
   b) Build a model of each compound with play dough.
   c) Draw a picture of one molecule of each compound in the final column of the table.

   [12 marks]

Formula of the compound	Name of the compound	Picture of one molecule of the compound
NH_3		
CO_2		
$CuCl_2$		
SO_2		

3. What are the formulae of the following compounds? [4 marks]

Formula of the compound	Name of the compound
	sodium chloride
	dinitrogen monoxide
	sulfur trioxide
	carbon monoxide

4. Here is a balanced chemical equation. Answer the four questions below that relate to this equation: [8 marks]

$CO + H_2O \rightarrow CO_2 + H_2$

a) Write the formulae of the reactants of this reaction.

---

b) Write the names of the reactants of this reaction.

---

c) Write the formulae of the products of this reaction.

---

d) Write the names of the products of this reaction.

---

5. The table below contains the chemical formulae of a few compounds. You have to write the number of atoms of each element(s) combined in one molecule of each compound. The first row has been filled in for you as an example. [8 marks]

Chemical formula	**What it is made of?**
H_2O	2 hydrogen atoms and 1 oxygen atom
SF_4	
NO_2	
Fe_2O_3	
Na_2O	

Total [44 marks]

Here is your chance to discover the possibilities. What else can this beaker be?

2 Chemical reactions

KEY QUESTIONS:

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

NEW WORDS

- bond
- reactant
- product
- chemical reaction
- macroscopic
- submicroscopic
- symbolic

In Gr. 8 Matter and Materials we learnt about **chemical reactions** for the first time. Can you remember the main ideas about chemical reactions? Here they are again:

- During chemical reactions, materials are changed into new materials with new chemical and physical properties.
- The materials we start with are called **reactants**, and the new materials that form are called **products**.
- During a chemical reaction, atoms are rearranged. This requires that bonds are broken in the reactants and new bonds are formed in the products.

In this chapter we are going to build on these ideas. We will focus on two things:

1. how to write chemical reaction equations; and
2. how to balance chemical reaction equations.

This will prepare us for the chapters that follow this one, in which we will be looking at different types of chemical reactions.

Before we get to chemical reactions, however, it is important that we remind ourselves of the different ways that we have been thinking about chemical compounds up to now. The next section will show how they all fit together.

2.1 Thinking about chemical reactions

Scientists learn to think about compounds on three different levels:

- macroscopic
- microscopic
- submicroscopic

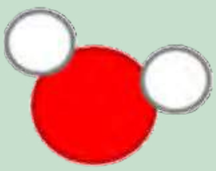
As a young scientist, you have already been introduced to this kind of thinking. The three levels can also be thought of as three different ways to represent compounds. The next activity will help you understand what this means.

ACTIVITY: Drawing water

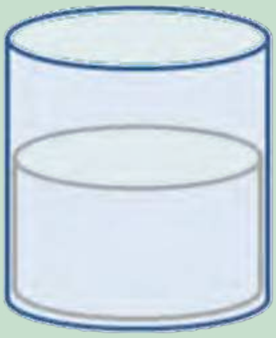
INSTRUCTIONS:

The instruction for this activity is really simple: Draw a picture of water. You may use the space below for your drawing.

Your drawing may look like one of the diagrams below. They all represent water. But which one is correct?



(i)



(ii)

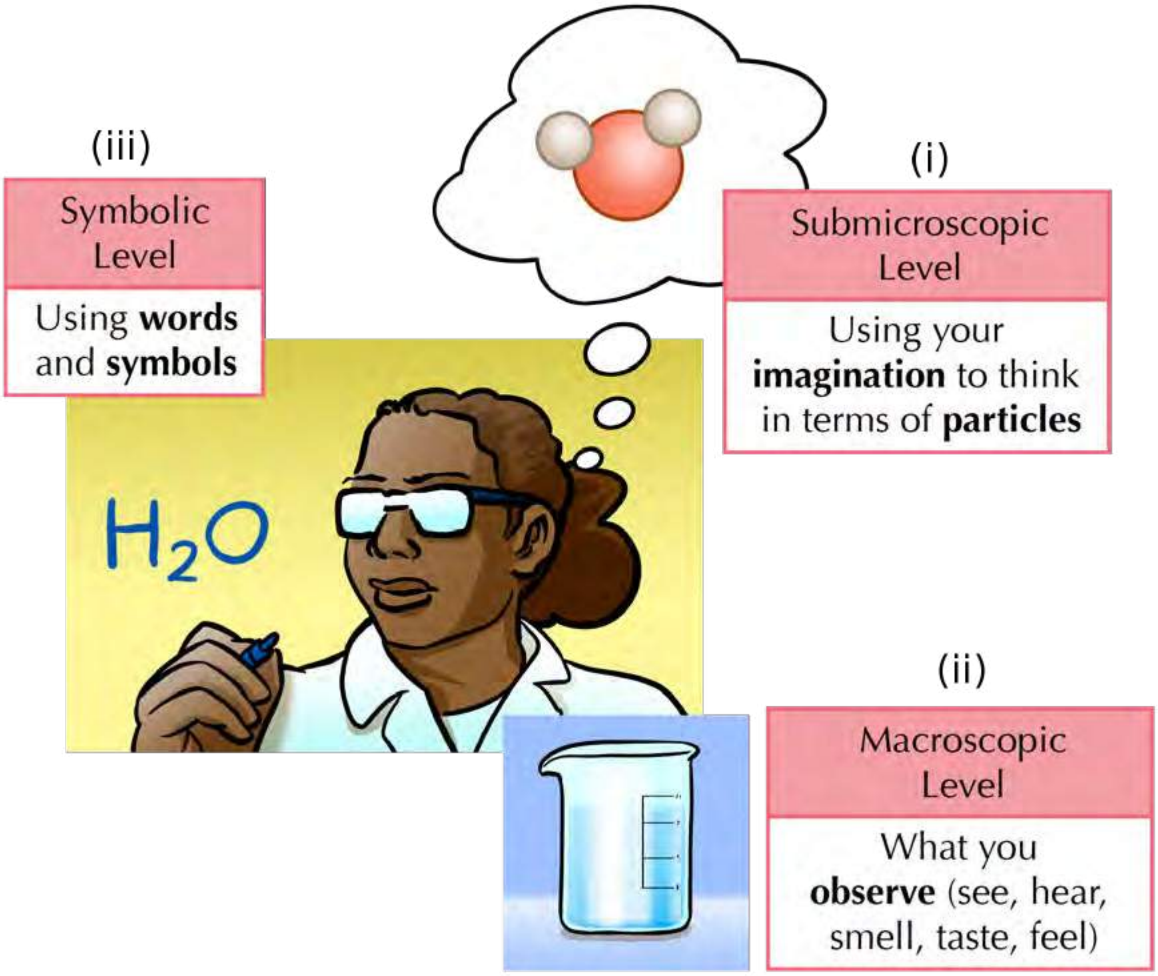
H_2O

(iii)

They are all correct!

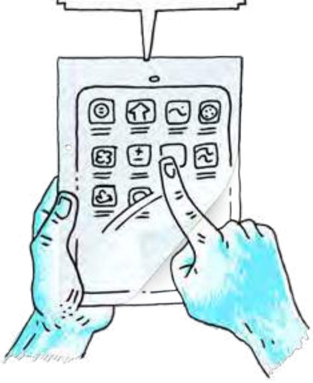
The three diagrams above all represent water, but they are very different from each other. We say that they are three different **representations** of the same thing, namely water.

The following diagram shows how the three representations fit together.



TAKE NOTE

Submicroscopic means 'smaller than microscopic', or 'too small to see through a microscope'. Sometimes it helps to think that this is what we would see if we had special 'submicroscopic goggles' on to 'see' at the atomic level!



The water molecule in the top right shows what a particle of water would look like (i). We cannot see water particles with our eyes, therefore we have to imagine them. This is why the water molecule is inside a thought bubble. We call this a **submicroscopic representation**.

The beaker of water shows what water looks like to our eyes (ii). We call this a **macroscopic representation**, because it is observable. That means it can be observed by using our senses such as seeing, feeling, hearing, tasting or touching.

The chemical formula on the left uses chemical symbols to represent water (iii). We have learnt that chemical formulae are made up of element symbols. We can think of chemical symbols and formulae as a chemical 'language', because they tell a story. The 'story' told by the formula H_2O is that a water molecule consists of two atoms of H and one atom of O. The formula 'H_2O' is a **symbolic representation**.

Experienced scientists can move easily between these three levels. They can translate the symbolic language of chemical formulae to submicroscopic pictures in their mind. This is what we will practice in this chapter.

VISIT

Find out about special microscopes which enable people to 'see' atoms

bit.ly/19YIOCU

Before moving on, try another example where you draw the 3 different levels of carbon dioxide in the space below. Label each level.

VISIT

The world's smallest movie made with atoms bit.ly/168BHFa and how the scientists made it

bit.ly/1cYU80s

2.2 How do we represent chemical reactions?

How would you define a chemical reaction? Write down some of your ideas. The following words may help you formulate your sentences.

reactants, products, bonds, rearranged, atoms, molecules, new compounds

NEW WORDS

- chemical equation
- coefficient
- subscript

A chemical reaction is a rearrangement of atoms in which one or more compounds are changed into new compounds.

All chemical reactions can be represented by equations and models. To some people, chemical equations may seem very hard to understand. Since atoms and molecules can not be seen they have to be imagined and that can be quite difficult! Luckily, we have had some preparation because we have been drawing molecules since Gr. 7.

Anytime that atoms separate from each other and recombine into different combinations of atoms, we say a chemical reaction has occurred. No atoms are lost or gained, they are simply rearranged.

1. Word equations

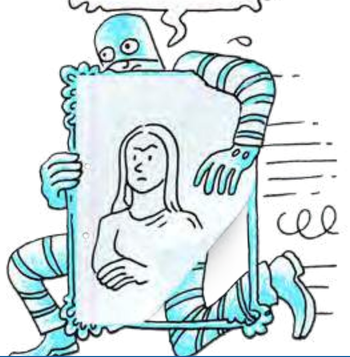
When we represent a chemical reaction in terms of words, we write a **word equation**. For example, when hydrogen gas reacts with oxygen gas to form water, we can write a word equation for the reaction as follows:

hydrogen + oxygen $\rightarrow$ **water**

To the left of the arrow, we have the 'before' situation. This side represents the substances we have before the reaction takes place. They are called the **reactants**. What are the reactants of this reaction?

TAKE NOTE

In mathematic equations we use an equal sign (=) for example 2 + 2 = 4, but in scientific chemical equations, we use an arrow ($\rightarrow$), for example $C + O_2 \rightarrow CO_2$.



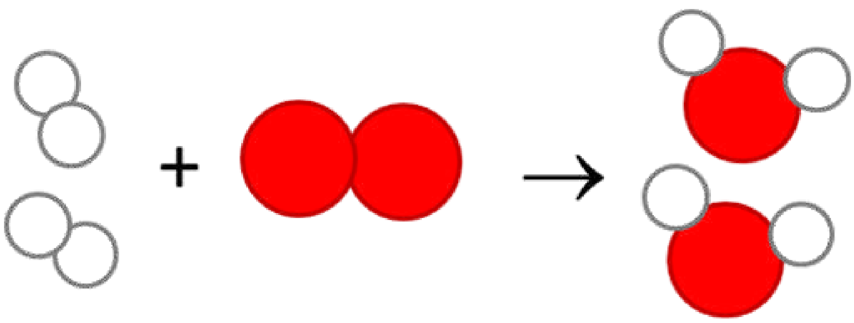
To the right of the arrow we have the 'after' situation. This sides represents the substances that we have after the reaction has taken place. They are called the **products**. What is the product of this reaction?

---

2. Picture equations

The same reaction of hydrogen reacting with oxygen, can also be represented in pictures called submicroscopic diagrams. The diagram below shows that the atoms in two hydrogen molecules (H_2) and one oxygen molecule (O_2) on the left rearrange to form the two water molecules (H_2O) on the right of the arrow. Hydrogen atoms are white circles and oxygen atoms are red circles.

What kind of representation is this: macroscopic, submicroscopic, or symbolic?



Now we are going to convert our submicroscopic picture to a symbolic one:

What is the product of the above reaction? What are the reactants of the above reaction? Write their formulae.

---

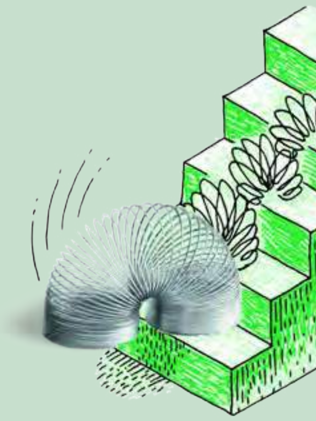
3. Chemical equations

When we represent a chemical reaction in terms of chemical formulae (symbols), it is called a **chemical equation**. The chemical equation for the above reaction would be as follows:

$\mathbf{2\ H_2 + O_2 \rightarrow 2\ H_2O}$

What kind of representation is this: macroscopic, submicroscopic, or symbolic?

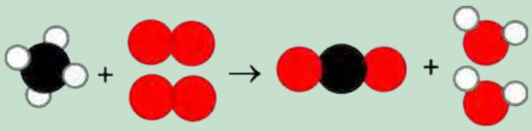
We still have reactants on the left and products on the right.



ACTIVITY: Identifying the different types of equations

INSTRUCTIONS:

1. Complete the following table by identifying the different types of equations which have been shown, namely word, picture or chemical equations.

Equation	Type of equation
	
carbon dioxide + water $\rightarrow$ glucose + oxygen	
$Fe + O_2 \rightarrow Fe_2O_3$	
	
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$	

QUESTIONS:

1. What process does the equation, carbon dioxide + water $\rightarrow$ glucose + oxygen, represent?

2. What process does the equation, $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$, represent?

When you look at the reaction equation above you will notice two kinds of numbers:

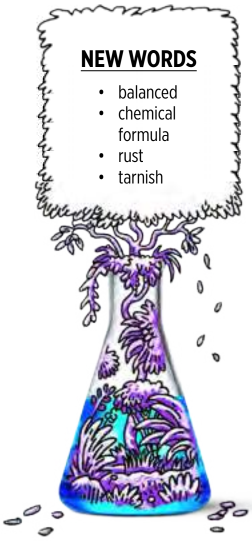
- Numbers *in front of* chemical formulae in the equation. They are called **coefficients**.
- Smaller numbers used *inside and below* the chemical formulae. These are called **subscripts**.

Coefficients and subscripts mean different things, as you will see in the next section.

Coefficients and subscripts in chemical equations

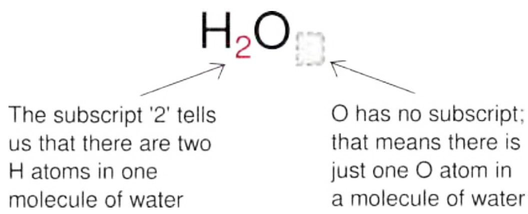
Why is there a '2' in front of the formula for water (H_2O) in the chemical equation for water? This is because two molecules of H_2O can be made from two molecules of H_2 and one molecule of O_2 in our reaction.

The numbers in front of the formulae in the chemical equation are called **coefficients**. They represent the numbers of individual molecules that are in the chemical reaction.



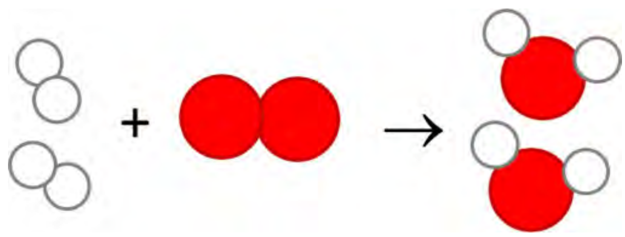
You will notice that O_2 does not have a coefficient in the reaction above. When there is no coefficient, it means that just one molecule of that substance takes part in the reaction.

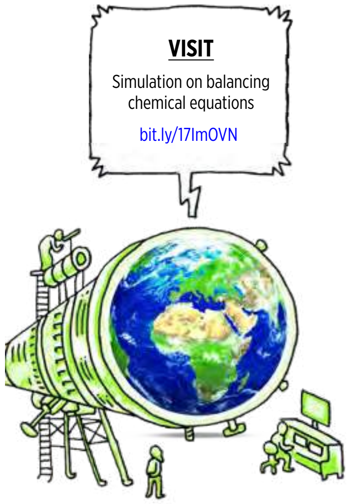
In the previous chapter, we learnt how to interpret chemical formulae. When we read the formula, the **subscripts** tell us how many atoms of a particular element are in one molecule of that compound.



2.3 Balanced equations

Now we are going to learn what it means when a reaction is **balanced**. Here is our submicroscopic picture again.





Count how many H atoms are on the left side of the reaction. How many on the right?

Count how many O atoms are on the left side of the reaction. How many on the right?

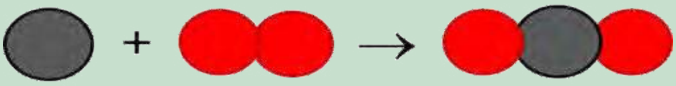
Did you notice that the numbers and types of atoms are the same on the left and on the right of the reaction? The reactants have four H atoms and two O atoms. The products have four H atoms and two O atoms.

When this is true of a reaction equation, we say the equation is **balanced**.

ACTIVITY: When is a reaction balanced?

INSTRUCTIONS:

1. Study the equation below. The black atoms are carbon (C), and the red atoms are oxygen (O). They will not always necessarily be this colour - this is just a representation.
2. Answer the questions that follow.



QUESTIONS:

1. What kind of representation is this: macroscopic, submicroscopic or symbolic?

---

2. Write a symbolic representation (a chemical equation) for the above reaction.

---

3. Write the formulae for the reactants of this reaction.

---

4. Write the formula for the product of the reaction.

---

5. Count how many C atoms are on the left side of the reaction. How many on the right?

---

6. Count how many O atoms are on the left side of the reaction. How many on the right?

---

7. Is the reaction balanced? Why do you say so?

Now that we know how to recognise a balanced equation, we are going to learn how to balance them!

What is a balanced equation? Write down your own definition.

We are going to use a few examples of real reactions to learn how to balance equations. In the chapters following this one, we are going to see what these reactions look like in real life, but for now, we will just focus on how to balance equations.

ACTIVITY: Magnesium burning in oxygen

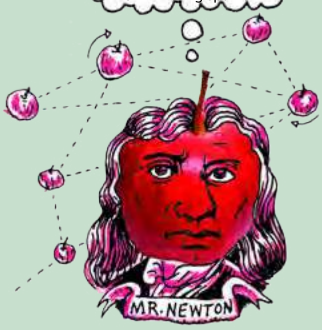
When magnesium metal burns in oxygen, we can write the following word equation for the reaction that occurs between these two elements:

magnesium + oxygen → magnesium oxide

Magnesium flakes burning in oxygen in a sparkler.

DID YOU KNOW?

Magnesium flakes are often used in some fireworks, such as sparklers, because when they burn they create the bright, shimmering sparks.



QUESTIONS:

1. What are the reactants of the reaction?

2. What is the product?

We can change the word equation into a chemical equation:

$Mg + O_2 \rightarrow MgO$

3. What kind of representation is this: macroscopic, submicroscopic, or symbolic?

4. Is the equation balanced? If you are not sure, count the number of each type of atom on the left, and on the right. Perhaps it will help to look at a submicroscopic representation (a particle diagram) of the reaction:

You can write your results in the table below:

Number of atoms	Reactants	Products
Mg		
O		

5. What is your conclusion: Is the equation balanced? Explain your answer.

So how could we balance the equation to describe magnesium burning in oxygen? When balancing reactions, there is one simple rule:

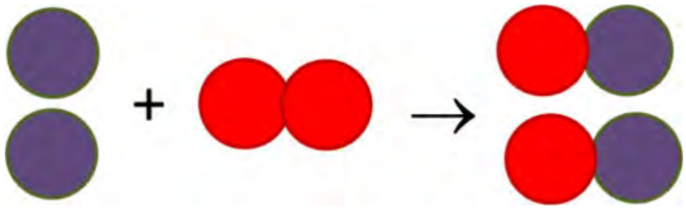
You may only add compounds that are already in the equation. This means only coefficients may be changed, not subscripts!

Let's try a few alternative solutions. Would it help to add an O atom on the right, like this?

Now the O atoms are balanced on both sides of the equation, but we don't have MgO on the right anymore. We have changed the formula on the right to MgO_2. That means we have changed a subscript in the formula. You cannot change the formula of a compound when balancing chemical equations.

Adding single atoms to any side of the equation is also not allowed. That means the following equation is also not correct:

Remember that we may only use the chemical formulae that are already in the equation. We need two MgO's on the right to balance the two O's in O_2. We also need two Mg's on the left to balance the two MgO's on the right.



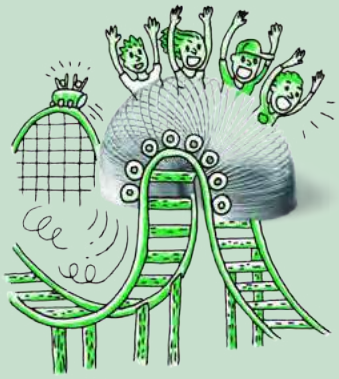
Can you build this equation with play dough balls or beads? When you convert the play dough 'reactants' to 'products', are there any unused 'atoms' left behind afterwards?

Now, let us take this a step further. We are going to convert our balanced submicroscopic equation to a symbolic chemical equation. Write down a balanced equation for magnesium burning in oxygen to produce magnesium oxide.

Here are a few important rules for balancing chemical equations:

- When we balance reaction equations we may ONLY add coefficients to the chemical formulae that are already in the equation.
- We may NOT change the chemical formulae of any of the reactants or products by changing the subscripts in a formula.
- We may NOT add other reactants or products. This includes adding single atoms of any of the elements already in the reaction equation.
- We may NOT remove reactants or products.

We are now ready to practice balancing other reaction equations.



ACTIVITY: Iron reacts with oxygen

When iron rusts, it is because the iron metal reacts with oxygen in the air to form iron oxide.

An old car with rust on the bonnet.

A closeup photo of a rusted barrel.

The word equation is the following:

iron + oxygen → iron oxide

The chemical equation is the following:

$Fe + O_2 \rightarrow Fe_2O_3$

Is the equation balanced? Draw a submicroscopic picture to help you decide.

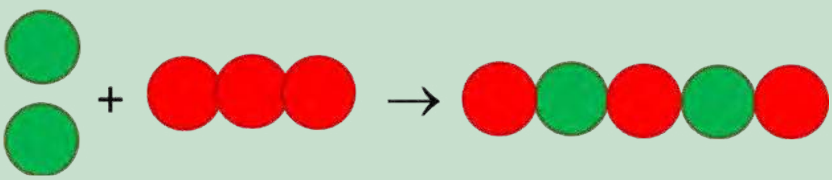
You could also use a table like the one below:

Number of atoms	Reactants	Products
Fe		
O		

What is your verdict: Is the equation balanced? Explain your answer.

How could we balance the reaction? Three possibilities (Plans A, B and C) are given below. You must evaluate each plan, and say if it is allowed or not.

<u>Plan A</u>



Changes made	Is this change allowed? Yes/no?	Reason
Add one Fe atom on the reactant side.		
Change O_2 to O_3 on the reactant side of the equation.		

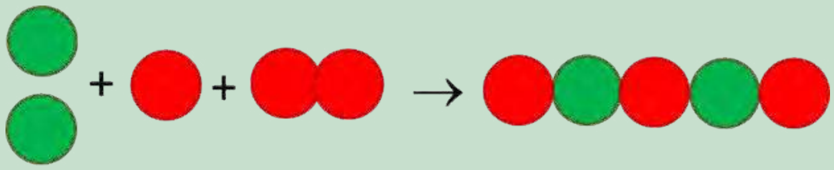
1. Convert the picture equation above to a chemical equation.

2. Did any coefficients change? Remember that this is allowed.

3. Did any formulae change, or were any new formulae added? Remember that this is NOT allowed.

4. What do you think: Can this plan work? Explain your answer.

Plan B



Changes made	Is this change allowed? Yes/no?	Reason
Add one Fe atom on the reactant side.		
Add one O atom on the reactant side.		

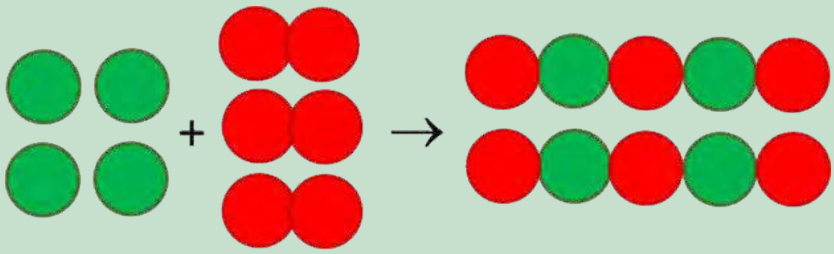
1. Convert the picture equation to a chemical equation.

2. Did any coefficients change? Remember that this is allowed.

3. Did any formulae change, or were any new formulae added? Remember that this is NOT allowed.

4. What do you think: Can this plan work? Explain why or why not.

Plan C



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

1. Convert the picture equation to a chemical equation.

2. Did any coefficients change? Remember that this is allowed.

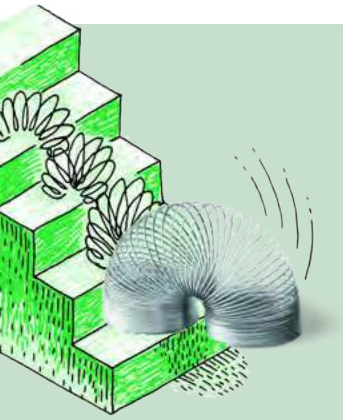
3. Did any formulae change, or were any new formulae added? Remember that this is NOT allowed.

4. What do you think: Can this plan work? Explain why or why not.

5. Which of the three plans (A, B or C) helped us to balance the equation using only moves that are allowed?

6. Are there any other plans that you can think of to balance this equation?

In the next activity we will balance an equation that is much simpler, but we are not going to include all the explanations of the previous activity.



ACTIVITY: Copper reacts with oxygen

Have you ever noticed how copper items tarnish over time?

This dark layer of tarnish is the result of a slow reaction between copper and oxygen, to form copper oxide.

One of these copper coins is tarnished as it has become coated in a black substance.

QUESTIONS:

1. Write the word equation for this reaction. The words are all in the sentence above, they just need to be placed in the correct positions.

$$\boxed{} + \boxed{} \rightarrow \boxed{}$$

2. Convert the word equation into a chemical equation. You do not have to balance it yet.

$$\boxed{} + \boxed{} \rightarrow \boxed{}$$

3. Convert the chemical equation to a picture equation. It does not have to be balanced.

4. Now, redraw the picture equation so that it is balanced. Remember that no 'new' compounds may be added; we are only allowed to draw more of the molecules that are already there.

5. Convert the balanced picture equation to a balanced chemical equation.

$\boxed{} + \boxed{} \rightarrow \boxed{}$

In the chapters that follow, there will be more opportunities to write and balance chemical equations.

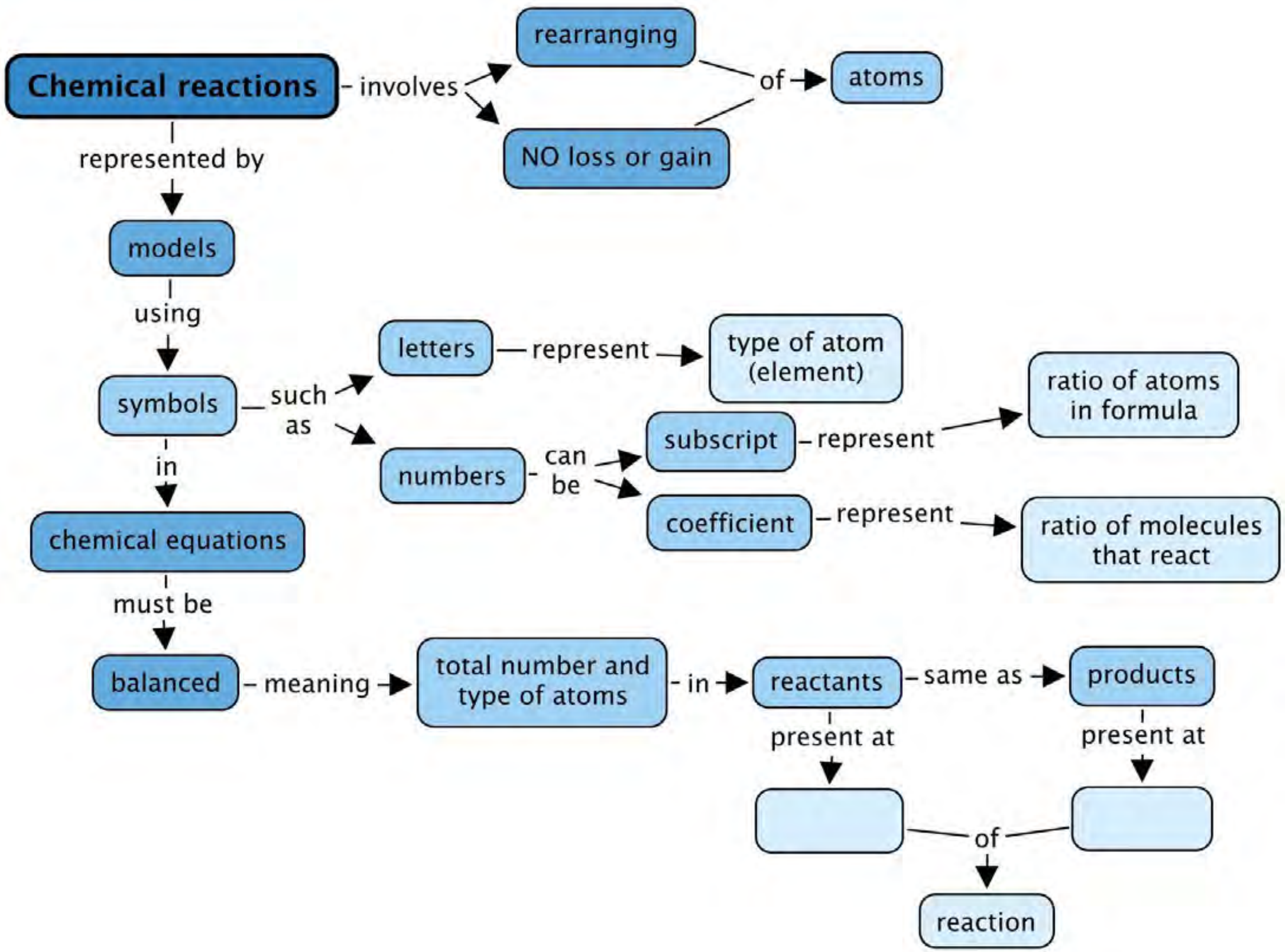
SUMMARY:

Key Concepts

- There are a number of different ways to represent chemical equations:
  - With models and pictures (in submicroscopic representations);
  - with symbols and formulae (in chemical equations); and
  - with words (in word equations).
- Numbers are used in two different ways in chemical equations:
  - Coefficients in front of chemical formulae indicate the numbers of atoms or molecules of a specific type that take part in the reaction; and
  - Subscripts inside chemical formulae indicate the number of atoms of a specific type in that particular compound.
- Chemical reactions happen when atoms in compounds rearrange; no atoms are lost or gained during a chemical reaction.
- In a balanced equation equal numbers of the same kinds of atoms are on opposite sides of the reaction equation.

Concept Map

The following concept map is incomplete. You need to describe when you get reactants and when you get products in a chemical reaction.


Chemical reactions
involves
rearranging
NO loss or gain
of
atoms
represented by
models
using
symbols
such as
letters
represent
type of atom (element)
numbers
can be
subscript
represent
ratio of atoms in formula
coefficient
represent
ratio of molecules that react
in
chemical equations
must be
balanced
meaning
total number and type of atoms
in
reactants
same as
products
present at
present at
of
reaction

REVISION:

1. Why can we not change the subscripts in the formulas of reactants and products when we want to balance an equation? [2 marks]

2. Write the balanced chemical equation between carbon and oxygen to form carbon dioxide. [1 mark]

3. Write the balanced chemical equation between hydrogen and oxygen to form water. [1 mark]

4. Here is a balanced chemical equation:

$$\mathbf{C + H_2O \rightarrow CO + H_2}$$

Answer the four questions below that relate to this equation: [8 marks]

a) Write the formulae of the reactants of this reaction.

b) Write the names of the reactants of this reaction.

c) Write the formulae of the products of this reaction.

d) Write the names of the products of this reaction.

5. The balanced equation below represents the reaction between nitrogen monoxide (NO) and bromine (Br_2):

$$\mathbf{2\ NO + Br_2 \rightarrow 2\ NOBr}$$

Complete the table by counting how much of each atom is on each side of the reaction equation. [6 marks]

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

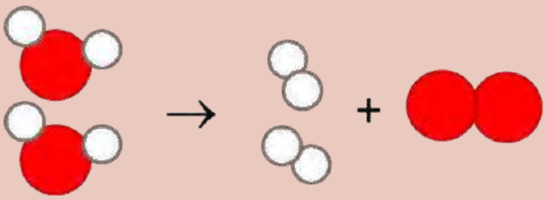
6. Turn the following chemical equations into word equations: [2 x 3 = 6 marks]
   a) $2\ CO + O_2 \rightarrow 2\ CO_2$

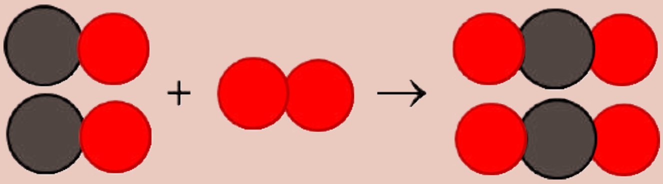
   b) $2\ Mg + O_2 \rightarrow 2\ MgO$

7. Turn the following word equations into chemical equations: [2 x 3 = 6 marks]
   a) sulfur + oxygen → sulfur dioxide

   b) carbon monoxide + water → carbon dioxide + hydrogen

8. Turn the following picture equations into chemical equations. [2 x 3 = 6 marks]
   - The red circles represent oxygen (O) atoms.
   - The white circles represent hydrogen (H) atoms.
   - The grey circles represent carbon (C) atoms.
   - The yellow circles represent sulfur (S) atoms.





9. Write the following chemical equations as word equations: [4 x 1 = 4 marks]
   a) $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$

   b) What does this product look like?

   c) $2\ Mg + O_2 \rightarrow 2\ MgO$

   d) What does the product look like?

10. Turn the following chemical equations into picture equations: [2 x 4 = 8 marks]
   a) $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

   b) $CS_2 + 3\ O_2 \rightarrow CO_2 + 2\ SO_2$

Total [48 marks]

3 Reactions of metals with oxygen

KEY QUESTIONS:

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

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

- magnesium + oxygen $\rightarrow$ magnesium oxide
- iron + oxygen $\rightarrow$ iron oxide
- copper + oxygen $\rightarrow$ copper oxide

Which groups do magnesium, iron and copper come from?

TAKE NOTE

The metals will react similarly with the other elements in the same group as oxygen (group 16).

In these reactions, the elements that react with oxygen are all **metals**. If you are not convinced of this, find them on the Periodic Table below in the front of your book. Can you see that they are all found in the region occupied by the metals? Where are metals located on the Periodic Table?

The names of the products of the three reactions above have something in common. Write down the names. Can you see what they have in common?

The products are all **metal oxides**. What exactly are metal oxides? As we will see later when we draw diagrams and write formulae to represent these reactions, they are compounds in which a metal is combined with oxygen, in some fixed ratio.

We are going to look at two of the reactions shown previously in greater detail in this chapter. Remember that they are not the only reactions of metals with oxygen; they are just the ones that have been chosen as examples.

First, we will observe the actual reactions. Your teacher will demonstrate, while you make observations. Afterwards we will write about these reactions using 'scientific language' as we write reaction equations for each one. Before we start, here is a reminder of something we discussed in Chapter 1.

ACTIVITY: Three different levels of interpretation in science

In the first chapter of Gr. 9 Matter and Materials, we learnt that scientists interpret chemical reactions on three different levels. Those three levels are:

- the macroscopic level;
- the submicroscopic level; and
- the symbolic level.

Check whether you still remember what each level refers to, by completing the following table.

When we do the following:	We are operating on this level: Macroscopic/submicroscopic/symbolic
Observe actual reactions (see, hear, smell, touch, taste). Describe what we see in words.	
Imagine the behaviour of particles during reactions. Draw pictures of particles in substances.	
Write chemical formulae. Write reaction equations.	

Soon your teacher will demonstrate two reactions, while you will be making observations. Which of the three levels will you be operating at?

___

NEW WORDS

- combustion

The purpose of these demonstrations is to give you a chance to make macroscopic observations of the chemical changes that take place during the reactions. This chapter will also help you to link those macroscopic observations with pictures and equations that you learnt to write in the previous chapter.

3.1 The reaction of iron with oxygen

We will be looking at how iron reacts with oxygen. In some cases, you might use steel wool for these experiments. Do you know what steel wool is? It is wire wool made of very fine steel threads. Steel is an alloy made mostly of iron. So, when we look at how steel wool burns in oxygen, we are actually looking at how iron reacts with oxygen.

TAKE NOTE

A metal alloy is a solid mixture of two or more different metal elements. Examples are steel and brass.

Steel wool spinning creates interesting photos as the iron burns in oxygen and creates orange sparks.

Iron shavings look like sparks when they burn in the blue flame of a Bunsen burner.

Your teacher will perform a demonstration in which iron is burned in air. When a substance burns in air, the reaction is called a **combustion reaction**. When a substance combusts in air, it is really reacting with oxygen.

ACTIVITY: The reaction of iron with oxygen

MATERIALS:

- Bunsen burner or spirit burner
- matches
- safety goggles
- steel wool
- tongs

INSTRUCTIONS:

1. Your teacher will demonstrate the combustion of iron in oxygen (which is present in air).
2. You should make careful observations during the demonstration and write these down in the spaces provided below. To guide you, some questions have been provided.

VISIT

You can see a video of steel wool burning here:
bit.ly/1cYPyz7

QUESTIONS:

1. We used steel wool in this demonstration, but what is steel wool mostly made of?

___

___

2. Look at the metal before it is burned. Describe what it looks like.

___

___

3. Can you see the oxygen that the metal will react with? Can you describe it?

4. What do you observe during the reaction? Describe anything you see, hear, or smell.

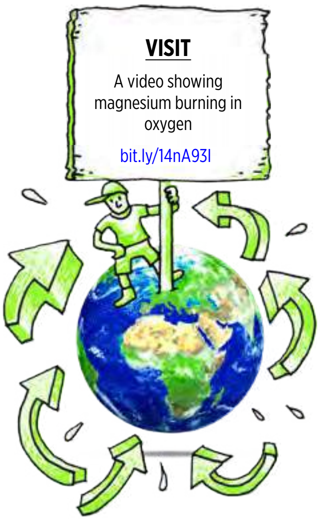
5. What does the product of the reaction look like? Describe it in as much detail as possible.

If you think the reaction when iron burns in oxygen is spectacular, the next demonstration will amaze you!

3.2 The reaction of magnesium with oxygen

Your teacher will perform a demonstration in which magnesium is burned in air.

Magnesium burns with a bright white flame.



ACTIVITY: The reaction of magnesium with oxygen

MATERIALS:

- Bunsen burner or spirit burner
- matches
- safety goggles
- magnesium ribbon
- tongs
- watch glass or beaker

INSTRUCTIONS:

1. Your teacher will demonstrate the combustion of magnesium in oxygen.
2. You should make careful observations during the demonstration and write these down in the spaces provided below.

QUESTIONS:

1. Describe the physical form (shape) of the metal in this experiment.

2. What do we call reactions where a substance burns in air?

3. How would you describe the physical appearance or colour of the metal before it is burned?

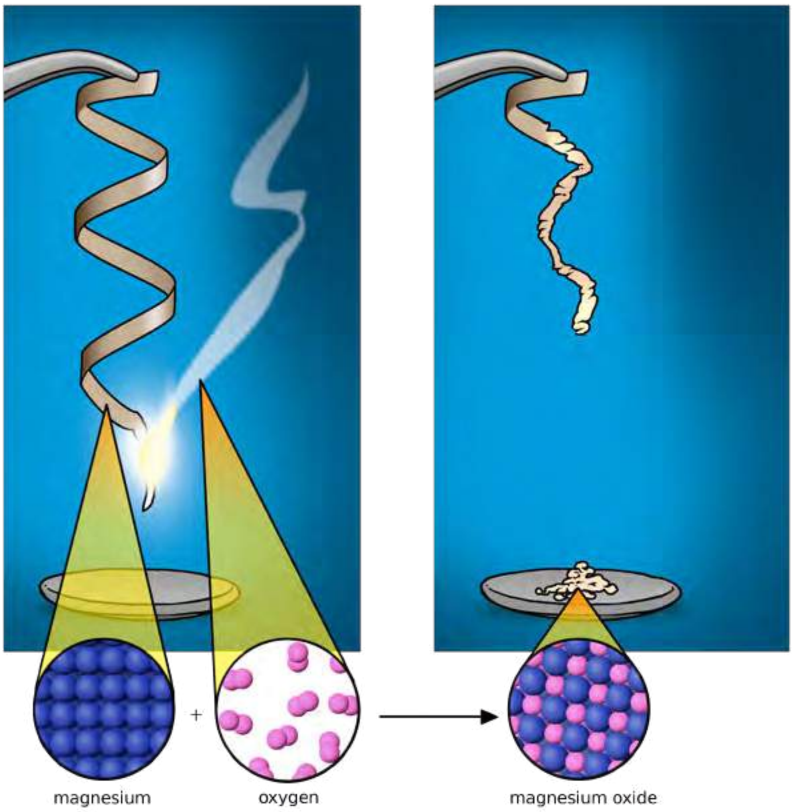
4. Can you see the oxygen that the metal will react with? Can you describe it?

5. What do you observe during the reaction? Describe anything you see, hear, or smell.

6. What does the product of the reaction look like? Describe it in as much detail as possible.

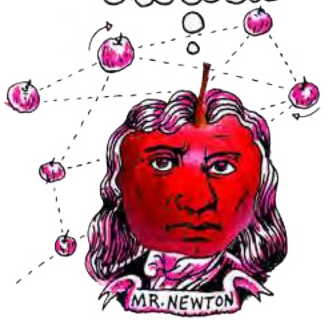
Magnesium is in group 2 in the Periodic Table. Do you remember that we said that elements in the same group will behave similarly. This means that they will react in a similar way. We have studied how magnesium reacts with oxygen, but calcium, for example, will behave in a similar way. You can watch the video in the visit link to confirm this.

The following diagram combines the macroscopic, submicroscopic and symbolic representations of the reaction that you have just observed.



DID YOU KNOW?

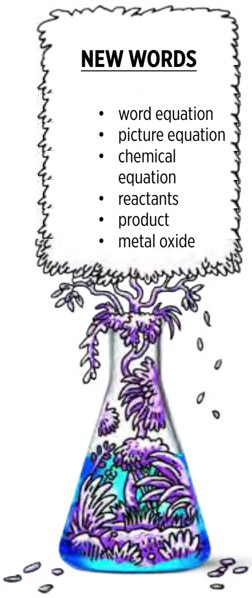
To take a photo in the dark, we need a camera flash. Most cameras have built in flashes these days. But, the earliest flashes worked with flash powder that contained magnesium grains. They had to be lit by hand and burned very brightly, for a very short period.



A photographer using an antique camera and flash that works with magnesium powder.

Now that we have made our macroscopic observations of the two reactions, we are ready to write about these reactions in scientific language.

3.3 The general reaction of metals with oxygen



Let us start by writing word equations for the two reactions that we have just performed. Word equations are often easier to write than picture equations or chemical equations and so they are a good starting point when we want to write reactions.

Write the word equation for the reaction between iron and oxygen and for the reaction between magnesium and oxygen.

The word equation

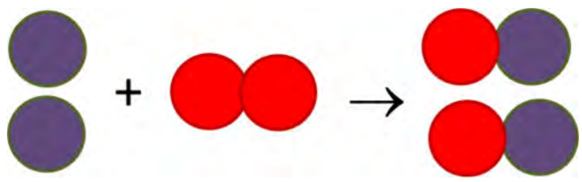
We can write a general word equation for reactions in which a metal reacts with oxygen:

metal + oxygen → metal oxide

When we use words to describe a reaction, we are still operating on the macroscopic level. Next, we are going to translate our word equation to a picture equation.

The picture equation

When we represent a chemical reaction as a particle diagram, such as in the picture equation below, we are operating on the submicroscopic level.



Can you identify the reactants in the above equation? The purple atoms are magnesium and the oxygen atoms are red. Write down the name and chemical formula of the product of the reaction.

The picture is not the same for all reactions of metals with oxygen.

The chemical equation

We can go further and translate the picture equation for the reaction between magnesium and oxygen to a chemical equation:

$2\ Mg + O_2 \rightarrow 2\ MgO$

Since the chemical equation consists of symbols, we can think of this as a symbolic representation.

Can you remember what the numbers in front of the formulae in the chemical equation are called? Can you remember what the numbers inside a chemical formula are called?

As we have said, the metals in the same group will react in the same way as each other with oxygen. So, calcium reacts with oxygen in the same way as magnesium reacts with oxygen. The chemical equations also show similarities. The chemical equation for the reaction between calcium and oxygen is:

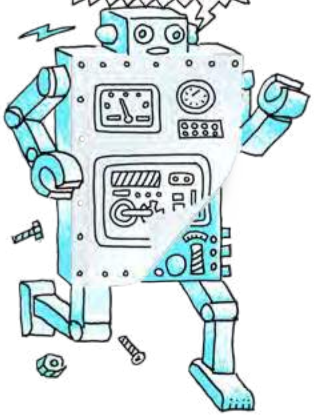
$2\ Ca + O_2 \rightarrow 2\ CaO$

What is the product called in this reaction?

What group are calcium and magnesium from?

TAKE NOTE

Metal oxides of the types M_2O_3 and MO_2 also occur, but we will limit our discussion to the first two types.



A metal oxide has the the general formula MO or M_2O. In the formula, M represents a metal atom and O represents oxygen. We can therefore say that metals from Group 2 will react with oxygen and have the following general equation, where **M** represent a Group 2 metal:

$2M + O_2 \rightarrow 2MO$

To know whether MO or M_2O will be the correct formula, here are two simple rules for you to remember:

1. **Metal oxides from group 1 on the Periodic Table will have the formula M_2O.**
   Can you write two examples? Look at the Periodic Table at the front of the book, pick any two metals from group 1 and write their formulae using this rule.

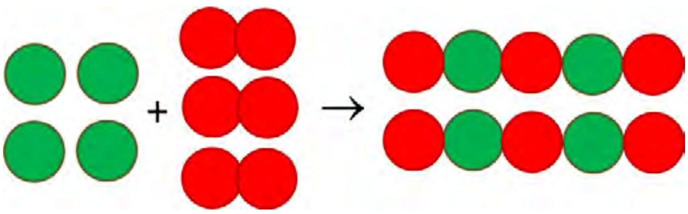
DID YOU KNOW?

Group 1 metals are referred to as the **Alkali Metals** and Group 2 metals are referred to as the **Alkaline Earth Metals**.

2. **Metal oxides from group 2 will have the formula MO.**

Can you write 2 examples?

Iron is from Group 8. Here is the picture equation of the reaction between iron and oxygen (iron is green and oxygen is red).



Write the chemical equation and word equation for this reaction underneath the picture equation.

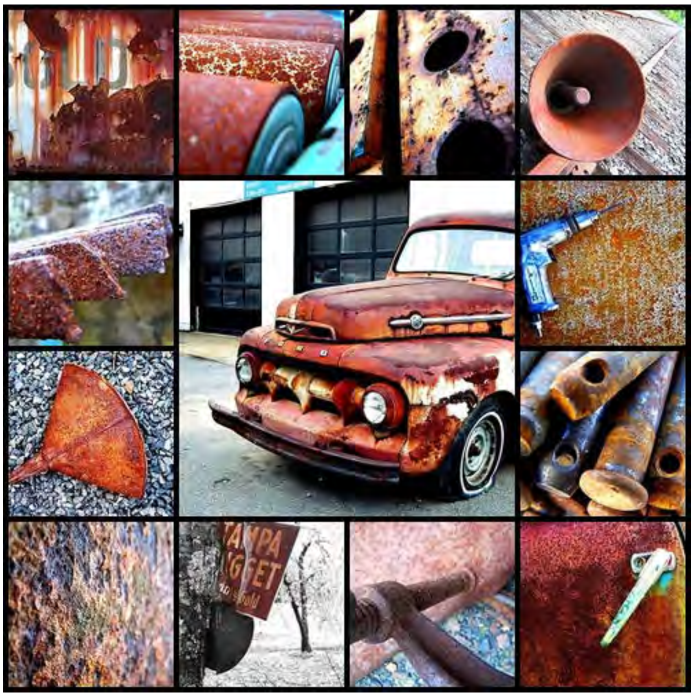
NEW WORDS

- rust
- corrosion
- corrosive
- rust-resistant
- steel

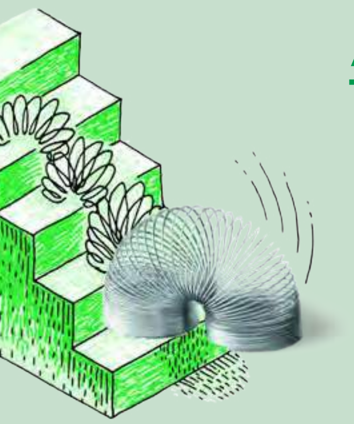
In the next section, we are going to return to the macroscopic world to see another example of the reaction between iron and oxygen that you should be very familiar with - the formation of rust.

3.4 The formation of rust

Do you know what rust is? The pictures below will provide some clues.



Different objects which rust.



ACTIVITY: The reaction between iron and oxygen in air

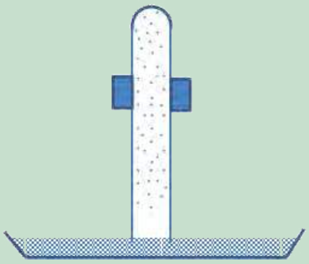
MATERIALS:

- test tube
- clamp
- retort stand
- dish
- iron filings
- water

INSTRUCTIONS:

1. Rinse a test tube with water to wet the inside.
2. Carefully sprinkle a spatula of iron filings around the sides of the test tube.
3. Invert the test tube in a dish of water. Use a clamp attached to a retort stand to hold the test tube in place.
4. Over the three days the water must remain above the lip of the test tube.

Here is a simple diagram showing the experimental setup with the clamp holding the test tube upright.



QUESTIONS:

1. What do the iron filings look like at the start of the experiment?

___

2. What are the reactants in this experiment?

___

3. Is there something present that is aiding or speeding up the reaction?

___

4. What does the product look like at the end of the reaction?

___

Rust is a word to describe the flaky, crusty, reddish-brown product that forms on iron when it reacts with oxygen in the air.

When your teacher burned the iron earlier, it reacted quickly with oxygen to form iron oxide. Here is a picture of iron oxide to remind you what it looked like.

A sample of iron oxide.

Rust is a form of iron oxide

When iron is exposed to oxygen in the air, a similar reaction occurs, but much more slowly. The iron is gradually 'eaten away' as it reacts slowly with the oxygen. Under wet conditions iron will rust more quickly.

Rust is actually a mixture of different oxides of iron, but the Fe_2O_3 of our earlier example is an important part of that. The rusting of iron is actually a good example of the process of corrosion.

Rusting tends to happen much faster near the ocean. Not only are there water droplets, but these droplets have salt in them and this makes them even more corrosive. Rusting also happens more quickly in the presence of acids. Inside laboratories, or factories where acids are used or stored, the air is also very corrosive. When the air in a specific area contains moisture mixed with acid or salt, we refer to the area as having a **corrosive climate.**

If you live in a corrosive climate, for example near the ocean, it is often better to make the window frames and doors of your house from wood instead of iron and steel, because wood does not rust. Many people also use aluminium as this metal does not rust.

An abandoned car quickly rusts and corrodes near the sea.

The problem with rust

A garden sculpture that was intended to rust to give it more texture.

Rust is a natural process and its effects can be quite beautiful.

However, iron and rust (iron oxide) are completely different materials and therefore have different properties.

ACTIVITY: Why is rust a problem?

1. Let's imagine we have manufactured something out of iron. What properties of iron do we want to take advantage of?

___

___

2. What objects do you think we make out of iron where these properties are desirable?

___

___

A rusted chain.

A rusted door hinge.

3. When an item is made of iron, we might want to protect it from rust, to prevent it from losing those desired properties. Do you think the rusty chain and door handle in the following photos will be as strong and flexible as when they were new? Why not?

You might have learnt in previous grades that iron can be strengthened, and made more resistant to rust, by mixing it with other elements to turn it into **steel**.

Steel is used in the construction of buildings, because it is very strong. Steel is not completely rust-resistant, however, and needs to be protected against rust, especially in moist and corrosive climates.

NEW WORDS

- collide
- barrier
- exposed
- porous
- penetrate
- chromed metal
- galvanised metal
- galvanise
- oxidise

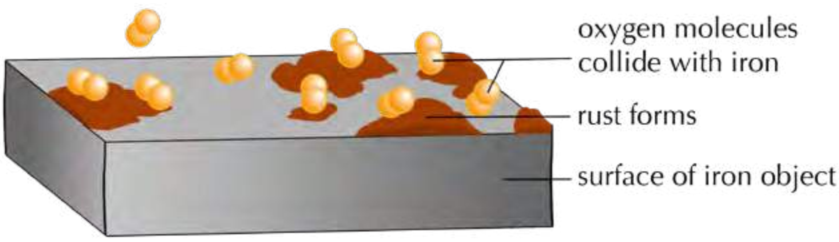
A building under construction. You can see the framework made of steel.

Steel reinforcement to support a building. As you can see, steel can also rust.

In the next section, we will learn about the different ways in which iron and steel can be protected against rust.

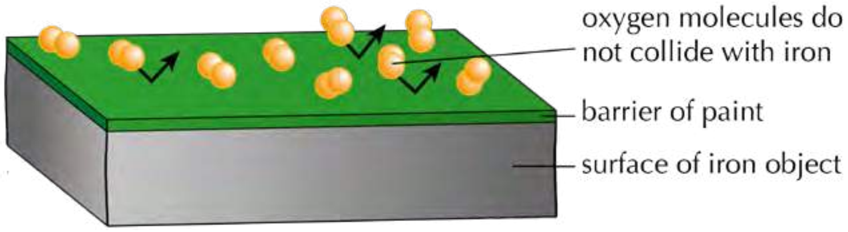
3.5 Ways to prevent rust

Rust forms on the surface of an iron or steel object, when that surface comes into contact with oxygen. The oxygen molecules collide with the iron atoms on the surface of the object, and they react to form iron oxide. If we wanted to prevent that from happening, what would we have to do?



Paint provides a barrier to rust

If we wanted to prevent the iron atoms and oxygen molecules from making contact, we would need to place a barrier between them. That is what we are doing when we paint an iron surface to protect it from rust.



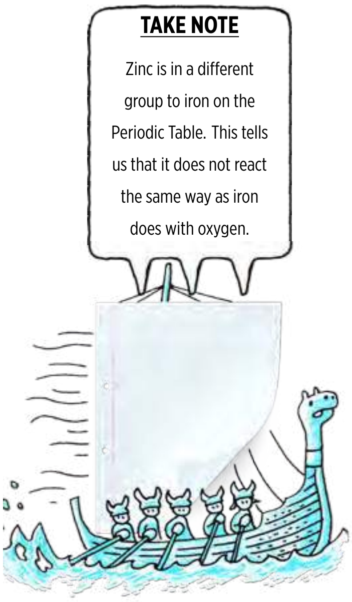
Paint is not the ultimate barrier, though. If the paint surface is scratched, or it starts to peel off, the metal will be exposed and rust can still form.

Other metals as barriers to rust

Rust is a porous material. This means that air and water can penetrate through the rust on the surface of the object to reach the iron underneath. The iron will continue to corrode even if it has a thick layer of rust covering it. So even though the iron surface is covered, it is not protected, because the oxygen molecules can still reach the iron to react with it.

There are a number of other ways to stop or slow down rust. One way to protect the iron surface is to cover it with a metal that does not corrode, like chromium, for instance. Taps and bathroom fittings are often made of iron that has been 'chromed'. They have been covered with a layer of chromium to protect the iron surface from contact with the air.

Chromed taps in a basin.



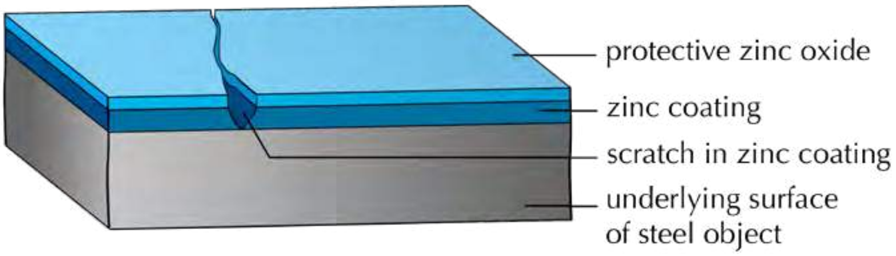
Zinc also reacts with oxygen to form zinc oxide:

$2\ Zn + O_2 \rightarrow 2\ ZnO$

What group is zinc in?

Zinc oxide (ZnO) is not a porous oxide, but forms a dense protective layer that cannot be penetrated by oxygen or water. Iron can be coated with a thin layer of zinc in a process called **galvanising**. The zinc layer quickly reacts with oxygen to become zinc oxide. This layer protects the zinc underneath it from being further oxidised. It also protects the iron underneath the zinc from contact with oxygen.

The following diagram shows a segment of galvanised steel, with a scratch in the protective coating. What do you think will happen to the steel that is exposed to the air by the scratch in the coating?



A segment of galvanised steel, showing damage to the zinc coating.

Iron that is galvanised is used for many different purposes. You would most probably have seen it being used as galvanised roof panels or other galvanised building materials, such as screws, nails, pipes, or floors.

Galvanised panels used for walls or roofs.

A galvanised watering can.

Galvanised nuts and bolts.

Galvanised flooring.

In this chapter we learnt how metal oxides form. We saw two demonstrations of reactions in which metals oxides formed as products. Finally, we learnt about a metal oxide (iron oxide or rust) from our everyday experience as well as ways to prevent objects from rusting, especially those used in buildings and industry.

VISIT

Why do apples turn brown? (video)

bit.ly/17iQvh2

DID YOU KNOW?

Cut apple slices turn brown as the iron compounds in the apple flesh are reacting with the oxygen in the air! The reaction is aided by an enzyme in the apple, so dripping lemon juice onto the slices will destroy the enzyme and prevent them from turning brown.

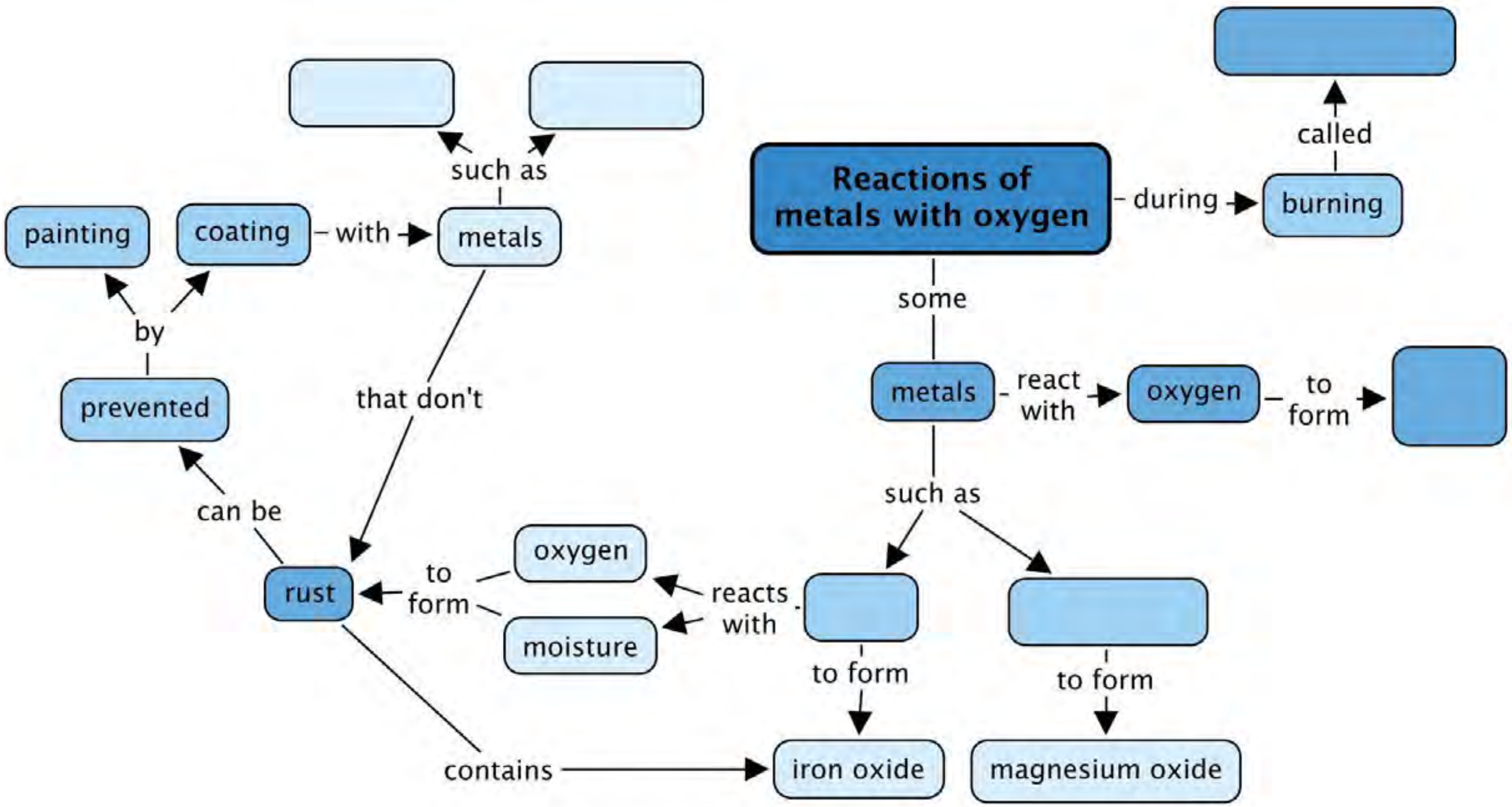
SUMMARY:

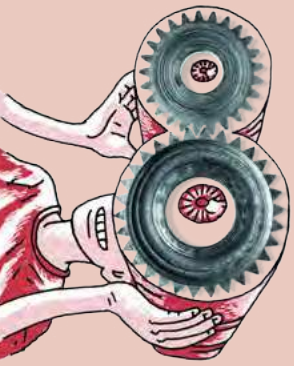
Key Concepts

- When a metal reacts with oxygen, a metal oxide forms.
- The general equation for this reaction is: metal + oxygen $\rightarrow$ metal oxide.
- Some metals will react with oxygen when they burn. These reactions are called combustion reactions. Two examples of combustion reactions are:
  - Iron reacts with oxygen to form iron oxide:
    $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$
  - Magnesium reacts with oxygen to form magnesium oxide:
    $2\ Mg + O_2 \rightarrow 2\ MgO$
- Rust is a form of iron oxide and it forms slowly when iron is exposed to air.
- Iron can be transformed to steel (an alloy), which is more resistant to rust.
- Rust can be prevented by coating iron surfaces with paint, or with rust-resistant metals such as chromium or zinc.

Concept Map

What is the proper name for 'burning'? Fill this into the concept map. Fill in the examples of the metals that you studied in this chapter. You will have to look at the products formed to know where to put which one. Lastly, give two examples of metals that you learnt about in this chapter which do not rust.


Reactions of metals with oxygen
during
burning
called
some
metals
react with
oxygen
to form
such as
to form
iron oxide
to form
magnesium oxide
reacts with
oxygen
moisture
to form
rust
contains
can be
prevented
by
painting
coating
with
metals
such as
that don't



REVISION:

1. Read the sentences and fill in the missing words. Write the missing word on the line below. [9 marks]
   a) A chemical reaction where a compound and oxygen react during burning to form a new product is called a ___________ reaction.

   ____

   b) Magnesium + ___________ → magnesium oxide

   ____

   c) ___________ + oxygen → iron oxide

   ____

   d) copper + oxygen → ___________

   ____

   e) Another word for iron oxide is ___________.

   ____

   f) Metal that is covered by a thin layers of zinc and zinc oxide is called ___________ metal.

   ____

   g) The gradual destruction of materials (usually metals) by chemical reaction with the environment is called ___________.

   ____

   h) When the air in a specific area contains moisture mixed with acid or salt, we refer to the area as having a ___________ climate.

   ____

   i) The product of the reaction between a metal and oxygen is called a ___________.

   ____

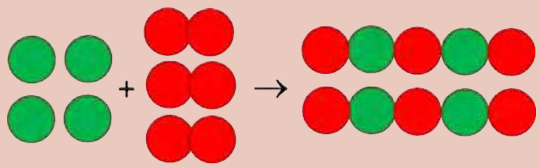
2. List three materials that can be used to protect iron or steel from corrosion. [3 marks]

   ____

   ____

   ____

3. Complete the table by providing the missing equations for the reaction between iron and oxygen [4 marks]

Word equation	
Chemical equation	
Picture equation	

4. Complete the table by providing the missing equations for the reaction between magnesium and oxygen [4 marks]

Word equation	magnesium + oxygen $\rightarrow$ magnesium oxide
Chemical equation	
Picture equation	

5. Complete the table by providing the missing equations for the reaction between copper and oxygen [4 marks]

Word equation	
Chemical equation	$2\ Cu + O_2 \rightarrow 2\ CuO$
Picture equation	

6. Complete the table by providing the missing equations for the reaction between zinc and oxygen [6 marks]

Word equation	
Chemical equation	
Picture equation	

Total [30 marks]

4 Reactions of non-metals with oxygen

KEY QUESTIONS:

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

NEW WORDS

- alternative
- fuel
- fossil fuel
- generate
- inert
- non-metal oxide
- non-renewable
- oxidise
- reactive
- renewable

Oxygen is all around us in the air we breathe. It is a very **reactive** element. When an element is reactive, it means that it will readily react with many other substances. We saw evidence of the reactive nature of oxygen when we observed how it reacted with iron and magnesium to form metal oxides.

In this chapter we look at a few reactions of non-metals with oxygen. Where do we find non-metals on the Periodic Table?

4.1 The general reaction of non-metals with oxygen

When a non-metal burns in oxygen, a **non-metal oxide** forms as product. Here is the word equation for the general reaction:

non-metal + oxygen → non-metal oxide

Can you see that it looks similar to the word equation for the reaction between a metal and oxygen? The only difference is that the word 'metal' has been replaced with 'non-metal' on both sides of the equation. Non-metal oxides have different chemical properties to metal oxides. We will learn more about this later on in the term.

Let's look at a few specific examples of reactions in which non-metals react with oxygen. The first one is one that you are already familiar with, namely the reaction of carbon and oxygen.

TAKE NOTE

Substances that are not reactive are called unreactive or **inert**.

4.2 The reaction of carbon with oxygen

Have you ever seen coal burning in air?

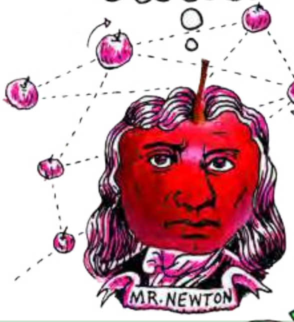
Coal is a form of carbon that is used as **fuel** for many different purposes. It is one of the primary **fossil fuels** that humans use to **generate** electricity for powering our industries, our activities and our living spaces. We will look at this in more detail next term in Energy and Change.

Coals burning in a fire.

A coal-powered power station.

DID YOU KNOW?

37% of the electricity generated worldwide is produced from coal.



ACTIVITY: Coal burning in air

The energy in coal comes from the energy stored in plants and other organisms that lived hundreds of millions of years ago. Over the millennia, layers of dead plants and other biological waste were covered by layers of water and soil. The heat and pressure from the top layers caused the plant remains to turn into energy-rich coal.

The energy released by burning coal is used to generate electrical energy in coal-powered power stations.

Coal is a form of carbon and when it burns in oxygen we can represent the reaction with the following word equation:

carbon + oxygen → carbon dioxide

Draw a picture equation for this reaction in the space below.

Convert the picture equation into a chemical equation. Is it balanced?

What group is carbon in on the Periodic Table?

The other elements in the same group as carbon will react in the same way as carbon with oxygen.

Since coal is a **non-renewable** energy source as well as one that causes pollution and other environmental problems, scientists and engineers continue to look for alternative fuels and energy sources to eventually replace coal as an energy source. Can you think of the names of some **alternative**, **renewable** energy sources?

NEW WORDS

- toxic
- preservative

In the next section, we are going to look at the formation of another, less well-known, non-metal oxide named sulfur dioxide. Which non-metal do you think reacts with oxygen to form sulfur dioxide? See if you can write down the formula for sulfur dioxide before we carry on. Here is a hint: What does the *di*- in *di*oxide mean?

4.3 The reaction of sulfur with oxygen

VISIT

A video on sulfur burning in oxygen

bit.ly/15tuqd1

What is the name of the product of the reaction between sulfur and oxygen? Use the name of the product and the general equation given at the start of the chapter to complete the following word equation:

sulfur + oxygen $\rightarrow$

Sulfur burns in oxygen to form sulfur dioxide. Your teacher will not demonstrate this reaction, because the sulfur dioxide that forms is a poisonous gas that you and your classmates should not be exposed to.

Sulfur is a yellow substance and it burns with a blue flame in oxygen.

Sulfur mining is very dangerous to the miners who inhale the toxic sulfur dioxide gas.

VISIT

A video bit.ly/14CAGmJ and a photo essay bit.ly/1bofGSi on sulfur mining.

Sulfur dioxide is sometimes used as a **preservative** for dried fruits, such as dried peaches and apricots and the guava rolls that so many of us love to eat. The fact that it is **toxic** means that very small quantities of it can be added to food to preserve it. In very small quantities SO_2 does not permanently harm a large organism such as a human being, but bacteria cannot survive when it is present. Sulfur dioxide is also an important preservative in many South African wines.

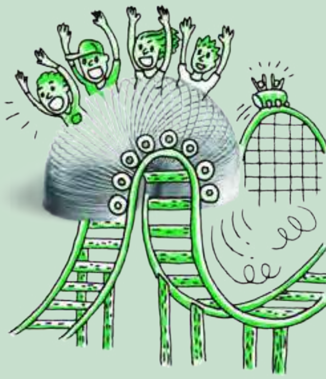
Dried fruit, such as apricots, are preserved with sulfur dioxide.

Many South African wines are preserved with sulfur dioxide.

DID YOU KNOW?

The archaic (very old) name for sulfur is 'brimstone'.

ACTIVITY: The reaction between sulfur and oxygen



In the following activity we are going to review word equations, picture equations and chemical equations, using the reaction between sulfur and oxygen as our context.

You wrote the word equation for the reaction between sulfur and oxygen above. Did you write the following?

sulfur + oxygen $\rightarrow$ sulfur dioxide

QUESTIONS:

1. What group is sulfur in on the Periodic Table?

2. What are the reactants of this reaction? Write their names and formulas.

3. What is the product of the reaction? Write its name and formula.

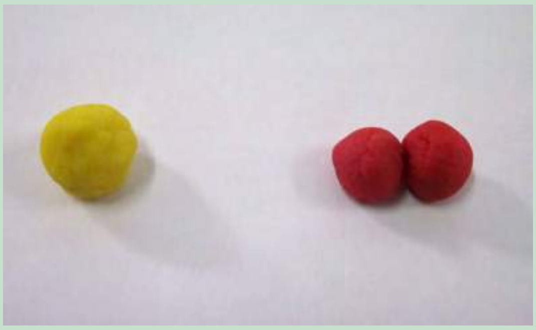
4. Now, use the formulas of the reactants and products to write a chemical equation.

5. When is a reaction balanced?

6. Is your reaction above balanced? Why do you say so?

7. Draw a picture equation for the reaction, using the example of carbon above as guide.

8. Use play dough or clay to build models of the reactants and products of the reaction. This is what your starting reactants could look like:



Challenge question: How many bonds were broken and how many bonds were formed during this reaction?

NEW WORDS

- dioxide
- systematic name

4.4 Other non-metal oxides

We have looked at two examples of non-metals reacting with oxygen to form non-metal oxides. Both of our examples had a **dioxide** as product (carbon dioxide and sulfur dioxide). Do all non-metals form non-metal dioxides when they react with oxygen? What do you think?

TAKE NOTE

You might not cover this section in class as it is an extension.

Not all non-metal oxides are dioxides, as the following examples show.

The reaction between phosphorus and oxygen

Phosphorus is a very **reactive** non-metal. Can you remember what reactive means?

When phosphorus reacts with oxygen the chemical equation for the reaction is the following:

$\mathbf{4\,P + 5\,O_2 \rightarrow 2\,P_2O_5}$

How many phosphorus atoms are in P_2O_5? How many oxygen atoms are in P_2O_5?

What is the **systematic name** of the product of this reaction? (If you are unsure how to name it, sneak a peek at the first chapter!)

VISIT

Video on phosphorus burning in oxygen

bit.ly/11YyPaD

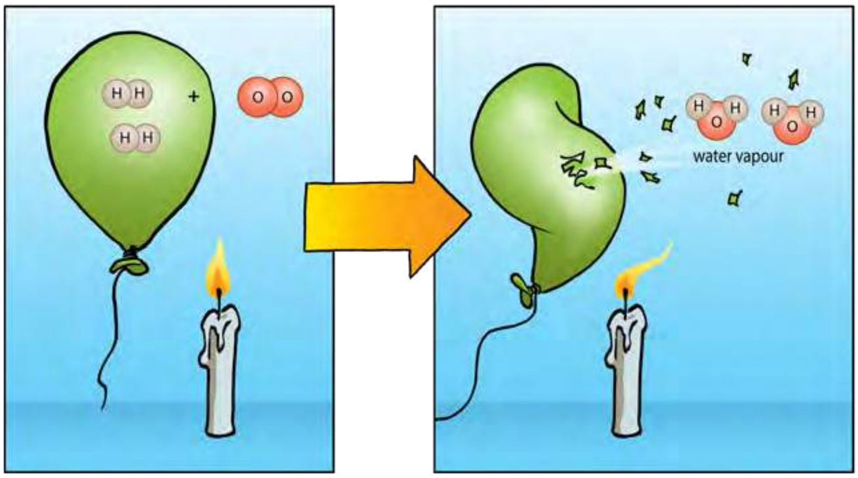
Can you write a word equation for this reaction?

Our final example is a compound that you should be very familiar with!

The reaction between hydrogen and oxygen

Hydrogen and oxygen also react spectacularly. The reaction between a large quantity of hydrogen and oxygen in the air produces a beautiful orange fireball and a very loud boom! (You can watch the video in the visit box to see this in slow motion.)

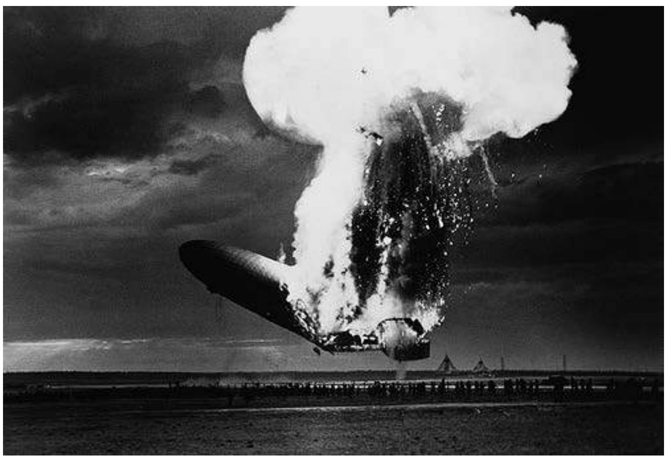
Here is a diagram to show what is really happening to the compounds in this reaction. The purpose of the candle shown in the picture is to set the hydrogen gas alight, in other words: to provide enough energy for the reaction to start.



Can you complete the following chemical equation? The reaction is between hydrogen and oxygen. Write the product where it belongs.

$2\ H_2 + O_2 \rightarrow$

What is the common name of the product of this reaction? What is the systematic name of the product of this reaction? (If you are unsure how to name it, sneak a peek at the first chapter!)



In 1937, a German airship exploded and fell to the ground in a huge fireball as the hydrogen gas which kept it floating ignited and reacted with the oxygen in the air.

In this chapter we learnt about some of the reactions between non-metals and oxygen. Some of the skills that we practised during this chapter were: writing equations (word, picture and chemical equations) and naming compounds.

SUMMARY:

Key Concepts

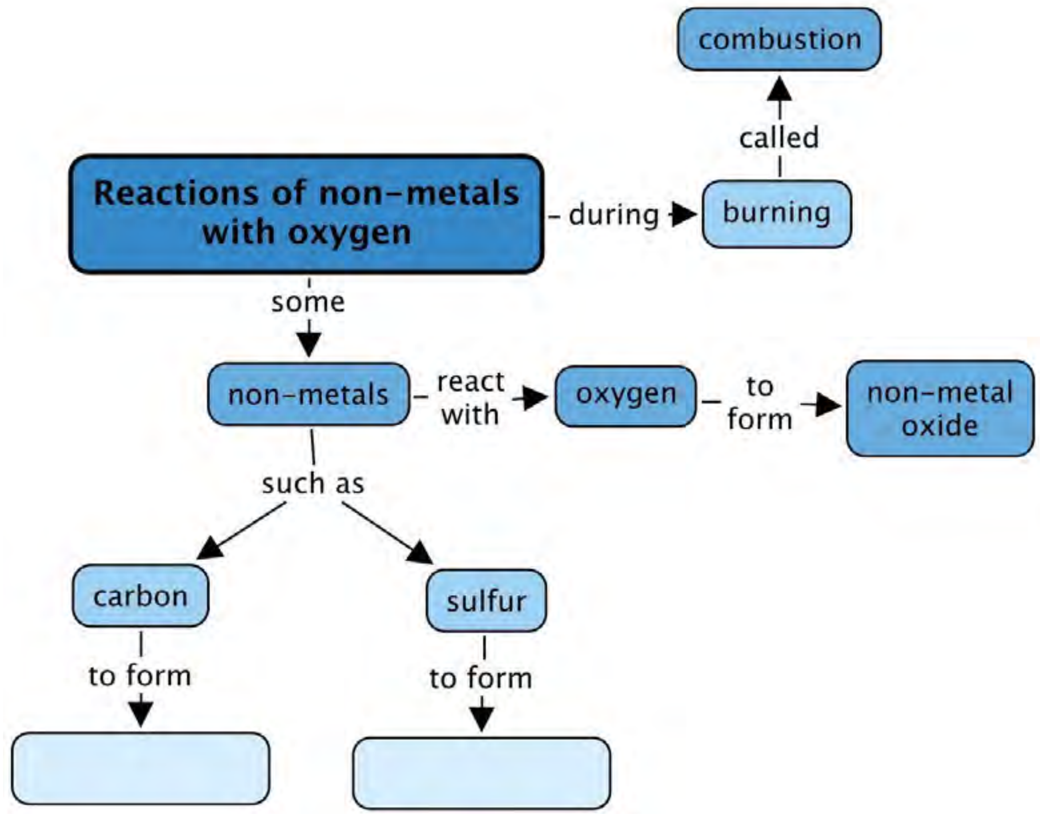
- Non-metals react with oxygen to form non-metal oxides.
- The non-metal and oxygen gas (O_2) are the *reactants* in this type of reaction, and a non-metal oxide is the *product*.
- The reactions of carbon and sulfur with oxygen are examples of non-metals reacting with oxygen.
- Carbon and sulfur both form dioxides with oxygen, but this is not true of all non-metals.

Concept Map

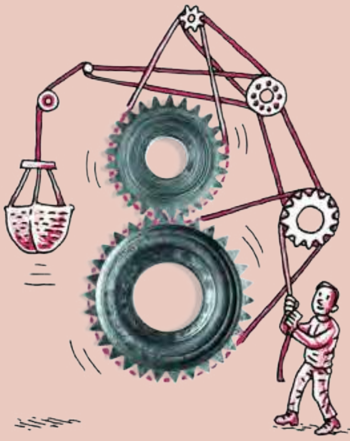
Complete the concept map on the following page. What will you fill in for the products when the two different non-metals react with oxygen during combustion?

DID YOU KNOW?

When a substance reacts with oxygen, we say it**oxidises**. It is called an oxidation reaction. Early chemists used the term oxidation for all reactions in which oxygen was a reactant. The definition of an oxidation reaction is broader and includes other reactions which you will learn about in Gr. 10 if you continue with Physical Sciences.


Reactions of non-metals with oxygen
during
burning
called
combustion
some
non-metals
react with
oxygen
to form
non-metal oxide
such as
carbon
to form
sulfur
to form

REVISION: Revision questions



1. Fill in the missing words in these sentences. Write the word on the line below. [5 marks]
   a) A substance that will react readily with many other substances is called a ______________________ substance.

   ___

   b) Substances that do not react with other substances and do not change into other compounds are called ______________________ or ______________________.

   ___

   c) When a non-metal reacts with oxygen the product of the reaction is a ______________________.

   ___

   d) When a compound reacts with oxygen, we say it has become ______________________.

   ___

2. Write a short paragraph (3 or more sentences) to explain what you understand each of the following terms to mean, in your own words. [3 x 3 = 9 marks]
   a) systematic name

   ___

   ___

   ___

   ___

   ___

   ___

   b) preservative

   ___

   ___

   ___

   ___

c) non-renewable energy source

3. For each of the following reactions, complete the tables by providing the missing equations.
   a) The reaction between carbon and oxygen [6 marks]

Word equation	
Chemical equation	
Picture equation	

   b) The reaction between sulfur and oxygen [6 marks]

Word equation	
Chemical equation	
Picture equation	

Total [26 marks]

Is this just a piece of paper? What do you think it could be? Be curious and draw.

5 Acids, bases and the pH value

KEY QUESTIONS:

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

NEW WORDS

- unit
- acidity
- pH

5.1 What is the pH value?

In Grade 7 we learnt about acids and bases. Can you remember how to distinguish between them? Here is a table that highlights the main characteristics of acids and bases.

Acids	Bases
Taste sour Feel rough between your fingers Can be corrosive Can make bases lose their basic character Turn blue litmus red	Taste bitter Feel slippery between your fingers Can be corrosive Can make acids lose their acidic character Turn red litmus blue

We used the criteria in the table above to classify a number of substances as either acids, bases, or neutral substances. The table below contains some examples and shows their classification.

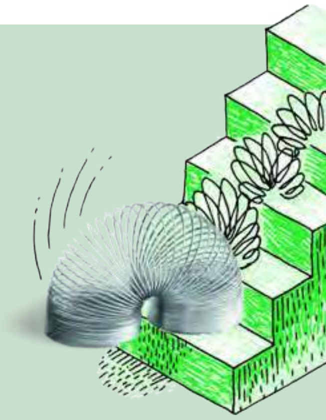
Acids	Bases	Neutral substances
Orange juice Vinegar Lemon juice Citric acid Gastric acid (stomach acid)	Bicarbonate of soda (baking soda) Soaps Bleach Ammonia solution	Water Table salt solution Cooking oil

Finally, we learnt that there are substances that we can use that will show whether we have an acid or a base. Can you remember what they were called? Hint: They *indicate,* or show, whether we have an acid or base.

Indicators can show us if a substance is an acid or a base. In this chapter we are going to link some important new learning to what we already know about acids and bases.

A word or two on measurement

Let us talk briefly about 'measuring'.



ACTIVITY: Measuring instruments and units

What would you measure with each of the measuring instruments below?

The measuring tape and ruler measure...

____

Measuring tapes and a ruler

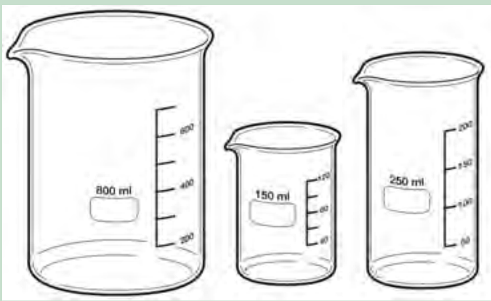
The balance measures...

____

A triple beam balance.

These measuring beakers measure...

____



Different size beakers.

The thermometer measures...

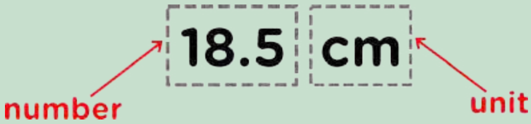
____

A thermometer.

A measurement always consists of two things: a number and a **unit**. To explain what this means, let's imagine we are measuring the length of a pencil.

What is the length of the pencil in the picture?

____



The unit is a very important part of the measurement because it shows the relative size of the measurement. If you said: "The pencil is 18.5 long", people would not be sure if you meant centimeters, millimeters, or even meters!

What unit would you use to measure the length of your classroom?

____

What unit would you use to measure your mass?

____

What unit would you use to measure temperature?

____

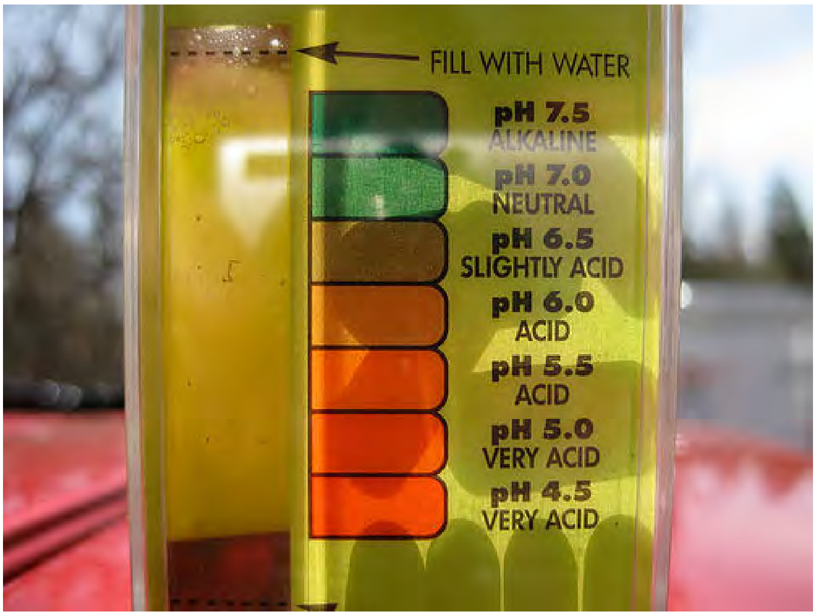
Can we 'measure' how acidic or basic a substance is?

Measuring acidity and basicity

The unit that we use to measure the **acidity** of a substance (how acidic that substance is) is called **pH**. We pronounce the two letters, 'p' and 'H' separately when we say pH.

Have you ever heard the term pH?

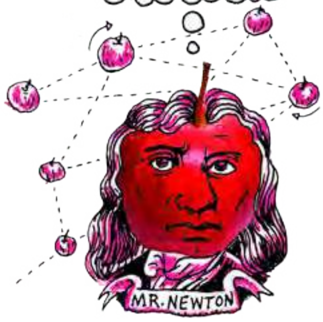
Perhaps you have heard of a certain shampoo being 'pH balanced', or a skin soap that is 'neutral'. Perhaps you have heard that it is important for the water in a swimming pool to have 'the right pH'?



A kit for testing swimming pool water pH.

DID YOU KNOW?

The term "pH" was first described by Danish biochemist Søren Peter Lauritz Sørensen in 1909. The definite origin is disputed, but it is widely accepted that pH is an abbreviation for "power of hydrogen" where "p" is short for the German word *potenz* (meaning power or exponent of) and H is the element symbol for hydrogen.

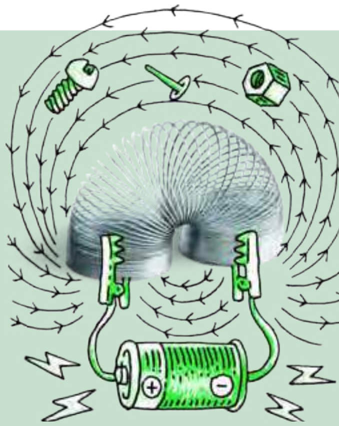


The pH scale ranges between the values of 1 and 14.

In science and in everyday life, we measure the acidity of substances in pH **units**. We could say that the 'acidity' of a specific shampoo has a pH of 5.5. pH is the unit of measurement and 5.5 is be the number indicating the relative acidity on the pH scale. It has become acceptable, however, for us to rather say: "The pH of this shampoo is 5,5."

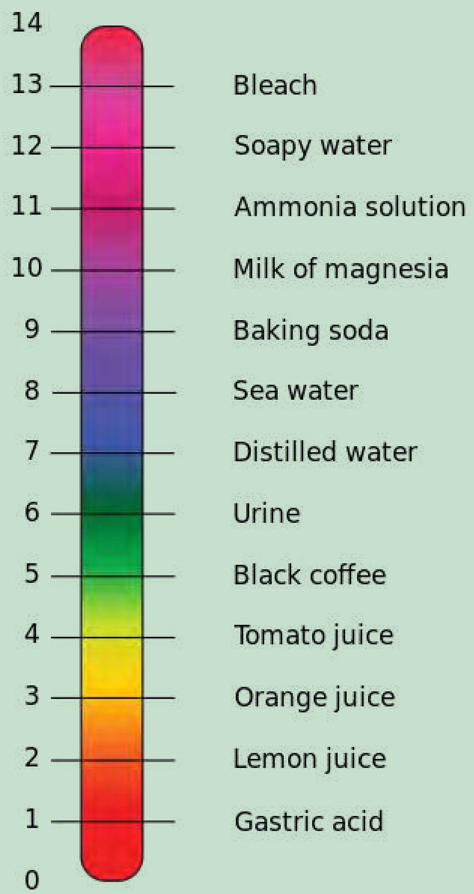
In the next activity, we are going to get to know the pH scale a little better.

ACTIVITY: The pH scale



INSTRUCTIONS:

1. In the following picture the pH values of a variety of substances are shown on the pH scale
2. Use the picture to answer the questions.



The pH scale.

QUESTIONS:

1. Which of the substances in the table at the start of this chapter can you find on the pH scale above? Write their names and approximate pH values in the table below.

Name of substance	Approximate pH

2. Circle the names of all the acids in the table above with a red pen or koki.

3. Write the lowest and highest pH values of these acids. This represents the pH range of the acids on our list.

4. Does this range lie below or above pH 7?

5. Circle the names of all the bases in the table above with a blue pen or koki on the pH scale above.
6. Write the lowest and highest pH values of these bases below. This represents the pH range of the bases on our list.

7. Does this range lie below or above pH 7?

8. Find water on the scale and circle it with a green pen or koki. Is water an acid or a base? Or is it perhaps something else?

9. What is the pH of water?

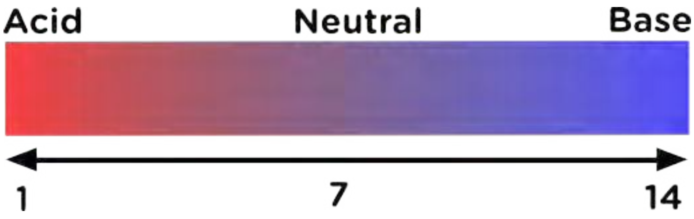
10. Which do you think is more acidic: orange juice or lemon juice? If you are not sure, ask yourself this question: Which one is more sour?

11. Which one has the lower pH: orange juice or lemon juice?

In the above activity we learnt a number of important things:

- Acids have pH values below 7;
- Bases have pH values above 7; and
- Neutral substances have pH values equal to 7.

This information has been summarised visually in the following diagram.



VISIT

Now that you have learnt about pH, test your knowledge with this fun online game

bit.ly/13dHNnm

We saw in the activity that lemon juice, which is more sour than orange juice, has a lower pH than orange juice. Does that mean that the relative pH of a substance will tell us *how* acidic or basic it is?

Can we measure how acidic or basic something is?

When we compared orange juice and lemon juice earlier, we learnt something important: The lower the pH of a substance, the more acidic it is. For bases we can state the folllowing: The higher the pH of a substance, the more basic it is.

Here is a summary:

- The closer to pH 1, the more strongly acidic the solution;
- The closer to pH 14, the more strongly basic the solution; and
- pH 7 is a neutral substance.

We have learnt that the pH value of a substance tells us if it is an acid or a base. But how do we measure pH? One way to measure pH is with the help of acid-base indicators. Can you remember what they are? The next section will refresh your memory.

5.2 Indicators

NEW WORDS

- indicator
- litmus
- universal indicator
- red cabbage indicator

What is an acid-base-indicator?

We know that some substances change colour when they react with an acid or a base. These substances are called acid-base **indicators**, which can show us if a substance is an acid or a base.

Different indicators change colour at different pH values. The table below shows a selection of acid-base indicators and the colours they will have at different pH values.

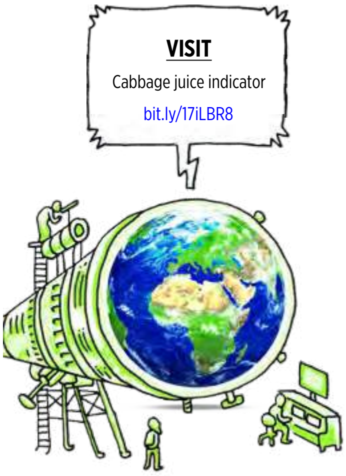
Indicator	Colour in acid (pH < 7)	Colour at pH = 7	Colour in base (pH > 7)
Red cabbage water	red, pink	purple	blue, green, yellow
Red onion water	red	violet	green
Turmeric water	yellow	yellow	red
Phenolphthalein	colourless	colourless	pink, red
Bromothymol blue	yellow	green	blue
Red litmus	red	red	blue
Blue litmus	red	blue	blue
Universal indicator	red, orange, yellow	green	Blue, violet, purple

In Grade 7 we made and indicator from red cabbage and even made some **red cabbage indicator** paper. Can you find red cabbage water on the table above? In acids, the red cabbage water will turn red or pink. In neutral solutions it will be purple or violet. Which colours will the red cabbage indicator be when it is mixed with a base?

If red cabbage indicator is mixed with something that is only slightly basic, it will turn blue. If it is mixed with something that is strongly basic, it will turn yellow.

When you look at the table above and you compare the information given for red cabbage water with the picture below, the colour changes you observed in the red cabbage water (in Grade 7) will make sense!

Red cabbage water mixed with base (left) and with acid (right). The blue drop at the top is the juice in a neutral solution (water).



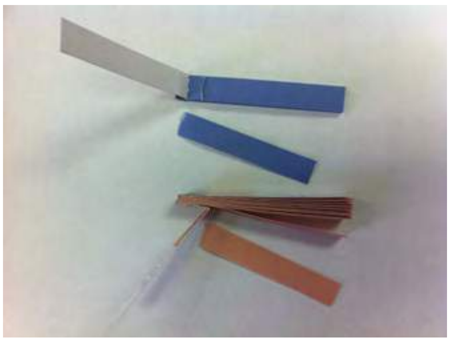
You may recall that we also learnt about **litmus**, the most widely used of all acid-base indicators. Can you find litmus on the table of indicators?

Litmus 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.

Litmus can be bought as a solution or as litmus paper, although the paper is more commonly used.

By changing to different colours in the presence of an acid or a base, indicators can show us if a substance is an acid or a base. In the next section we are going to learn about a special indicator that is so sensitive that it not only tells us whether a substance is an acid or a base, but also what its approximate pH is!



Blue and red litmus paper

Universal indicator

Unlike litmus, **universal indicator** can show us much more accurately how acidic or basic a solution is. Can you find universal indicator on the previous table of indicators? Universal indicator can change into a whole range of colours, depending on the pH of the solution. In the following picture, solutions of increasing pH were mixed with universal indicator to show its full range of colours.

DID YOU KNOW?

Universal indicator solution can display so many colours is because it is actually a mixture of several different indicators.

Universal indicator can have many different colours, from red for strong acids to dark purple for strong bases. The liquid inside the middle test tube is neutral (pH = 7) and this is shown by the green colour of the indicator.

Like litmus, universal indicator also comes in paper form, with the pH colour range of the indicator printed on the packaging.
In the next investigation we will test a number of household substances with red cabbage indicator paper and with universal indicator paper.

INVESTIGATION: Universal indicator paper and red cabbage indicator paper

The purpose of this investigation is to determine whether universal indicator and red cabbage can be used to show whether one substance is more acidic or basic than another.

INVESTIGATIVE QUESTION:

What question are we trying to answer with this investigation?

___

HYPOTHESIS:

What do you think the answer to the investigative question is? You should try to make a prediction.

___

IDENTIFY VARIABLES:

1. What will you be changing in this investigation? What is this variable called?

2. What will you be measuring in this investigation? What is this variable called?

3. What will you keep the same? What is this variable called?

MATERIALS AND APPARATUS:

- small containers (test tubes or yoghurt tubs) containing the following substances:
  - clean water
  - soda water
  - vinegar
  - lemon juice
  - sugar solution (1 tablespoon dissolved in a cup of water)
  - baking soda (bicarbonate of 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. Do not use strong acids or bases, or bleach. Suggestions include: tea, coffee, rooibos tea, milk, tartaric acid, salt water, Sprite.
- universal indicator paper
- red cabbage indicator paper
- glass or plastic rods (plastic teaspoons or straws will also work well).
- white tile or sheet of A4 printer paper.

METHOD:

1. Use a small strip (1 cm long) of universal indicator paper for each substance that you will be testing. Place them on a sheet of printer paper or a white tile.
2. Dip the glass rod or straw into the first solution and transfer a drop of it to the first piece of universal indicator paper. Does the paper change colour? Write the colour of the paper with each substance in your table, in the appropriate place.
3. Compare the colour of the test strip with the colour range on the packaging of the universal indicator paper roll to find the pH of the solution. Write this in your table as well.
4. Rinse the straw very thoroughly with tap water before testing the next solution. Do so every time you move from one solution to the next.
5. Test all the solutions and record their colours.
6. Save the solutions to now test them again with red cabbage indicator paper.
7. Use a small strip (2 cm long) of red cabbage paper for each substance that you will be testing.
8. Dip a fresh piece of paper into each of the test solutions and place it on the tile or white paper to dry. For each test solution, write the colour of the red cabbage paper in the table in the appropriate place.

RESULTS AND OBSERVATIONS:

Record your observations in the table.

Substance	Colour with universal indicator paper	pH of the substance	Colour with red cabbage paper
Water			
Soda water			
Vinegar			
Lemon juice			
Sugar water			
Baking soda			
Handy Andy			
Aspirin			
Dishwashing liquid			

1. Sequence the substances that you tested according to the colour change of the universal indicator, from the most acidic (darkest red) to the most basic (purple).

QUESTIONS:

1. Which of the test substances are acids?

2. Which of the test substances are bases?

3. Which of the test substances are neutral substances?

4. Which substance is the strongest acid?

5. Which substance is the strongest base?

6. Count all the different colours that were possible with the red cabbage.

7. What colour(s) did the red cabbage paper turn in the test substances that were acids?

8. What colour(s) did the red cabbage paper turn in the test substances that were bases?

9. What colour(s) did the red cabbage paper turn in the test substances that were neutral?

10. Do you think red cabbage indicator can be used to actually *measure* pH? Why or why not?

CONCLUSIONS:

1. What is your conclusion(s)? (Here you should answer the investigative question.)

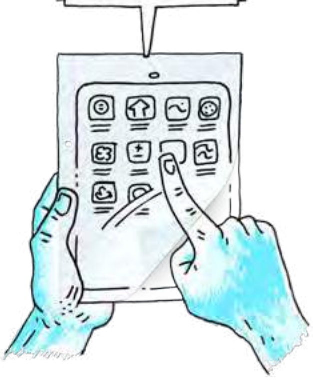
Something to think about: Extension question

1. What could we do to make red cabbage indicator suitable for measuring pH?

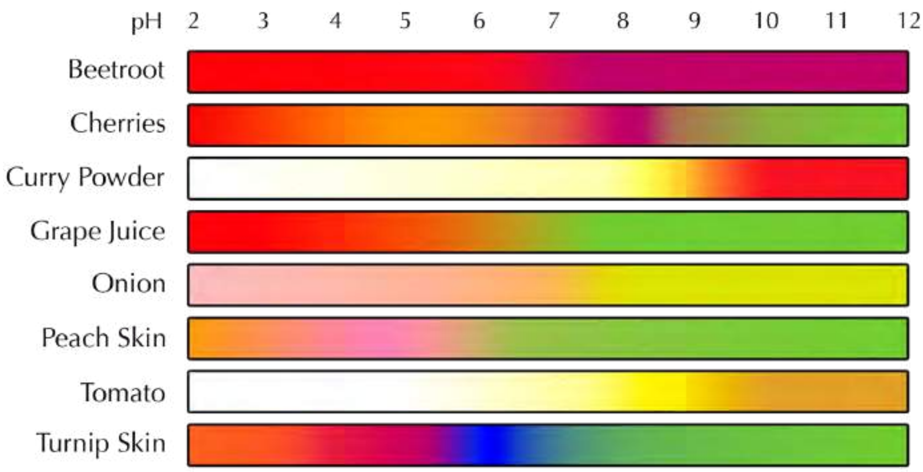
In the last investigation we explored whether or not universal indicator paper or red cabbage indicator paper could tell us whether a substance is more acidic or basic than another. The advantage of using universal indicator over other indicators is that universal indicator can give us more accurate pH measurements. This is because it has different colours for different pH values. Most other indicators change colour only once or twice over the entire pH

TAKE NOTE

Universal indicators give a range of colours that can be used to determine the pH of a solution. Litmus paper can only indicate whether a solution is acidic, neutral or basic.



Many other colourful foods can be used to make acid-base indicators. Check out the diagram below for some examples. You could even try out a few of them at home!



pH indicators made from edible substances.

Measuring pH with indicator solutions or paper is easy, economical and convenient if we have only a few measurements to make. If we have many pH measurements to make, tearing and dipping paper strips and matching them up with a colour chart can become quite tedious and time-consuming.

What other quick and easy ways are there to measure pH?

How else can we measure pH?

Scientists use a pH meter to quickly and accurately measure the pH of a substance. While they are much more expensive to purchase than indicator paper or solution, they are a worthwhile investment for a laboratory that has to make many pH measurements daily and need these measurements to be done quickly.

A portable pH meter.

A pH meter is an electronic instrument with a special sensor at the end that is sensitive to acids and bases. This is more accurate than the universal indicator. Help the scientist to read the pH of the solutions in the photos and classify them as acidic, neutral or basic!

In this chapter we have learnt about the pH scale. We have also learnt how to make pH measurements and how to interpret pH values.

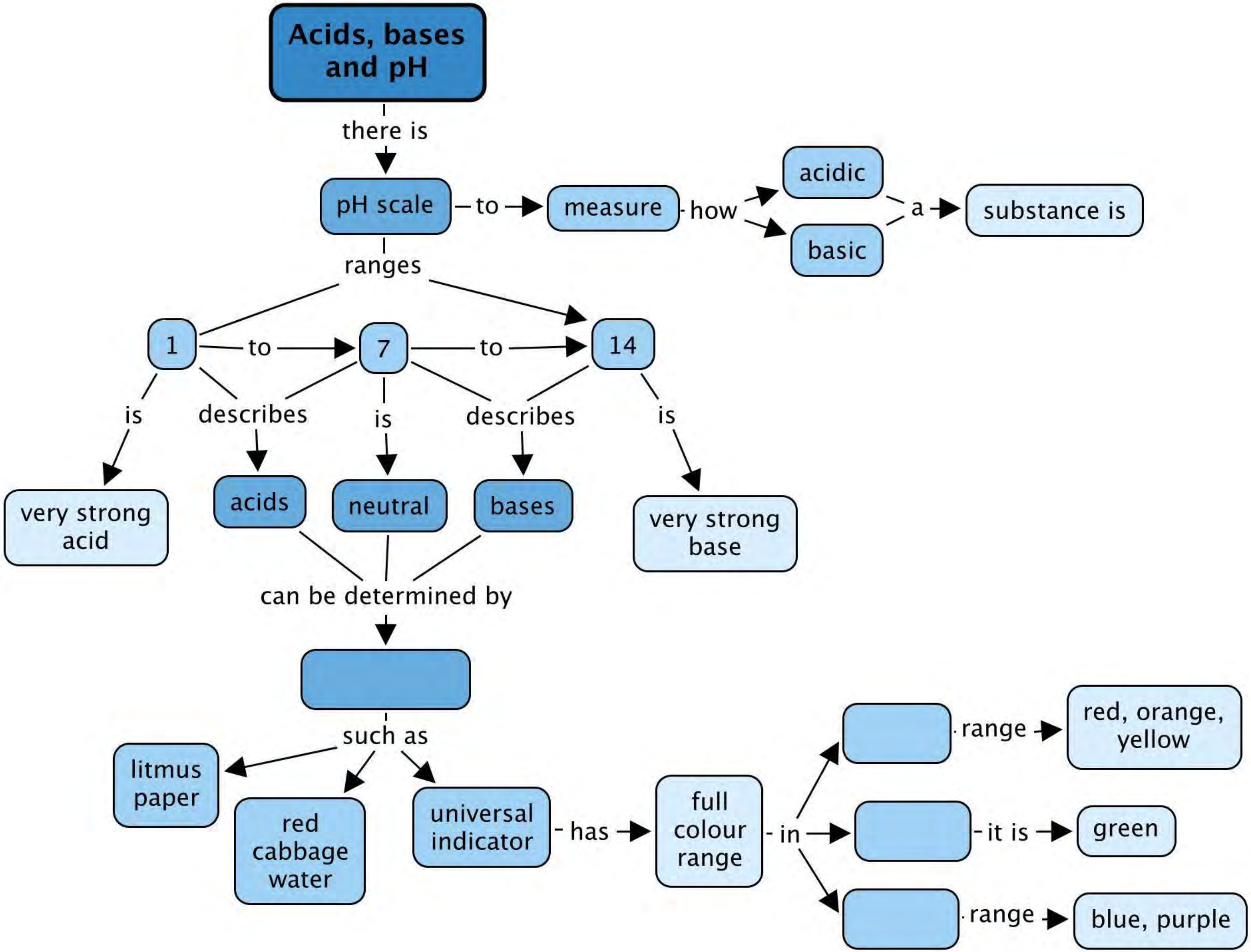
SUMMARY:

Key Concepts

- When we want to decide whether a solution (in water) is acidic or basic, we can measure its pH.
- One of the ways pH can be measured, is with an acid-base indicator, such as universal indicator.
- An acid-base indicator is a substance that changes its colour depending on the pH of the solution that it is added to.
- The pH scale ranges between 1 and 14:
  - Acids have pH values lower than 7;
  - Bases have pH values higher than 7; and
  - Neutral substances have pH values approximately equal to 7.
- How acidic or basic a solution is, depends on its relative pH value:
  - The more acidic a solution is, the closer its pH value will be to 0; and
  - The more basic a solution is, the closer its pH value will be to 14.

Concept Map

What can you use to determine whether a substance is an acid, base or neutral? Fill this in on the concept map. Finally, complete it by completing the information for the universal indicator. Fill in acid, base or neutral, depending on the colours listed.


Acids, bases and pH
there is
pH scale
to
measure
how
acidic
basic
a
substance is
ranges
1
to
7
to
14
is
describes
is
describes
is
very strong acid
acids
neutral
bases
very strong base
can be determined by
such as
litmus paper
red cabbage water
universal indicator
has
full colour range
in
range
red, orange, yellow
it is
green
range
blue, purple

REVISION:

1. Fill in the missing words in these sentences. Write the word on the line below. [6 marks]

   a) Something which shows whether a substance is an acid or a base, by changing colour when we add it to that substance, is called an ____________________.

   ____

   b) The pH scale ranges between the values ____________ and ____________.

   ____

   c) ____________ have pH values less than 7.

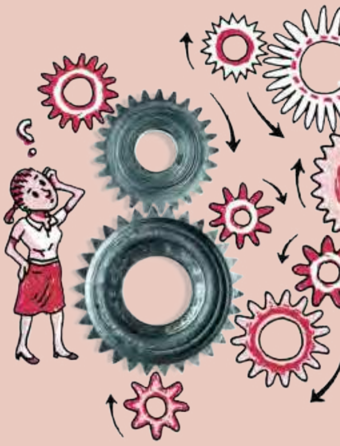
   ____

   d) Bases have pH values ranging between ____________.

   ____

   e) ____________ substances have pH values approximately equal to 7.

   ____



2. Imagine we start with a beaker of clean, distilled water. Answer the following questions. [4 marks]

   a) What will be the pH of the clean, distilled water?

   ____

   b) How will the pH change if we add a small amount of acid to the water?

   ____

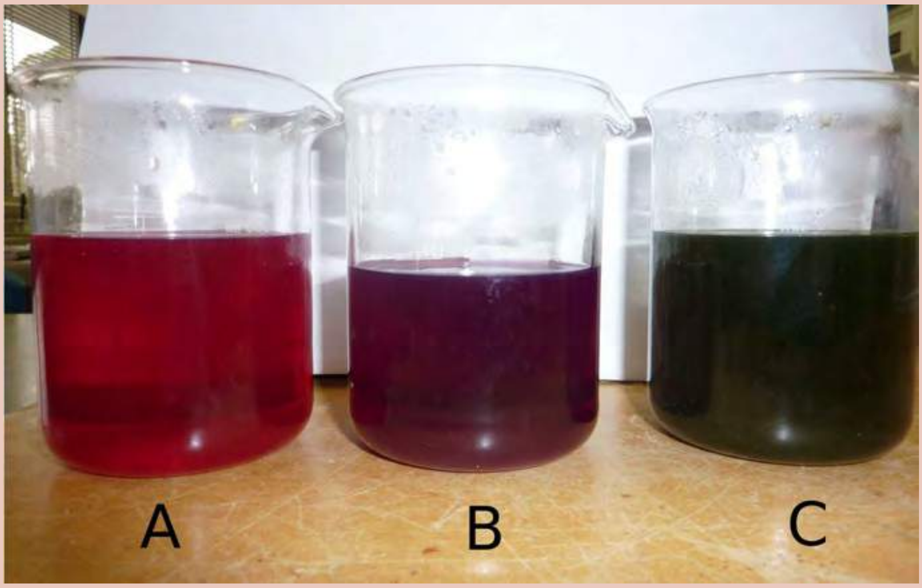
   c) How could we get the pH to increase?

   ____

   d) How could we get the pH to increase to a higher value, for example 13?

   ____

3. In the following picture, the three beakers contain three different solutions. Red cabbage water was added to each of the beakers. Answer the following questions. [4 x 2 = 8 marks]



a) Which solution, A, B or C, is the most acidic? Motivate your answer.

___

___

b) Which solution, A, B or C, is the most basic? Motivate your answer.

___

___

c) Which solution, A, B or C, is neutral? Motivate your answer.

___

___

d) What do you think would happen to the colour of solution A if we mixed it with solution B? Motivate your answer.

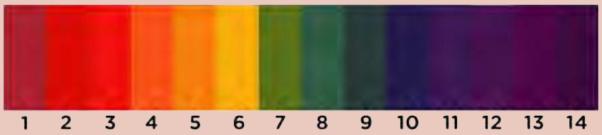
___

___

___

4. A scientist is given 6 solutions labelled A to F. The scientist tests each solution with universal indicator and records her results as follows:

Solution	Colour of universal indicator
A	Yellow
B	Blue
C	Green
D	Red
E	Purple
F	Orange



Use the results in the table and the colour guide for universal indicator underneath the table, to answer the following questions:

a) Which solutions are acidic? Write their labels below. [2 marks]

b) Which solutions are basic? Write their labels below. [2 marks]

c) Which solution is neutral? Write its label below. [2 marks]

d) Arrange the solutions in order from most acidic to most basic in the table below. Also write the colour and the approximate pH range of each solution in the table. [6 marks]

Solution	Colour of the solution	Approximate pH range of the solution

Total [30 marks]

6 Reactions of acids with bases

KEY QUESTIONS:

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

6.1 Neutralisation and pH

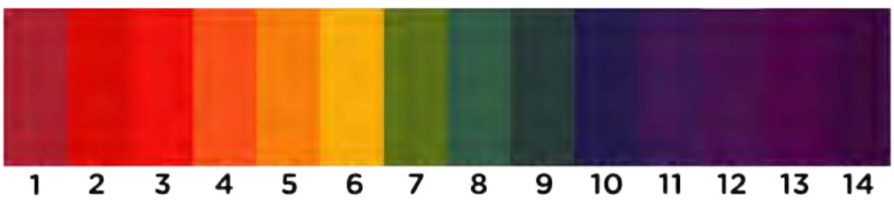
NEW WORDS

- neutralisation reaction
- neutralise
- neutral solution
- potency
- detour
- exchange reaction
- laboratory acids
- corrosive
- acid rain

In the previous chapter we learnt about a new concept, namely pH. If we want to know whether something is an acid or a base, we can measure its pH:

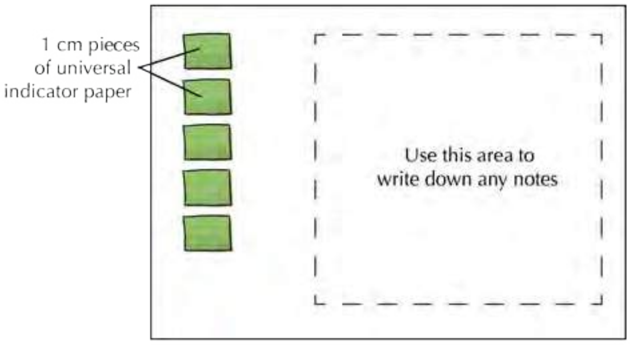
- Acids have pH values below 7. The lower the pH value, the more strongly acidic the substance.
- Bases have pH values above 7. The higher the pH value, the more strongly basic the substance.
- Neutral substances have pH equal to 7.

Another useful thing we learnt in the previous chapter is that we can use universal indicator to measure the pH of a solution. Universal indicator has different colours at different pH values. Below is a colour chart showing the range of colours for universal indicator and the pH values they correspond to. You will need it for all the activities of this chapter, because we are going to do lots of pH measurements!



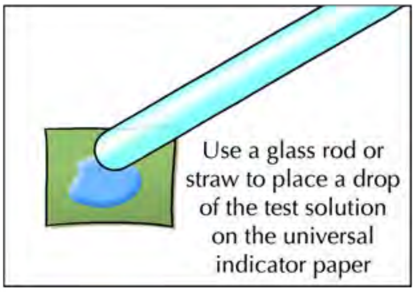
Can you remember how we used the universal indicator paper in the previous chapter? Here are some suggestions for the investigations of this chapter:

1. Before you start, place 1-cm lengths of universal indicator paper on a sheet of white paper, like this:



Later, if you want to write down a note or an observation, you can do so directly on the paper and copy it to your workbook afterwards.

2. Instead of dipping the paper in the solutions you are testing, use a glass rod or drinking straw to transfer a drop of the test solution to the indicator paper.

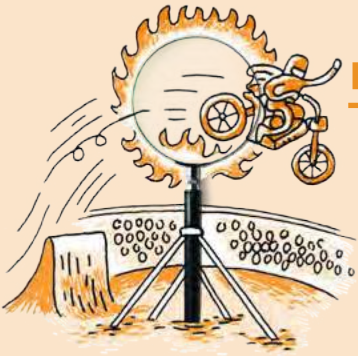


What is neutralisation?

What do you think would happen if we mixed an acid and a base?

We are going to do an investigation to find out. We are going to mix vinegar with baking soda. But first, a little revision: is vinegar an acid or a base? If you are not sure, imagine putting a drop of vinegar on your tongue. What would it taste like?

Is baking soda an acid or a base? If you are not sure, turn back to the previous chapter and look at the activity *'The pH scale'.*



INVESTIGATION: The reaction between vinegar and baking soda

The purpose of this experiment is to investigate how the pH changes when vinegar is added to baking soda.

INVESTIGATIVE QUESTION(S):

1. What question do you hope to answer with this investigation?

___

___

OVERVIEW OF THE INVESTIGATION:

1. We will measure the pH of a solution of baking soda with universal indicator paper to confirm whether it is acidic or basic. What range do you expect the pH of this solution to fall in?

___

2. We will add vinegar to the baking soda solution in small portions and measure the pH after each portion has been added. What changes do you expect to observe? Will the pH increase, decrease or stay the same?

___

___

HYPOTHESIS:

1. What is your prediction? Your hypothesis should be a prediction of the finding(s) of the investigation. You should write it in the form of a possible answer to the investigative question.

___

___

MATERIALS:

- baking soda
- vinegar
- water
- glass beaker or small yoghurt tub
- universal indicator paper (cut into 1 cm strips)
- sheet of white printer paper
- plastic teaspoon

METHOD:

1. Prepare the universal indicator paper by neatly placing five 1-cm pieces underneath each other on the sheet of paper.
2. Place one teaspoon of baking soda in the beaker or yoghurt tub.
3. Add approximately 10 teaspoons of water to the baking soda.
4. Use the teaspoon to stir the solution until all the baking soda has dissolved. We will be calling this the 'test solution' from now on.
5. Transfer one drop of the test solution to the first piece of universal indicator paper using the teaspoon or a straw.
6. Compare the colour of the paper with the colour guide given at the start of the chapter, to find the pH of the solution. Record this pH in your results table.
7. Add 1 teaspoon of the vinegar to the test solution. Stir it gently and transfer another drop of the solution to a fresh strip of the universal indicator.
8. Read the pH of the solution off the colour guide and record it in your results table.
9. Repeat steps 6 and 7 until the pH of the test solution drops below 7. You may need more than 5 pieces of universal indicator paper.

RESULTS:

Present your results in a neat table. Use appropriate headings for your table. 'Number of teaspoons of vinegar added' and 'Colour of the universal indicator paper' and 'pH of the test solution' are suggested headings for your columns.

Draw a line graph to illustrate your results. What will be on the x-axis and what will be on the y-axis? Give your graph a heading.

CONCLUSIONS:

What conclusions can be made from the results of your investigation? Here you can rewrite your hypothesis, but change it to reflect your findings if they are different from what you predicted earlier.

Were you able to confirm or reject your hypothesis?

In this investigation, you probably noticed that the pH of the mixture dropped every time you added more vinegar to the baking soda! Why did this happen?

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 'acidity' and the base will lose its 'basicity'.

What have we learnt so far? We have learnt that acids and bases neutralise each other:

- If we add a base to an acid, the pH of the resulting solution will increase, because the acid will lose some of its **potency**.
- If we add an acid to a base, the opposite will happen. The pH will decrease, because the base will lose some of its potency.

What are the products of an acid-base reaction? Can we predict what they will be?

The products of acid-base reactions

In order to understand how an acid-base reaction works, we have to take a quick **detour** and say something about **exchange reactions**. Acid-base reactions are exchange reactions.

In the reaction below, two substances AB and CD are undergoing an exchange reaction:

AB + CD → AD + CB

Can you see that A and C have exchanged partners so that A is now combined with D, while C combined with B?

What does this have to do with acids and bases? Well, acids and bases undergo exchange reactions too. Here are some examples. See if you can figure out which parts have exchanged with which.

Example 1

$HCl + NaOH \rightarrow NaCl + HOH$

In the above equation HOH should actually be written: H_2O. The reaction equation becomes:

$HCl + NaOH \rightarrow NaCl + H_2O$

or, in words:

hydrochloric acid + sodium hydroxide → sodium chloride + water

In this example, the following happened:

- the acid gave its H towards making a water molecule;
- the base gave OH towards making a water molecule; and
- the Na from the base and the Cl from the acid combined to form a salt.

Example 2

$2\ HCl + MgO \rightarrow MgCl_2 + HOH$

In the above equation HOH should actually be written: H_2O. The reaction equation becomes:

$2\ HCl + MgO \rightarrow MgCl_2 + H_2O$

or, in words:

hydrochloric acid + magnesium oxide → magnesium chloride + water

TAKE NOTE

In Grade 11 you will learn that the mechanisms of these reactions are actually slightly more complex than this, but for now, understanding it at this level is good enough.

VISIT

What happens if you put a burger in concentrated hydrochloric acid? (video)

bit.ly/14COOMG

In this example, the following happened:

- the acid gave 2 H's towards making a water molecule;
- the base gave OH towards making a water molecule; and
- the Mg from the base and the 2 Cl's from the acid combined to form a salt.

Acid-base reactions always produce water and a salt. In both of the examples above the general equation was:

acid + base → salt + water

There is one class of acid-base reactions that produces an additional product, but we will learn more about that later.

Which laboratory acids should we know about?

When we investigated acids and bases in the previous chapter, we considered only household acids like lemon juice and vinegar. There are a few **laboratory acids** that you should know the names and formulae of and they have been listed in the following table:

Name of the acid	Formula of the acid
hydrochloric acid	HCl
nitric acid	HNO_3
sulfuric acid	H_2SO_4

These acids are very **corrosive**, even when they have been diluted with water and should always be handled with great care.

Hydrochloric acid is the acid we will be using in our investigations in this chapter.

Look out for this label on bottles which contain corrosive substances, such as strong acids.

In the next sections will discuss the classes of substances that are typically acids or bases. Two important things to remember are the following:

- Non-metal oxides form acidic solutions when they are dissolved in water.
- Metal oxides, metal hydroxides and metal carbonates all form basic solutions when they are dissolved in water.

First, we will look at the non-metal oxides.

Non-metal oxides form acidic solutions

Can you name a few non-metal oxides? Write down their formulae. If you are not sure you can take a peek at the Periodic Table and pick a few non-metals from the right-hand side of the table. Add oxygen and you have a non-metal oxide!

How do we know that non-metal oxides form acidic solutions? Experiments have shown this.

You may not know this, but when CO_2 gas is bubbled through water some of it dissolves in the water to form carbonic acid. Here is the reaction equation:

$CO_2 + H_2O \rightarrow H_2CO_3$

To see this happen, try the following quick activity.

ACTIVITY: CO_2 bubbled through water

MATERIALS:

- tap water
- glass
- straw
- indicator paper

INSTRUCTIONS:

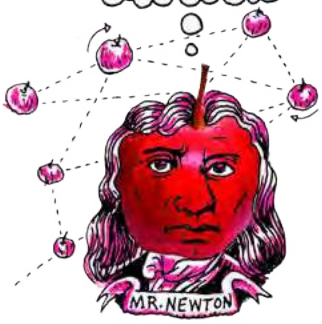
1. Test the pH of clean tap water. It should be approximately 7. How would you do that?

---

2. Now exhale into the water using a straw. Your breath contains CO_2 and some of this will dissolve in the water if you carry on doing this for a few minutes.

DID YOU KNOW?

Carbonic acid is added to soft drinks to make it fizzy. The carbonic acid decomposes and forms carbon dioxide (CO_2)



1. If you measure the pH of the solution now, you will see that it has decreased! What do you think the pH will be?

The pH of the solution is now below 7 because it contains carbonic acid (H_2CO_3). Carbonic acid is not a very strong acid, but still acidic enough to have a pH lower than 7.

When sulfur dioxide (a gas) is bubbled through water it dissolves in the water to form an acid called sulfurous acid:

$SO_2 + H_2O \rightarrow H_2SO_3$

These are two of the reactions that produce a phenomenon called **acid rain**. SO_2 and CO_2 are released as waste products from factories and power stations. For example, burning wood and fossil fuels releases carbon dioxide and sulfur dioxide into the atmosphere. These gases then dissolve in water droplets in the atmosphere to form acids, in a similar way that the CO_2 in your breath dissolved in the water in the last activity to produce an acidic solution. When it rains, these acids are present in the raindrops that fall back to earth. Sulfurous acid (H_2SO_3) is strong enough to damage plant life and to acidify water sources.

DID YOU KNOW?

Volcanoes also release non-metal oxides into the air (mainly SO_2) that can contribute to acid rain.

Acid rain forms when CO_2 and SO_2 from factories and other air pollutants combine with water in the atmosphere.

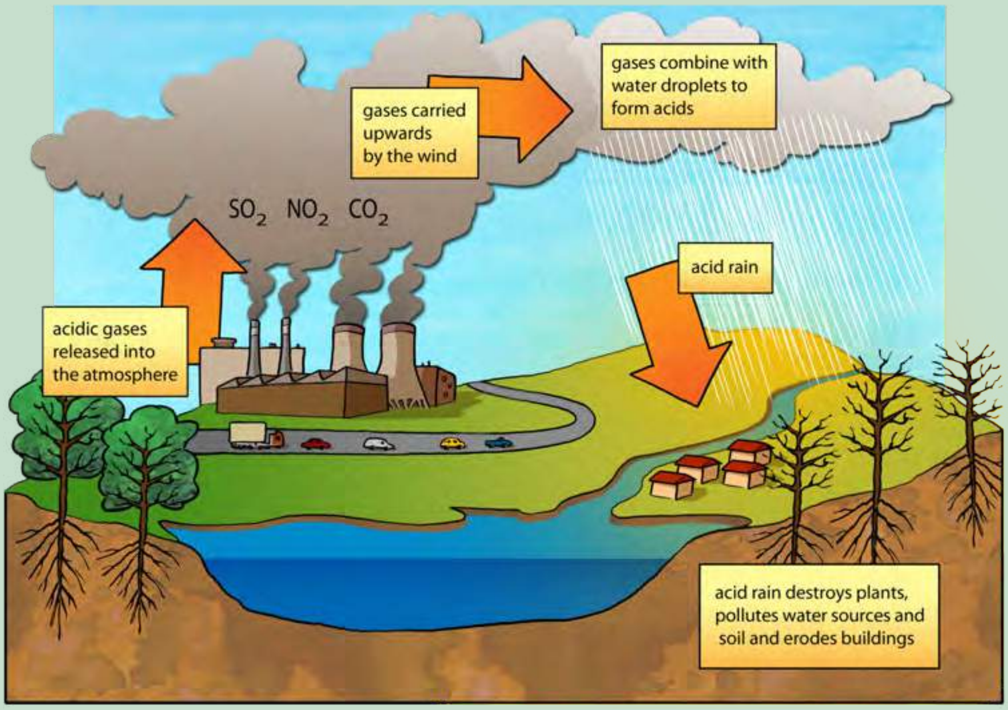
A forest that has been destroyed by acid rain.

ACTIVITY: What is acid rain?

For the next activity, you have to do some research on acid rain.

INSTRUCTIONS:

1. Study the diagram showing how acid rain forms.
2. Do some extra reading and research about acid rain.
3. Answer the questions about acid rain.



QUESTIONS:

1. Which three gases are shown in the diagram that contribute to the formation of acid rain? Write their names and formulae.

2. What are some of the sources of these gases? You can do some extra reading about this to help you answer this question.

3. Write the equations for how two of these gases which you have learnt about react with the water in the atmosphere to form acids.

4. What are the names of these two acids?

5. What are some of the environmental impacts of acid rain? Study the diagram for some clues and do some extra reading.

6. Acid rain can also damage buildings as it 'eats away' the stone. What property of acids allow it to do this?

7. Factories used to have quite short funnels to let out the smoke, but it was found that this caused many problems in the local towns and cities near the factory as the gases would combine with water in the immediate environment to cause acid rain. Factories then started to build much higher smoke funnels so that the smoke was let out high enough to be blown further away. Do you think this is an efficient way to help reduce acid rain? Explain your answer.

8. Do some research to find out about the possible ways to prevent or minimize the formation of acid rain. Write a paragraph to summarize these methods below.

We have now learnt about non-metal oxides, but what about metal oxides? What kind of solutions do they form in water? We will find out more about them and other metal compounds in the next section.

Metal oxides, metal hydroxides and metal carbonates form basic solutions

Metal oxides

Do you remember learning about some of the metal oxides in Chapter 3? We already learnt these rules to write the formulae of metal oxides.

1. **Metal oxides from group 1 on the Periodic Table will have the formula M_2O,** where M stands for any metal in group 1.

Can you write two examples? Look at the Periodic Table at the front of the book, pick any two metals from group 1 and write their formulae using this rule.

2. **Metal oxides from group 2 will have the formula MO,** where M stands for any metal in group 2.

Can you write 2 examples?

What do you think the pH will be of a solution of a metal oxide in water?

The next class of compounds that form basic solutions in water are the metal hydroxides.

Metal hydroxides

A metal hydroxide forms when a metal reacts with water. A metal hydroxide has the general formula MOH or $M(OH)_2$. In the formula, M represents a metal atom, O represents an oxygen atom and H represents a hydrogen atom.

To know whether the MOH or $M(OH)_2$ will be the correct formula, here are two simple rules for you to remember:

1. **Metal hydroxides from group 1 on the Periodic Table will have the formula MOH.**

Can you write two examples? Look at the Periodic Table at the front of the book, pick any two metals from group 1 and write their formulae using this rule.

2. **Metal hydroxides from group 2 will have the formula $M(OH)_2$.**

Can you write two examples?

What do you think the pH will be of a solution of a metal hydroxide in water?

The final class of compounds that forms basic solutions in water is the metal carbonates. Baking soda is a special kind of carbonate, called a **bicarbonate** (or hydrogen carbonate). You may remember that it was one of the bases we tested with universal indicator earlier.

Metal carbonates

A metal carbonate has the general formula MCO_3 or M_2CO_3. In the formula, M represents a metal atom, C represents a carbon atom and O represents an oxygen atom.

To know whether the MCO_3 or M_2CO_3 will be the correct formula, there are two simple rules to remember:

1. **Metal carbonates from group 1 on the Periodic Table will have the formula M_2CO_3.**

Can you write two examples?

2. **Metal hydroxides from group 2 will have the formula MCO_3.**

Can you write two examples?

What do you think the pH will be of a solution of a metal carbonate in water?

In the next sections we will be investigating real reactions!

6.2 The general reaction of an acid with a metal oxide

NEW WORDS

- metal oxide

In the previous section we learnt about two classes of oxides, namely **metal oxides** and non-metal oxides. Here is what we know about them so far:

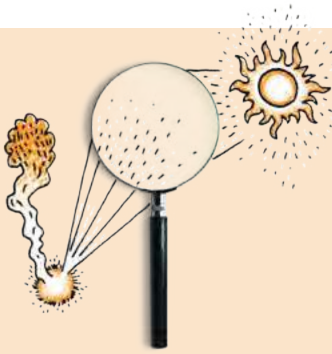
- Metal oxides are formed from the reaction between a metal and oxygen. Metal oxides are basic. When we dissolve them in water, they form solutions with pH values above 7.
- Non-metal oxides are formed from the reaction between a non-metal and oxygen. Non-metal oxides are acidic. When they dissolve in water, they form solutions with pH values below 7.

Here is the same summary, in table form, with some examples added:

Metal oxides	**Non-metal oxides**
metal + oxygen $\rightarrow$ metal oxide	non-metal + oxygen $\rightarrow$ non-metal oxide
basic	acidic
pH > 7	pH < 7
Examples: Li_2O, Na_2O, MgO, CaO	Examples: CO_2, SO_2, NO_2, P_2O_5

In this section, we are going to learn about the reactions between metal oxides and acids.

INVESTIGATION: The reaction between magnesium oxide and hydrochloric acid



The purpose of this investigation is to:

- test whether a solution of magnesium oxide in water is acidic, basic or neutral; and
- determine whether the reaction between an aqueous solution of magnesium oxide and hydrochloric acid is a **neutralisation reaction**.

INVESTIGATIVE QUESTION(S):

What are the questions you hope to answer with this investigation? Write them in the space below. There are a few words to start you off.

1. When magnesium oxide is dissolved in water, will the resulting solution...

____

2. When a solution of magnesium oxide is treated with hydrochloric acid, will the pH of the mixture ...

____

OVERVIEW OF THE INVESTIGATION:

1. We will measure the pH of a solution of magnesium oxide (MgO) with universal indicator paper to confirm whether it is acidic or basic. Within what range do you expect the pH of the magnesium oxide solution to fall?

---

2. We will add hydrochloric acid (HCl) to the magnesium oxide solution in small portions and measure the pH after each portion has been added. What changes do you expect to observe - will the pH increase, decrease or stay the same?

HYPOTHESIS:

What are your predictions? Your hypothesis should be a prediction of the finding(s) of the investigation. You should write it in the form of a possible answer to the investigative question(s). Here are a few words to start you off:

1. When magnesium oxide is dissolved in water, the resulting solution will...

---

2. When a solution of magnesium oxide is treated with hydrochloric acid, the pH of the mixture will...

MATERIALS:

- magnesium oxide powder
- water
- universal indicator paper (cut into 1 cm strips)
- white tile or sheet of white printer paper
- glass rod (or plastic straw)
- test tube
- dropper
- hydrochloric acid (HCl) solution (0.1 M)

METHOD:

1. Prepare the universal indicator paper by neatly placing five 1 cm pieces in a column on the white tile or sheet of printer paper.
2. Place a small quantity (the size of a match head) of the magnesium oxide in a test tube.
3. Add approximately 2 ml of tap water to dissolve most of the magnesium oxide.
4. Use the glass rod (or plastic straw) to stir the solution until most the magnesium oxide has dissolved. We will be calling this the *test solution* from now on.
5. Transfer one drop of the test solution to the first piece of universal indicator paper.
6. Compare the colour of the paper with the colour guide to find the pH of the solution.
7. Record this pH in the table you prepared beforehand.

8. Add 10 drops of the hydrochloric acid solution to the test solution. Stir it gently and transfer another drop of the solution to a fresh strip of the universal indicator.
9. Read the pH of the solution off the colour guide and record it in your table.
10. Repeat steps 3 and 4 until the pH of the test solution drops below 7. You may need more than 5 pieces of universal indicator paper.

RESULTS:

1. Present your results in a table. You should prepare this beforehand. Use appropriate headings for your table. 'Number of drops of HCl added' and 'Colour of the universal indicator paper' and 'pH of the test solution' are suggested headings for your columns.

2. Draw a graph of your results. Here are some hints to help you decide which variable to put on which axis:
   a) What is your independent variable? (Which variable did you change?) This goes on the x-axis.

   b) What is your dependent variable? (Which variable did you measure?) This goes on the y-axis.

CONCLUSIONS:

What conclusions can be made from the results of your investigation? Rewrite your hypothesis, but change it to reflect your findings if they are different from what you predicted earlier.

____

____

____

____

VISIT

A video showing the reaction of copper(II)oxide with hydrochloric acid

bit.ly/19ncbyc

Were you able to confirm or reject your hypotheses?

____

Now that we have investigated a reaction between a metal oxide (MgO) and an acid (HCl), we can write an equation for the reaction. We will begin by writing a general equation and end with one that matches the reaction that we have just investigated.

General equation for the reaction of an acid with a metal oxide

Can you remember learning that an acid-base reaction is an **exchange** reaction? We learnt that:

- The acid contributes H towards making a water molecule;
- The base contributes O or OH towards making a water molecule; and
- Whatever is left of the the acid and the base after making a H_2O molecule, combines to form a salt.

The general word equation for the reaction between an acid and a base is:

acid + base $\rightarrow$ **salt + water**

Since the base in our reaction is a metal oxide we can write:

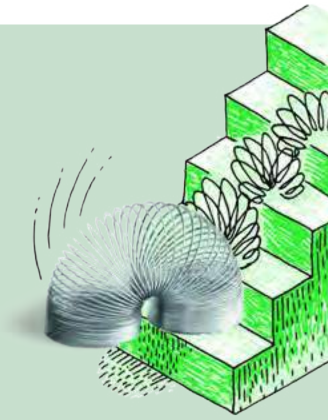
acid + <u>metal oxide</u> $\rightarrow$ **salt + water**

This is the general word equation for the reaction between an acid and a metal oxide. The type of salt that forms will depend on the specific acid and metal oxide which were used in the reaction.

Equations for the reaction between magnesium oxide and hydrochloric acid

Now we are going to learn how to write equations for our actual reaction.

ACTIVITY: Writing the chemical equation



The following steps will guide you:

1. The acid of our reaction was hydrochloric acid. Write its chemical formula.

___

2. What is the name and formula of the metal oxide we used?

___

3. Now, let's try to predict the products of the reaction. We know that water will be one of the products.
4. Write what remains of the base (MgO) after we have taken away the O (to make water).

___

5. Write what remains of the acid (HCl) after we have taken away the H (to make water). (Remember we need two H to make one H_2O).

___

6. Now put the two remaining fragments together. Place the metal first and remember that 2 HCl will leave 2 Cl after the 2 H has been given to O to make water. One Mg and 2 Cl makes...

Now, let's put it all together, first the reactants, then the products:

$2\ HCl + MgO \rightarrow MgCl_2 + H_2O$

7. Let's check quickly if the reaction is balanced.
   a) How many H atoms on the left hand side and on the right hand side? Are they balanced?

---

   b) How many Cl atoms on the left hand side and on the right hand side? Are they balanced?

---

   c) How many O atoms on the left hand side and on the right hand side? Are they balanced?

Since the numbers of each type of atom is the same on either side of the equation, we can confirm that it is balanced.

NEW WORDS
- metal hydroxide

Finally, let's use the chemical equation to write a word equation for the reaction:

hydrochloric acid + magnesium oxide → magnesium chloride + water

In the next section we are going to look at the reactions between acids and metal hydroxides.

6.3 The general reaction of an acid with a metal hydroxide

We will start this section with an investigation to illustrate the reaction between an acid and a **metal hydroxide**.

INVESTIGATION: The reaction between sodium hydroxide and hydrochloric acid

The purpose of this investigation is to:

- test whether sodium hydroxide is acidic or basic; and
- determine whether the reaction between sodium hydroxide and hydrochloric acid is a neutralisation reaction.

INVESTIGATIVE QUESTION(S):

1. What are the questions you hope to answer with this investigation? Write them below. You may use the previous investigation (of the reaction between magnesium oxide and hydrochloric acid) as guideline.

___

___

___

OVERVIEW OF THE INVESTIGATION :

1. We will measure the pH of a solution of sodium hydroxide (NaOH) with universal indicator paper to confirm whether it is acidic or basic. Within what range do you expect the pH of the sodium hydroxide solution to fall?

___

___

2. We will add hydrochloric acid (HCl) to the sodium hydroxide solution in small portions and measure the pH after each portion has been added. What changes do you expect to observe? Will the pH increase, decrease or stay the same?

___

___

HYPOTHESIS:

1. What are your predictions? Your hypothesis should be a prediction of the finding(s) of the investigation. You should write it in the form of a possible answer to the investigative question(s). If you are unsure, check the previous investigation.

___

___

___

MATERIALS:

- sodium hydroxide solution (0.1 M)
- universal indicator paper (cut into 1 cm strips)
- white tile or sheet of white printer paper
- glass rod or plastic straw
- test tube or small glass beaker
- plastic syringe (2.5 ml capacity)
- hydrochloric acid (HCl) solution (0.1 M)

METHOD:

1. Prepare the universal indicator paper by neatly placing five 1 cm pieces in a column on the white tile or sheet of printer paper.
2. Use the syringe to transfer 2 ml of the sodium hydroxide solution into the test tube or small glass beaker. We will be calling this the *test solution* from now on.
3. Rinse the syringe very thoroughly with water and dry it out with a clean tissue. Now fill it with hydrochloric acid solution and set it aside.
4. Transfer one drop of the sodium hydroxide (test solution) to the first piece of universal indicator paper.
5. Compare the colour of the paper with the colour guide to find the pH of the sodium hydroxide solution. Record this pH in your results table.
6. Add 0.5 ml of the hydrochloric acid solution from the syringe to the test solution. Stir it gently with the glass rod or straw and transfer another drop of the test solution to a fresh strip of the universal indicator paper.
7. Read the pH of the solution off the colour guide and record it in your results table.
8. Repeat steps 6 and 7 until the pH of the test solution reaches approximately 7.
9. How much of the hydrochloric acid solution have you used? Write the volume on the line below.

---

9. If you are quite sure that all the base has been neutralised by the acid (the pH should be 7 and the universal indicator paper should have turned green), pour the test solution into a small glass beaker and leave it in the window sill for a few days. Remember to come back to it later to see what has happened to it.

RESULTS:

1. Present your results in a neat table. Use appropriate headings for your table.

   The following are suggested headings for your columns.

   - Volume of HCl added
   - Colour of the universal indicator paper
   - pH of the test solution

1. Draw a graph of your results.
   a) What is your independent variable? (Which variable did you change?)

   b) What is your dependent variable? (Which variable did you measure?)

VISIT

A video illustrating the reaction of magnesium hydroxide with hydrochloric acid in the presence of universal indicator

bit.ly/11YINsP

CONCLUSIONS:

What conclusions can be made from the results of your investigation? Here you can rewrite your hypothesis, but change it to reflect your findings if they are different from what you predicted earlier.

____

____

____

Were you able to confirm or reject your hypothesis?

____

Now that we have investigated a reaction between a metal hydroxide (NaOH) and an acid (HCl), we can write an equation for the reaction. We will begin by writing a general equation and end with one that matches the reaction that we have just investigated.

General equation for the reaction of an acid with a metal hydroxide

You learnt that an acid-base reaction can be represented by the following general word equation:

acid + base → salt + water

The base in our reaction was a metal hydroxide, so the general equation becomes:

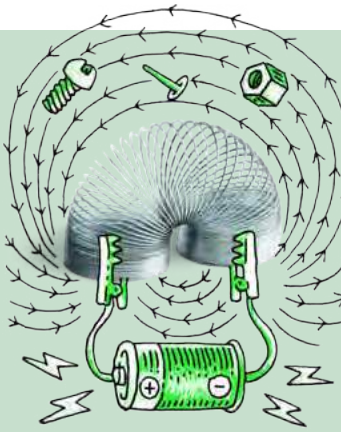
acid + metal hydroxide → salt + water

This is the general equation for the reaction between an acid and a metal hydroxide. The type of salt that forms will depend on the specific acid and metal hydroxide which were used in the reaction.

Equations for the reaction between sodium hydroxide and hydrochloric acid

Now we are going to learn how to write equations for our actual reaction.

ACTIVITY: Writing the chemical equation



The following steps will guide you:

1. The acid of our reaction was hydrochloric acid. Write its chemical formula.

---

2. What is the name and formula of the metal hydroxide we used?

---

3. Now, let's try to predict the products of the reaction. We know that water will be one of the products.
4. Write what remains of the base after we have taken away the OH to make water.

---

5. Write what remains of the acid after we have taken away the H to make water. Remember we need two H to make one H_2O, but NaOH has already contributed one O *and* one H. Now put the two fragments together. Place the metal from the base first and the non-metal from the acid. One Na and one Cl makes...

---

6. Now, let's put it all together, in the following order: Acid + metal hydroxide → salt + water

---

7. Let's check quickly if the reaction is balanced.
   a) How many H atoms on the left and on the right? Are they balanced?

   b) How many Cl atoms on the left and on the right? Are they balanced?

   c) How many O atoms on the left and on the right? Are they balanced?

8. Once you have performed this reaction and you are left with a **neutral solution**, you decide you want to recover the sodium chloride (table salt). How will you do this?

Finally, let's use the chemical equation to write a word equation for the reaction:

hydrochloric acid + sodium hydroxide → **sodium chloride + water**

In the next section we are going to look at the reactions between acids and metal carbonates.

6.4 The general reaction of an acid with a metal carbonate

In this section we will investigate the reaction between an acid and a **metal carbonate**.

NEW WORDS
- metal carbonate

Blackboard chalk is calcium carbonate, a metal carbonate.

INVESTIGATION: The reaction between calcium carbonate (chalk) and hydrochloric acid

The purpose of this investigation is to:

- test whether calcium carbonate is acidic or basic;
- determine whether the reaction between calcium carbonate and hydrochloric acid is a neutralisation reaction; and
- determine the products of the reaction between calcium carbonate and hydrochloric acid.

INVESTIGATIVE QUESTIONS:

1. What are the questions you hope to answer with this investigation? Write them on the lines below. You may use your previous investigations as a guideline.

OVERVIEW OF THE INVESTIGATION :

1. We will measure the pH of a suspension of calcium carbonate ($CaCO_3$) with universal indicator paper to confirm whether it is acidic or basic. Within what range do you expect the pH of the calcium carbonate to fall?

2. We will add hydrochloric acid (HCl) to the calcium carbonate in small portions and measure the pH after each portion has been added. What changes do you expect to observe? Will the pH increase, decrease or stay the same?

HYPOTHESIS:

1. What are your predictions? Your hypothesis should be a prediction of the finding(s) of the investigation. You should write it in the form of a possible answer to the investigative question(s). If you are unsure, check the previous investigation.

MATERIALS:

- chalk dust (calcium carbonate) suspended in a small quantity of water.
- universal indicator paper (cut into 1 cm strips)
- white tile or sheet of white printer paper
- glass rod or plastic straw
- test tube or small glass beaker
- plastic syringe (2.5 cm capacity) or dropper
- hydrochloric acid (HCl) solution (0.1 M)

METHOD:

1. Prepare the universal indicator paper by neatly placing five 1 cm pieces in a column on the white tile or sheet of printer paper.
2. Place approximately 2 ml of the calcium carbonate suspension into the test tube or small glass beaker. We will be calling this the *test solution* from now on.
3. Rinse the syringe very thoroughly with water and dry it out with a clean tissue. Now fill it with hydrochloric acid solution and set it aside.
4. Transfer one drop of the calcium carbonate (test solution) to the first piece of universal indicator paper.
5. Compare the colour of the paper with the colour guide below, to find the pH of the calcium carbonate solution. Record this pH in your results table.
6. Add 0.5 cm of the hydrochloric acid solution from the syringe to the test solution. Watch very carefully what happens. Do you see anything interesting? (Hint: Look for bubbles!) Stir the test solution gently with the glass rod and transfer another drop of it to a fresh strip of the universal indicator.
7. Read the pH of the solution off the colour guide and record it in your table.
8. Repeat steps 6 and 7 until the pH of the test solution reaches approximately 7. How much of the hydrochloric acid solution have you used? Write the volume in the space below.
9. Your teacher will repeat the experiment as a demonstration and will collect the gas that formed during the reaction, for testing with clear limewater.
10. Can you remember which gas we are testing for with clear limewater? Write its name and formula below.

RESULTS:

1. Present your results in a neat table. Use appropriate headings for your table. Suggested headings for your columns are as follows:

   - Volume of HCl added
   - Colour of the universal indicator paper
   - pH of the test solution

2. Draw a graph of your results.

   a) What is your independent variable? (Which variable did you change?)

____

   b) What is your dependent variable? (Which variable did you measure?)

____

CONCLUSIONS:

What conclusions can be made from the results of your investigation? Here you can rewrite your hypothesis, but change it to reflect your findings if they are different from what you predicted earlier.

VISIT
A video showing the reaction between metal carbonates and acids
bit.ly/17lyN5N

Were you able to confirm or reject your hypothesis?

Now that we have investigated a reaction between a metal carbonate ($CaCO_3$) and an acid (HCl), we can write an equation for the reaction. We will begin by writing a general equation and end with one that matches the reaction that we have just investigated.

General equation for the reaction of an acid with a metal carbonate

The general equation for the reaction between an acid and a base is as follows:

acid + base → salt + water

If we replace 'base' with 'metal carbonate', we get:

acid + metal carbonate → salt + water

But wait, there was a third product in our reaction! Can you remember what it was? (Hint: Bubbles formed, so it was a gas.)

We need to make it clear that CO_2 was a product of the reaction, so the correct general word equation would be:

acid + metal carbonate → salt + water + carbon dioxide

The type of salt that forms will depend on the specific acid and metal carbonate which were used in the reaction.

Equations for the reaction between calcium carbonate and hydrochloric acid

Now we are going to learn how to write equations for our actual reaction.

ACTIVITY: Writing the chemical equation

The following steps will guide you:

1. The acid of our reaction was hydrochloric acid. Can you write its chemical formula?

---

2. What is the name and formula of the metal carbonate we used?

---

3. Now, let's try to predict the products of the reaction. We know that water and carbon dioxide will be two of the products.
4. Write what remains of the base after we have taken away the CO_3 to make CO_2 and leave one O to make water.

---

5. Write what remains of the acid after we have taken away the H to make water. Remember we need two H to make one H_2O and $CaCO_3$ has only contributed one O.

---

6. Now put the two fragments together. Place the metal from the base first and the non-metal from the acid Ca and 2 Cl makes...

---

7. Now, let's put it all together, first the reactants, then the products:
   $2\ HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$
8. Let's check quickly if the reaction is balanced.
   a) How many H on the left and right? Are they balanced?

---

   b) How many Cl on the left and right? Are they balanced?

---

   c) How many O on the left and right? Are they balanced?

---

   d) How many C on the left and right? Are they balanced?

Finally, let's use the chemical equation to write a word equation for the reaction:

hydrochloric acid + calcium carbonate → calcium chloride + water + carbon dioxide

Applications for calcium carbonate

Calcium carbonate is found in many places outside of the laboratory. It is found in different types of rocks around the world, for example limestone, chalk and marble.

The Cango Caves near Oudtshoorn, South Africa, are situated in a limestone ridge and contain spectacular limestone formations. Such caves are the result of water high in carbonic acid acting upon limestone deposits in ancient rock layers.

DID YOU KNOW?

Dark green leafy vegetables such as broccoli, kale and cabbage are a dietary source of calcium carbonate, providing the body with calcium. You can also take calcium carbonate in the form of tablet supplements.

Calcium carbonate is also the main part of shells of various marine organisms, snails, pearls, oysters and bird eggshells. It is also found in the exoskeletons of crustaceans (such as crabs, prawns and lobsters).

Chunks of calcium carbonate from various shells.

Calcium carbonate also has many applications. In industry, the main application is in construction as it is used in various building materials and in cement. Calcium carbonate is used in many adhesives, paints and in ceramics. It is also used in swimming pools to adjust the pH. When do you think it would be added? If the pool was too acidic and you wanted to make it more basic, or if the pool was too basic and you wanted to make it more acidic?

____

Calcium carbonate is also used in agriculture in the form of lime powder. Agricultural lime is made by grinding up limestone or chalk. It is added to the soil if the soil is too acidic to increase the pH. It also provides plants with a source of calcium.

This tractor is busy depositing agricultural lime onto a field. This is called liming.

In this chapter we have investigated a number of reactions of acids with bases. We have learnt to write word equations for these reactions and practised converting between word and balanced chemical equations.

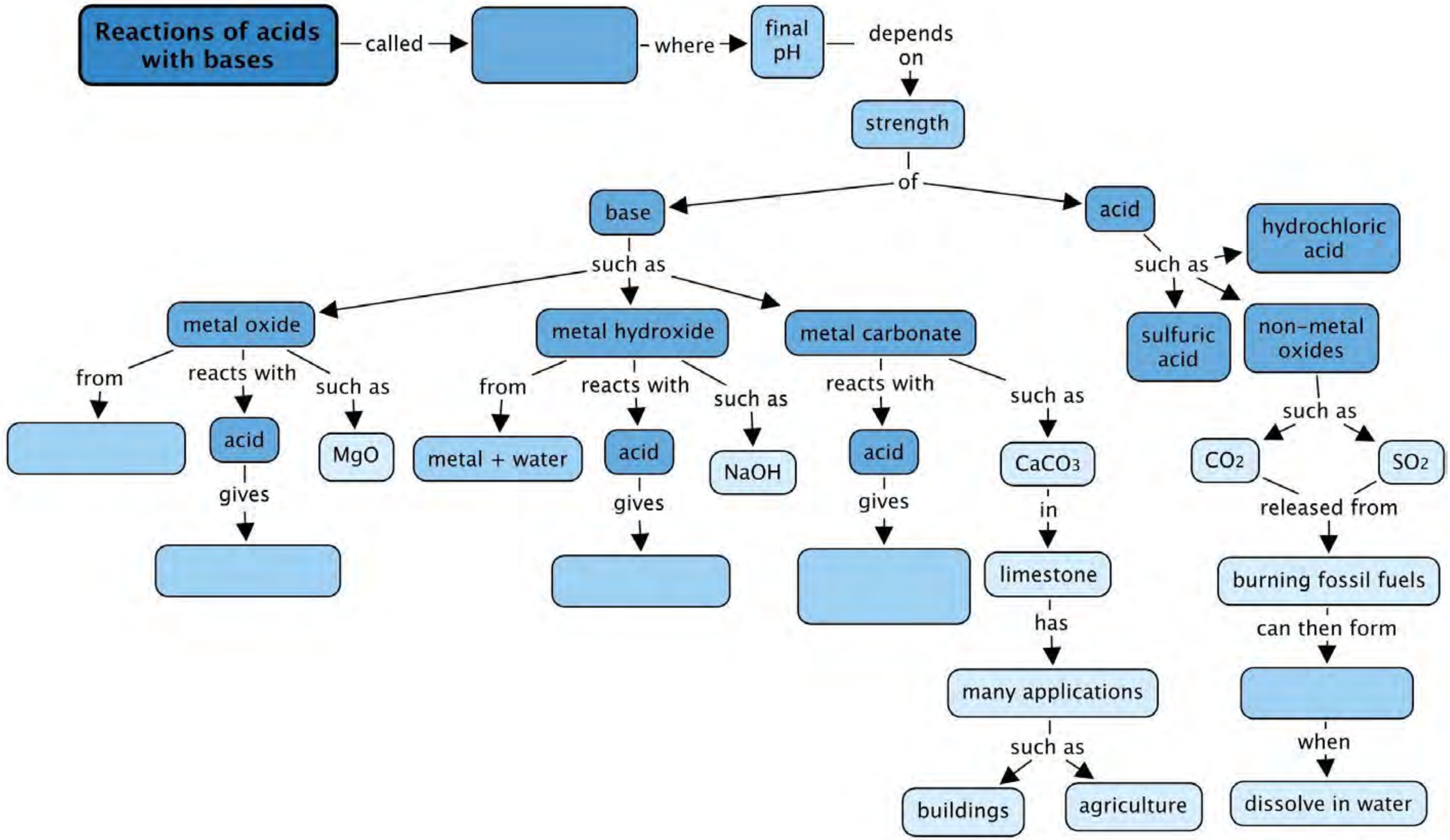
SUMMARY:

Key Concepts

- The reaction of an acid with a base is called a neutralisation reaction.
- When an acid (pH < 7) is added to a base (pH > 7), the pH of the resulting mixture will lie somewhere between that of the acid and the base. Even though the acid and base will be neutralised, the resulting solution will not necessarily be neutral.
- Some common laboratory acids are sulfuric acid (H_2SO_4), nitric acid (HNO_3) and hydrochloric acid (HCl).
- Non-metal oxides tend to form acidic solutions when they dissolve in water. These solutions will have pH values below 7.
- Metal oxides, metal hydroxides and metal carbonates form basic solutions in water; these will have pH values above 7.
- When a metal oxide, or a metal hydroxide reacts with an acid, a salt and water form as products.
- When a metal carbonate reacts with an acid, a salt, water and carbon dioxide form as products.
- The general word equations for the reactions of this chapter are the following:
  - acid + metal oxide $\rightarrow$ salt + water
  - acid + metal hydroxide $\rightarrow$ salt + water
  - acid + metal carbonate $\rightarrow$ salt + water + carbon dioxide

Concept Map

Complete the concept map by filling in the blank spaces..



Reactions of acids with bases
called
where
final pH
depends on
strength
of
base
acid
such as
metal oxide
metal hydroxide
metal carbonate
from
reacts with
such as
acid
MgO
gives
from
metal + water
reacts with
acid
gives
such as
NaOH
reacts with
acid
gives
such as
CaCO3
in
limestone
has
many applications
such as
buildings
agriculture
such as
hydrochloric acid
sulfuric acid
non-metal oxides
such as
CO2
SO2
released from
burning fossil fuels
can then form
when
dissolve in water

REVISION:

1. Fill in the missing words in these sentences. Write the word on the line below. [10 marks]
   a) To know if something is an acid or a base, we measure its ______________.

   ___

   b) The name of the laboratory acid with the formula H_2SO_4, is ______________.

   ___

   c) The formula of the laboratory acid named hydrochloric acid, is ______________.

   ___

   d) When a metal oxide reacts with an ____________, a salt and water will be formed.

   ___

   e) When a metal hydroxide reacts with an acid, a salt and __________ will be formed.

   ___

   f) When a metal carbonate reacts with an acid, a salt, water and ______________ will be formed.

   ___

   g) Metal oxides, metal hydroxides and metal carbonates all dissolve in water, forming ____________ solutions. This means the solutions will have pH values ________ than 7.

   ___

   h) The reaction of an acid with a base is called a ______________ reaction.

   ___

   i) Non-metal oxides tend to form ____________ solutions when they dissolve in water.

   ___

2. Write a short paragraph (3 or more sentences) to explain what you understand each of the following terms to mean, in your own words. [2 x 3 = 6 marks]

   a) neutralisation

   ____

   ____

   ____

   ____

   b) acid rain

   ____

   ____

   ____

   ____

3. For each of the following reactions, complete the tables by providing the missing equations.

   a) The reaction between hydrochloric acid and magnesium oxide [4 marks]

Word equation	
Chemical equation	
General equation	acid + metal oxide $\rightarrow$ salt + water

   b) The reaction between hydrochloric acid and sodium hydroxide [6 marks]

Word equation	
Chemical equation	
General equation	

   c) The reaction between hydrochloric acid and calcium carbonate [4 marks]

Word equation	
Chemical equation	$2\ HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$
General equation	

d) The reaction between hydrochloric acid and magnesium hydroxide
[4 marks]

Word equation	
Chemical equation	$2\ HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2\ H_2O$
General equation	

e) The reaction between hydrochloric acid and calcium oxide
[4 marks]

Word equation	
Chemical equation	$2\ HCl + CaO \rightarrow CaCl_2 + H_2O$
General equation	

f) The reaction between hydrochloric acid and potassium hydroxide
[6 marks]

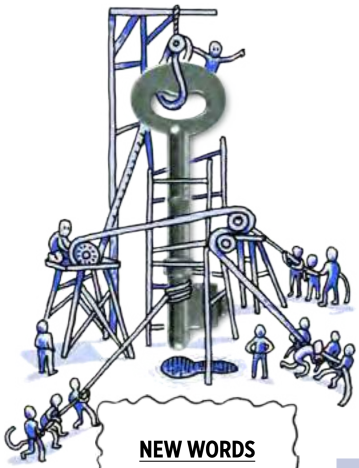
Word equation	
Chemical equation	
General equation	

g) The reaction between hydrochloric acid and sodium carbonate
[4 marks]

Word equation	hydrochloric acid + sodium carbonate → sodium chloride + water + carbon dioxide
Chemical equation	
General equation	

Total [48 marks]

7 Reactions of acids with metals



KEY QUESTIONS:

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

NEW WORDS

- diatomic
- density
- characteristic
- presence
- chemist
- pharmacist

7.1 The reaction of an acid with a metal

In the previous chapter we learnt about the reactions of acids with a variety of bases: metal oxides, metal hydroxides and metal carbonates. We learnt how to write general equations, word equations and chemical equations for those reactions.

In this chapter we will investigate one final type of reaction, namely the reaction between an acid and a metal.

First, we will do an investigation to observe the reaction and then we will write equations to represent it. Before we do this, however, we have to take a quick detour to learn something interesting about hydrogen gas.

ACTIVITY: Testing for hydrogen gas

1. What do you know about hydrogen gas? Perhaps you know its formula? Write it below.

____

2. Hydrogen gas is a **diatomic** gas. What does this mean?

____

3. What do you know about the position of hydrogen in the periodic table? Write what you know below.

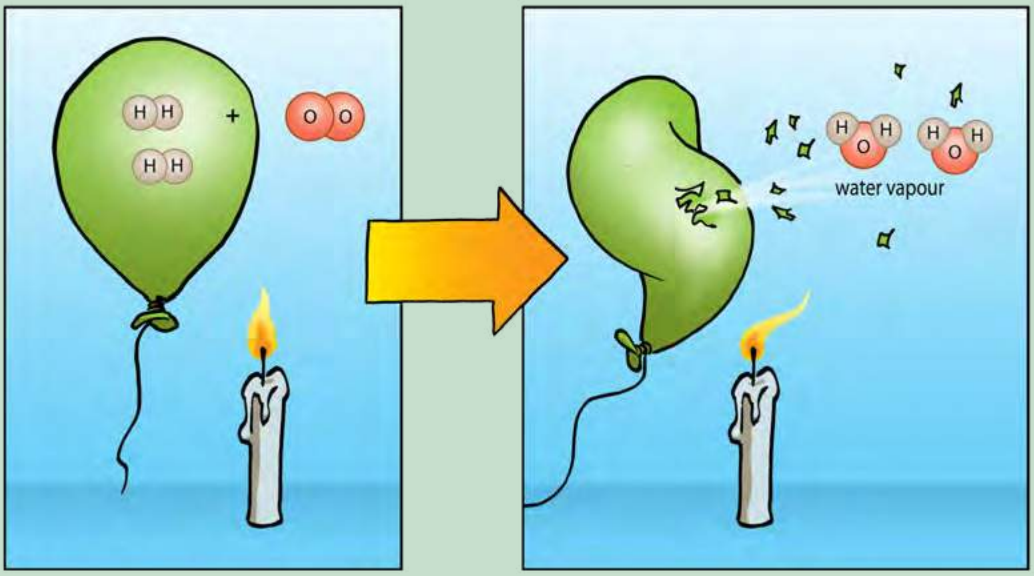
____

4. The position of hydrogen in the periodic table tells us that it is the lightest of all the elements. It has the smallest atomic mass. Because the element hydrogen is a gas (even though it is a diatomic one), it has one of the lowest densities of any substance. Can you remember what **density** means? Write your own definition below.

When hydrogen gas is released in a reaction it will immediately rise up, because **hydrogen is less dense than air**. If you filled a balloon with hydrogen, it would float up and you would need to tie a string to it to prevent it from floating away!

This man is about to launch a weather balloon filled with hydrogen gas. It will float upwards to collect information about the weather in Antarctica.

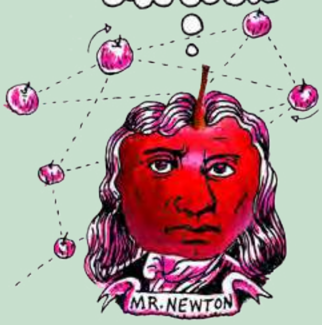
Another interesting thing about hydrogen is that it reacts explosively with oxygen if you bring a flame near it. You may remember learning about this in Chapter 4 about the reactions of non-metals with oxygen. The reaction between a large quantity of hydrogen and oxygen in the air produces a beautiful orange fireball and a very loud boom! Do you remember seeing the following diagram?



5. Write the balanced equation for the reaction between hydrogen gas and oxygen below.

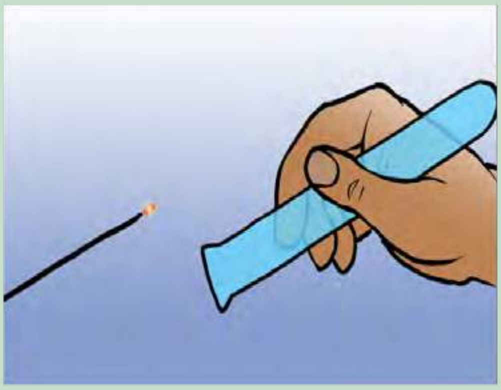
DID YOU KNOW?

The name hydrogen comes from the Greek words '*hydro*' and '*gen*' which means 'water generator'

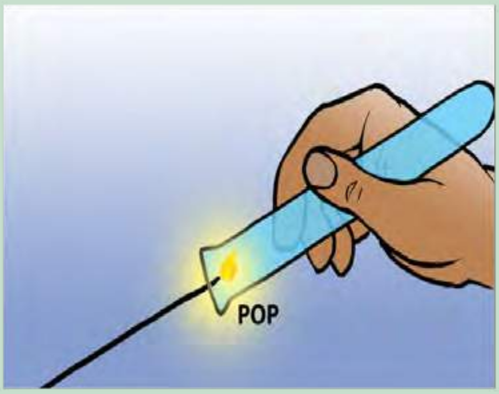


The reaction between a tiny amount of hydrogen and oxygen in the air produces a **characteristic** 'pop' sound and this serves as test for the **presence** of hydrogen. You can watch the short video clip in the visit box in the margin to see this 'pop'.

VISIT
Testing for hydrogen gas
bit.ly/14CyU4Q

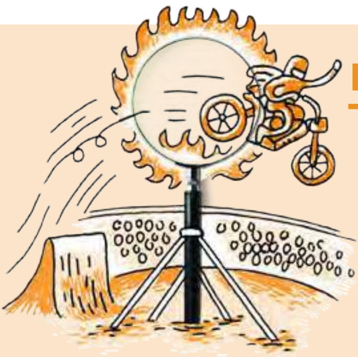


When a glowing splint is put into a test tube containing hydrogen gas...



...it makes a 'pop' sound.

Let's now investigate the reaction between an acid and a metal. You should listen carefully for this 'pop' sound during the investigation. If you hear it, it will signal the presence of hydrogen gas!



INVESTIGATION: The reaction between magnesium and hydrochloric acid

The purpose of this investigation is to:

- observe the reaction between hydrochloric acid and magnesium; and
- identify the gaseous product of the reaction between hydrochloric acid and magnesium.

Your teacher will demonstrate the reaction between magnesium and hydrochloric acid, while you make observations. Remember to watch carefully and take detailed notes.

INVESTIGATIVE QUESTION:

What question(s) do you hope to answer with this investigation?

____

____

HYPOTHESIS:

What do you predict will happen? Your hypothesis should be a prediction of the finding(s) of the investigation. You should write it in the form of a possible answer to the investigative question(s).

____

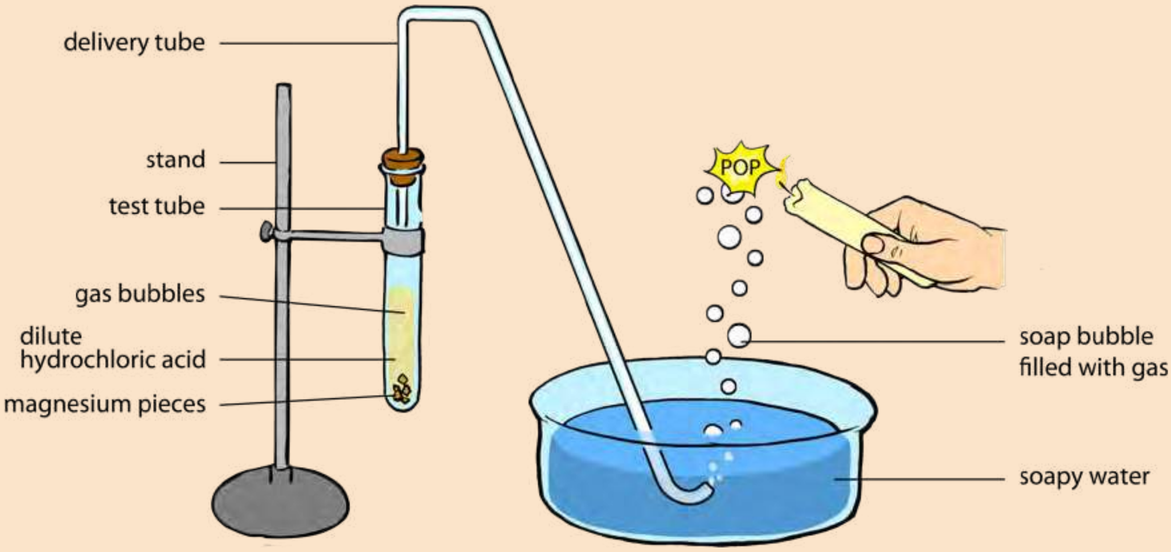
MATERIALS:

- magnesium ribbon (cut into smallish pieces)
- hydrochloric acid (HCl) solution (1 M)
- large test tube
- retort stand with clamp
- rubber stopper with short length of glass tubing pushed through it
- silicone or rubber tubing (or a glass delivery tube as shown in the set-up below)
- shallow dish filled with soapy water (made by mixing a few teaspoons of dishwashing liquid with water)

METHOD:

1. Use a piece of universal indicator paper to test the pH of the hydrochloric acid solution. Record its pH.

2. Set up the experiment as shown in the following diagram. Ensure that the end of the delivery tube is below the surface of the soap solution in the dish.



3. Place approximately 1 g of the magnesium pieces in the test tube, but do not add the hydrochloric acid until everything else is ready to be assembled.
4. Add approximately 40 ml of hydrochloric acid and immediately place the stopper on the test tube. The first few bubbles of gas that are released from the end of the delivery tube will be air.
5. When the soap bubbles start to float up, hold a burning candle to them and listen carefully for the sound they make when they pop. Do not hold the candle to the end of the delivery tube.
6. When the magnesium stops reacting and no further hydrogen bubbles are released, extinguish the candle and set it aside.
7. Disassemble the experiment and test the pH of the reaction mixture. Record the pH value.

RESULTS AND OBSERVATIONS:

Record your results in the following table:

pH of the 1 M hydrochloric acid before the reaction	
pH of the mixture after the reaction	

Use the following lines to write down any observations that you make during the investigation.

CONCLUSIONS:

What conclusions can be made from the results of your investigation? Rewrite your hypothesis, but change it to reflect your findings if they are different from what you predicted earlier.

QUESTIONS:

1. What did you observe in the test tube when the magnesium and hydrochloric acid were mixed?
2. What did you observe at the end of the gas delivery tube after the magnesium and hydrochloric acid were mixed?
3. Why do you think the soap bubbles floated upwards?
4. Which gas do you think was produced by the reaction? Write its name and formula below. What makes you think it was this gas?
5. What happened to the pH of the hydrochloric acid solution during the reaction?

6. What does the increase in pH mean?

7. Were you able to confirm or reject your hypothesis?

In our investigation hydrochloric acid reacted with magnesium (a metal). Our next task is to write an equation for the reaction. We will begin by writing a general equation and end with one that matches the reaction that we have just investigated.

General equation for the reaction of an acid with a metal

The general word equation for the reaction between an acid and a metal is:

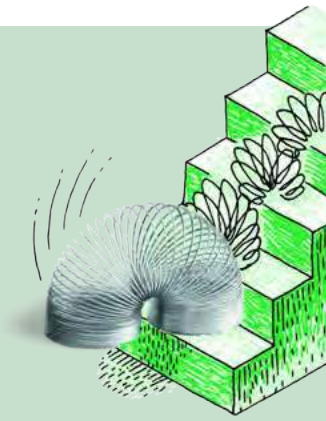
acid + metal $\rightarrow$ **salt + hydrogen gas**

The type of salt that forms will depend on the specific metal and acid which are used in the reaction.

Equations for the reaction between magnesium and hydrochloric acid

Now let's write equations for our actual reaction from the last investigation.

ACTIVITY: Writing the chemical equation



The following steps will guide you:

1. The acid of our reaction was hydrochloric acid. Can you write its chemical formula?

2. What is the name and formula of the metal we used?

3. Now, let's try to predict the products of the reaction. We know that hydrogen gas will be one of the products. Write the chemical formula for hydrogen gas.

4. Write what remains of the acid (HCl) after we have taken away the H to make H_2. (Remember we need two H to make one H_2).

5. The two Cl and the Mg are exactly what are needed to make magnesium chloride. Write the formula below.

6. Now, let's write the reaction; first the reactants, then the products:

$$\mathbf{2\ HCl + Mg \rightarrow MgCl_2 + H_2}$$

Let's check quickly if the reaction is balanced.

a) How many H on the left and right? Are they balanced?

b) How many Cl on the left and right? Are they balanced?

c) How many Mg on the left and right? Are they balanced?

VISIT

Coke cans made from aluminium (a metal) react with an acid and a base (video)

bit.ly/11YxBMO

Since the numbers of each type of atom is the same on either side of the equation, we can confirm that it is balanced.

7. Finally, let's use the chemical equation to write a word equation for the reaction.

VISIT

A useful site to find out more about some chemistry-related careers

bit.ly/15tsQI0

Chemist or Pharmacist?

When people hear that someone is a **'chemist'**, they often confuse this with being a **'pharmacist'**. In some countries the terms 'chemist' and 'pharmacist' are even used to describe the same kind of person. In South Africa the two words have different meanings. But what is the difference between being a chemist and being a pharmacist?

Look up these careers to identify the main difference between a chemist and a pharmacist and summarise them below:

Two chemists working in a laboratory.

- **Chemists:**

A pharmacist in his dispensary.

- **Pharmacists:**

ACTIVITY: Other careers in chemistry

INSTRUCTIONS:

1. Below is a list of different careers that all use chemistry in some way. Have a look through the list and then select the five careers you find most interesting.
2. Do an internet search to find out what each career is.
3. Write a one line description of this career.
4. If there is a career that really interests you, draw a smiley face next to it and be sure to do some extra reading around the topic and where chemistry might take you! Find out what level of chemistry you will need for this particular career.
5. There are many other careers besides the ones listed here which use chemistry in some way, so if you know of something else which is not listed here and it interests you, follow your curiosity and discover the possibilities!

Some careers involving chemistry:

- Agricultural chemistry
- Biochemistry
- Biotechnology
- Chemical education/teaching
- Dentistry
- Environmental chemistry

- Forensic science
- Food science/technology
- Geneticist
- Geochemistry
- Materials science
- Medicine and medicinal chemistry
- Mining
- Oil and petroleum industry
- Organic chemistry
- Oceanography
- Patent law
- Pharmaceuticals
- Space exploration
- Zoology

DID YOU KNOW?

Great scientists (including chemists) are observant, curious, patient and eager to learn more about their field every day.

Your descriptions of the careers you are interested in:

In this chapter we have studied the reaction of hydrochloric acid with magnesium, as an example of a reaction between an acid and a metal.

SUMMARY:

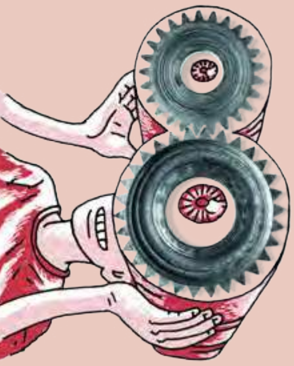
Key Concepts

- An acid will react with a metal to form a salt and hydrogen gas.
- The general word equation for the reaction between an acid and a metal is as follows:
  - acid + metal $\rightarrow$ salt + hydrogen

Concept Map

This was quite a short chapter, so the concept map has been left blank for you to do your own. Be sure to include something about the test for hydrogen.

Reactions of
acids with metals



REVISION:

1. Fill in the missing words in these sentences. Write the word on the line below. [3 marks]
   a) When an acid reacts with a metal, a salt and __________ gas forms.

   ____

   b) A molecule that consists of two atoms bonded together is called a __________ molecule.

   ____

   c) The scientific quantity represented by the mass of a substance in a given volume is called the __________ of that substance.

   ____

2. Write a short paragraph (2 sentences or more) to explain why a balloon filled with hydrogen will float upwards. [2 marks]

   ____
   ____
   ____
   ____

3. Imagine you are carrying out a reaction and you expect one of the products that will form is hydrogen. Write a short paragraph (2 sentences or more) to describe how you would confirm the presence of hydrogen gas. [2 marks]

   ____
   ____
   ____
   ____

4. When an acid reacts with a metal, do you think the pH of the solution will increase, decrease, or stay the same? Motivate your answer briefly. [3 marks]

   ____
   ____
   ____
   ____

5. Complete the following table by providing the missing equations for the reaction between hydrochloric acid and magnesium. [6 marks]

Word equation	
Chemical equation	
General equation	

6. Complete the following table by providing the missing equations for the reaction between hydrochloric acid and zinc. [4 marks]

Word equation	
Chemical equation	$2\,HCl + Zn \rightarrow ZnCl_2 + H_2$
General equation	

7. We have looked at many different chemical reactions this term. As a summary, complete the following table by giving the general equations in words for each of the chemical reactions in the second column, and provide an example for each type as a balanced chemical equation in the third column. [18 marks]

Type of chemical reaction	**General word equation**	**Example (balanced equation)**
metals with oxygen		
non-metals with oxygen		
acids with metal oxides		
acids with metal hydroxides		
acids with metal carbonates		
acids with metals		

Total [38 marks]

GLOSSARY

acidity:	this word is related to the word 'acid', so is the word 'acidic'; a substance is strongly acidic when it has a high (degree of) acidity
acid rain:	rainwater that is unusually acidic as a result of dissolved non-metal oxides that have entered the atmosphere
alternative:	different
atomic number:	a unique number that represents a given element, and shows its position on the periodic table; the number of protons found in the nucleus
balanced	: a balanced equation reaction has the same numbers of atoms of a particular type on opposite sides of the reaction equation
barrier	: a fence or other obstacle that keeps things apart
bond	: a force between atoms in a compound, holding them together
camera flash:	a device (usually attached to the camera) that provides a quick burst of light at the instant that the photo is taken
characteristic:	a quality or feature of an object or item; for example, one of the characteristics of an acid is that it is corrosive
chemical bond:	a special attractive force that holds the atoms in a molecule together
chemical equation:	an equation that describes a chemical reaction using the chemical formulae of the compounds involved in the reaction
chemical formula:	a combination of element symbols that shows the types and number of atoms in one molecule of a given compound; a unique string of symbols (letters and numbers) that represents a chemical compound
chemical reaction:	a process in which atoms in substances, called reactants, are rearranged to form new substances, called products
chemist	: a person who has studied chemistry and uses this knowledge to do his/her job
chromed metal:	metal that is covered by a thin layer of chromium
coefficient:	a number that is placed*in front of* a chemical formula in a reaction equation; it shows the number of molecules of that type taking part in the reaction, for example**2** Mg
collide	: to bump into something
combustion	: a type of chemical reaction where a substance and oxygen react during burning to form a new product

compound:	a pure substance in which atoms of two or more different chemical elements are bonded in some fixed ratio
convention:	a way in which something is usually done
corrosion:	the gradual destruction of materials (usually metals) by chemical reaction with substances in the environment
corrosive	: a corrosive substance is something that causes corrosion; substances that are corrosive can cause burns on the skin and damage to certain surfaces
crystal lattice:	in some compounds, the atoms are arranged in a regular pattern in a fixed ratio to form a lattice structure; a lattice looks like a mesh or trellis
density:	the mass of a substance in a given space (volume)
detour:	to take a roundabout route, either to make a visit along the way, or to avoid something
diatomic	: a diatomic molecule consists of two atoms; H_2, N_2, O_2, F_2, Cl_2, Br_2, and I_2 are all examples of elements that consist of diatomic molecules
dioxide	: a compound that contains two oxygen atoms in its chemical formula; examples are carbon dioxide (CO_2) and sulfur dioxide (SO_2)
electrons:	the smallest of the three types of sub-atomic particles; they are negatively charged and are located outside the atomic nucleus
element	: a pure substance that consists of only one type of atom throughout
exchange reaction:	a reaction in which the reactants break up in fragments that are then exchanged, or swapped around
exposed	: when a material is exposed, it is uncovered or unprotected (in this case from oxygen that will react with it)
fossil fuel:	a fuel that was formed from the prehistoric remains of plant and animal life (fossils); it usually has to be extracted from the earth; examples include oil, coal and natural gas
fuel	: a substance that will release energy when it reacts with another substance; in this context that other substance is usually oxygen
galvanised	**metal**: metal that is covered by thin layers of zinc and zinc oxide
galvanise:	to galvanise iron or steel means to cover it with a thin layer of zinc; the zinc reacts with oxygen to form zinc oxide when it is exposed to air and this forms a strong and impenetrable coating
generate	: to produce something; in this case it refers to some other source of energy being converted to electrical energy (electrical power or electricity)
group	: the vertical columns of the Periodic Table are called*groups*

identical:	exactly the same in every way
ignite	: to set something on fire
indicator	: a substance that changes colour in the presence of another substance, showing that that substance is present
inert:	unreactive; these substances do not react with other substances and do not change into other compounds
IUPAC:	International Union of Pure and Applied Chemistry (acronym)
IUPAC system:	a system for naming compounds in a way that is unique for each compound
laboratory acids:	acid commonly found in the laboratory
litmus	: a well known acid-base indicator that turns red when mixed with an acid and blue when mixed with a base
macroscopic	: the*macroscopic* world includes all the things we can observe with our five senses - things we can see, hear, smell, touch and taste
metal:	an element that is shiny, ductile and malleable; metals occur on the left and towards the middle of the periodic table
metal carbonate:	a compound with the the general formula MCO_3 or M_2CO_3 where M represents a metal atom, C represents a carbon atom and O represents an oxygen atom
metal hydroxide:	a compound with the the general formula MOH or $M(OH)_2$ where M represents a metal atom, O represents an oxygen atom and H represents a hydrogen atom
metal oxide:	the product of the reaction between a metal and oxygen; a compound with the general formula MO or M_2O where M represents a metal atom and O represents an oxygen atom
molecule	: two or more atoms that have chemically bonded with each other; the atoms in a molecule can be of the same kind (in which case it would be a molecule of an element), or they can be of different kinds (in which case it would be a molecule of a compound)
neutralisation reaction:	a reaction in which the reactants neutralise each other
neutralise:	to neutralise something means to take away its potency
neutral solution:	a solution with pH = 7
neutrons	: a type of sub-atomic particle similar to protons in mass and size, but neutral (without charge); neutrons together with protons make up the atomic nucleus
non-metal:	an element that does not have metallic properties; non-metals (excluding hydrogen) occur in the top right-hand corner of the periodic table

non-metal oxide:	the product of the reaction between a non-metal and oxygen
non-renewable:	non-renewable energy sources refer to sources that can be used up, such as fossil fuels (coal, oil, or natural gas)
oxidise	: when a compound reacts with oxygen, we say it is oxidised; in chemistry, the word oxidise means much more than this, but in this chapter we will limit ourselves to this simple definition
penetrate	: when liquid or air penetrates into a material, it passes into or through that material (usually because of tiny holes in the material); something that cannot be penetrated is called impenetrable
periodic table:	a table in which the chemical elements are arranged in order of increasing atomic number
period:	the horizontal rows of the Periodic Table are called*periods*
pharmacist	: a person who has studied pharmacy and uses this knowledge in the field of health science
pH	: pH measures the acidity and alkalinity of a solution as a number on a scale ranging between 0 and 14
picture equation:	an equation that describes a chemical reaction using diagrams of the particles of the compounds involved in the reaction
porous	: material that has tiny holes through which liquid or air may pass
potency	: power
prefix	: a bit added at the start of a word, usually to indicate number, e.g.,*mono-, di-, or tri-*
presence:	the state of something existing or being present in a place
preservative	: a substance that is added to products (usually food or beverages) to make them last longer; most preservatives are toxic to microorganisms, but are added in such small quantities that they do not pose significant harm to humans
product	: a substance that forms during the reaction; it will be present after the reaction has taken place
protons	: sub-atomic particles that are positively charged and occur inside the atomic nucleus along with neutrons
reactant:	the starting substances that undergo change in a chemical reaction
reactive	: elements and compounds that are*reactive* will readily react with many other substances
red cabbage indicator:	An acid-base indicator made from the sap of red cabbage; red cabbage indicator is also capable of displaying a range of colours, depending on the pH of the solution with which it is mixed
renewable:	a renewable source of energy cannot be used up, such as water, wind, or solar power

rust	: a reddish- or yellowish-brown, often flaky, coating of iron oxide that is formed on iron or steel by oxidation (when it reacts with oxygen in the air)
rust-resistant:	a rust-resistant material; one that does not rust
semi-metal:	an element that has properties of both metals and non-metals; the semi-metals occur in a narrow diagonal strip that separates the metals form the non-metals on the periodic table
steel	: a metal alloy composed of a mixture of iron and other elements (mostly metal); it is very strong and used widely in the construction industry (also in buildings)
submicroscopic:	the submicroscopic world includes things that exist but that we can't see; atoms and molecules can only be 'seen' as mental pictures and when we draw these, we refer to them as 'submicroscopic diagrams'
subscript	: a number that is placed*inside* a chemical formula; it shows the number of atoms of that type in one molecule of that compound, for example O_2
suffix	: a bit added at the end of a word, e.g.,*-ide*
symbolic	: the*symbolic* world includes letters and numbers that we use to represent atoms and molecules
symbol (or element symbol):	a unique letter (or letters) that represent a given element
systematic name:	The unique name that will be generated for a given compound, if the IUPAC system for naming compounds is followed correctly
tarnish:	when a metal surface gets dirty or spotty after reacting with oxygen or other substances in the air, we say it is tarnished
toxic	: poisonous, harmful to living organisms
unique	: the only one of its kind; unlike anything else
unit:	In this chapter, unit means a quantity used as a standard of measurement, e.g. units of time are second, minute, hour, day, week, month, year and decade
universal indicator:	An acid-base indicator that can display a range of colours, depending on the pH of the solution with which it is mixed
word equation:	an equation that describes a chemical reaction using the names of the compounds involved in the reaction

Image Attribution