Oxford excellence for the Caribbean

GRADE 8

Investigating Science for Jamaica

Integrated Science

June Mitchelmore

Advisors:

Willa **Dennie**

Richard **Johnson**

Peta-Gay **Kirby**

With online support

OXFORD

GRADE 8

Investigating Science for Jamaica

Integrated Science

June Mitchelmore
Formerly Education Officer (Science)
Ministry of Education, Jamaica

Advisors:
Willa **Dennie**
Richard **Johnson**
Peta-Gay **Kirby**

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS

Great Clarendon Street, Oxford, OX2 6DP, United Kingdom

Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
and education by publishing worldwide. Oxford is a registered trade mark
of Oxford University Press in the UK and in certain other countries

ISBN 978 0 19 842678 3

Printed in Great Britain by CPI Group (UK) Ltd., Croydon CR0 4YY

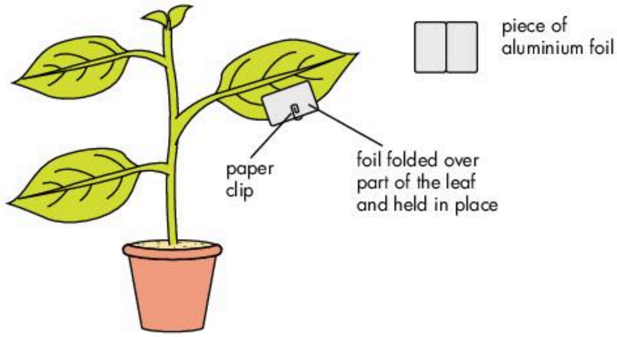
Acknowledgements

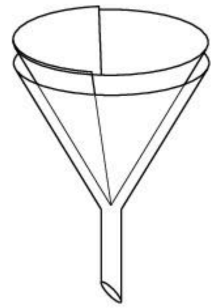
The author and publishers would like to thank:

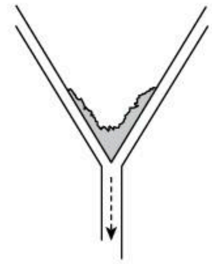
The Ministry of Education and Culture, Kingston, Jamaica, for the use made of the information in the Grade 9 National Standards Curriculum for Science subjects, June 2016; Dr Sylvia Mitchell for her useful feedback on the Units; Michael Rees for advice on computing and mathematics.

Photo credits:
Cover: Shutterstock.com
piv Voon Yian Khiam/Shutterstock; **piv** John-Alex/Shutterstock; **p1**: Peter Muller/Cultura/Getty Images; **p2**: Fotostorm/Getty Images; **p27 (T)**: Tommy Schultz/Fotolia; **p27 (B)**: POWER AND SYRED/SCIENCE PHOTO LIBRARY; **p28**: Hairy Mallow/Shutterstock; **p36 (c)**: Christina Rollo/ Alamy Stock Photo; **p36 (f)**: John Birdsall Social Issues Photo Library; **p45 (TL)**: E.R. Degginger/ Alamy Stock Photo; **p45 (BL)**: MARTYN F. CHILLMAID/SCIENCE PHOTO LIBRARY; **p50 (T)**: ANDREW LAMBERT PHOTOGRAPHY/SCIENCE PHOTO LIBRARY; **p50 (B)**: John-Alex/Shutterstock; **p54 (L)**: CHARLES D. WINTERS/Science Photo Library; **p54 (ML)**: Martyn Chillmaid; **p57 (a)**: Hayesphotography/iStockphoto; **p57 (b)**: Murat $en/iStockphoto; **p57 (c)**: Phil Degginger/Alamy Stock Photo; **p57 (d)**: Lebazele/iStockphoto; **p57 (e)**: Neil Corder/StockFood Creative/Getty Images; **p57 (f)**: Hroe/iStockphoto; **p57 (g)**: EHStock/iStockphoto; **p60**: Education Images/UIG/Getty Images; **p67 (T)**: Aluxum/iStockphoto; **p67 (B)**: imageBROKER/Alamy Stock Photo; **p69 (a)**: Art Directors & TRIP / Alamy Stock Photo; **p69 (b)**: John T. Fowler/Alamy Stock Photo; **p69 (c)**: Magdalena Kucova/Shutterstock; **p69 (d)**: CORDELIA MOLLOY/SCIENCE PHOTO LIBRARY; **p69 (e)**: BSIP TAULIN/SCIENCE PHOTO LIBRARY **p69 (f)**: BSIP CHASSENET/SCIENCE PHOTO LIBRARY; **p78**: STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY; **p86**: SCIENCE PHOTO LIBRARY; **p87**: GIPhotoStock/SCIENCE PHOTO LIBRARY; **p100 (T)**: James L. Amos/Corbis Documentary/Getty Images; **p100 (M)**: Howard Davies/Corbis Documentary/Getty Images; **p100 (B)**: Doug Steley B/Alamy Stock Photo; **p101**: Gabor Havasi/Shutterstock; **p107**: Shahjehan/ Shutterstock; **p109 (T)**: PetStockBoys / Alamy Stock Photo; **p109 (B)**: Larry Lilac/Alamy Stock Photo; **p112** Jaak/Fotolia; **p113**: Fotolia; **p120**: johnandersonphoto/iStockphoto; **p133 (T)**: BIOPHOTO ASSOCIATES/SCIENCE PHOTO LIBRARY; **p133 (B)**: CDC/DR SHERIF ZAKI/SCIENCE PHOTO LIBRARY; **p135**: Radius Images/Getty Images; **p141: (T)** Robin Skjoldborg/Cultura/ Getty Images; **p141 (B)**: KateChris/Shutterstock; **p145**: NASA; **p146**: Arunabh Bhattacharjee/ EyeEm/Getty Images; **p156**: NASA/JPL/Getty Images; **p158**: NASA; **p164**: Youngvet/iStockphoto; **p168**: Ingo Arndt/Nature Picture Library/Getty Images; **p171 (T)**: Flip Nicklin/Minden Pictures/ Getty Images; **p171 (B)**: Jacus/iStockphoto; **p173 (B)**: Greenwales/Alamy Stock Photo; **p181 (L)**: Sven Knie/Fotolia; **p181 (TR)**: Dsabo/iStockphoto; **p181 (MR)**: Mauro Fermariello/Science Photo Library; **p181 (BR)**: John Casey/Fotolia; **p183 (M)**: Picstodisc/iStockphoto; **p183 (B)**: Mevans/ iStockphoto; **p184**: Pusit Nimnakorn/Shutterstock. All other photos by June Hassall.

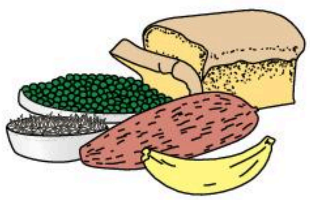
Artwork by Thomson Digital.

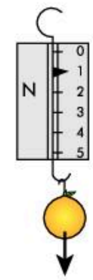






Introduction for students

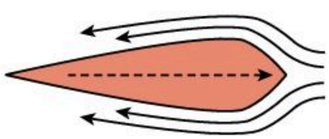




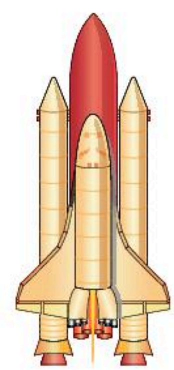
Your Science programme is changing. You will still cover the science content of:

- life processes and the environment
- matter and how it changes
- energy and forces.

But your Science topics are presented as part of STEAM (Science, Technology, Engineering, Art and Mathematics); and you will do more projects and investigations using the:

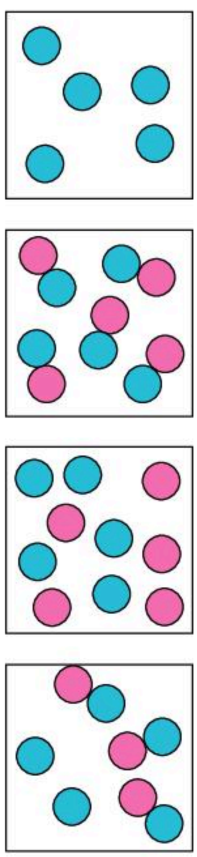


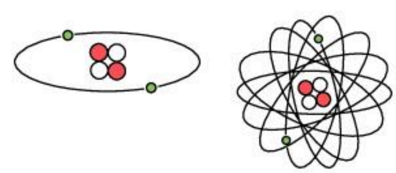
- Scientific method and
- Engineering Design Process (EDP).

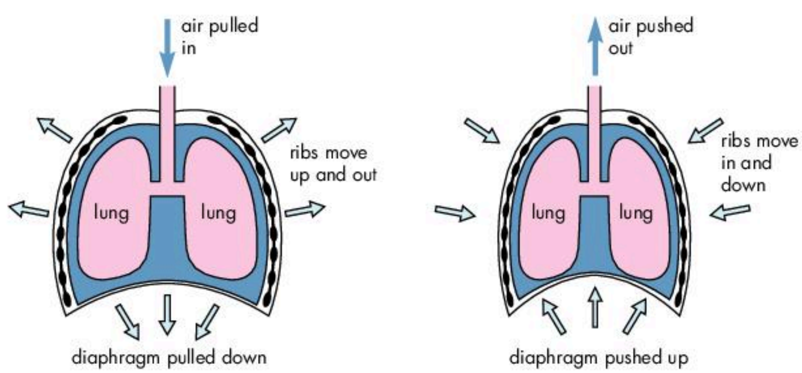


You will also:

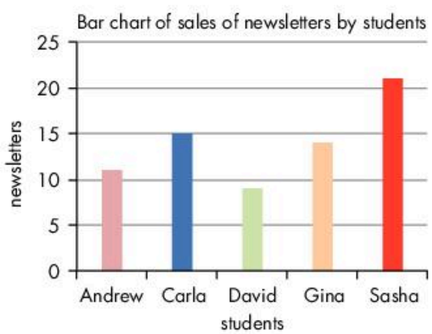
- be more involved with deciding what you will investigate and how you will do it
- do more Inquiry-Based Learning (IBL)
- use this Textbook as a resource, together with Information and Communication Technology (ICT) to research, present and share the results of your investigations
- use the Workbook to do the activities, puzzles, questions and Worksheets
- play a part in evaluating how well you are achieving the objectives.

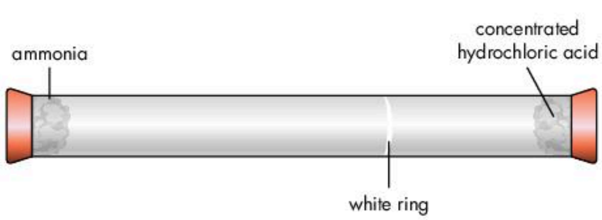


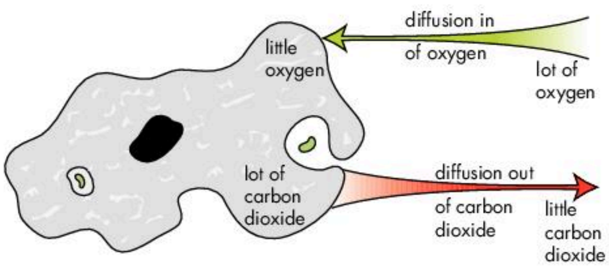


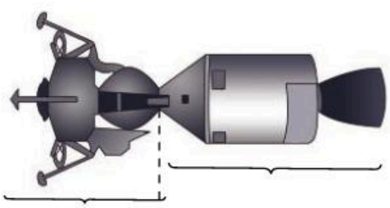


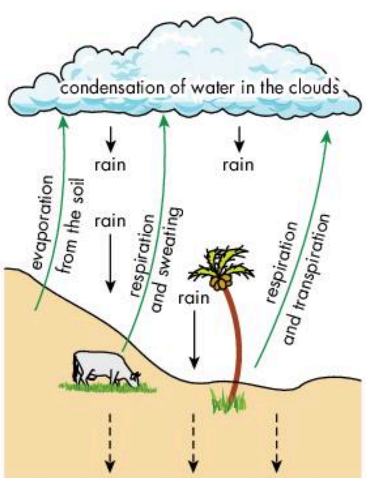
Contents


Bar chart of sales of newsletters by students
25
20
15
10
5
0
newsletters
Andrew
Carla
David
Gina
Sasha
students


ammonia
concentrated
hydrochloric acid
white ring


diffusion in
of oxygen
little
oxygen
lot of
oxygen
lot of
carbon
dioxide
diffusion out
of carbon
dioxide
little
carbon
dioxide


lunar module
lands on the
Moon
command module orbits
the Moon and then
returns astronauts to
Earth


condensation of water in the clouds
rain
rain
rain
rain
evaporation
from the soil
respiration
and sweating
respiration
and transpiration
if rain exceeds the other processes
then the aquifers will be refilled

For teachers

This book has been specially designed to cover the Jamaican National Standards Curriculum (NSC) for Grade 8 for Integrated Science. The book will also be useful with other secondary science syllabuses in the Caribbean. The text, activities and questions have been chosen to give a good foundation for the study of Integrated science, Biology, Chemistry and Physics syllabuses for CSEC®.

The book is arranged under profiles, similar to those used by CSEC®. Unit and topic objectives are given and there are related summaries, questions, key ideas and 'Fun facts' about science. Following the objectives of the NSC, the series is strongly based on investigations, with more student involvement. This Textbook is a resource for students to use as you set up the teaching process using projects and inquiry-based learning.

Science is presented as part of STEAM (Science, Technology, Engineering, Art and Mathematics). Investigations use science process skills and the scientific method, ICT to assist with the retrieval, handling and communication of data, the Engineering design process (EDP) for research and design, and Mathematics for the description of physical quantities and analysis of data.

A specially designed Workbook accompanies this book. The Workbook is an integral part of the programme and it contains tables for students to use during their science investigations and design projects. There are also extra practical activities, crossword puzzles, Worksheets, questions, summaries, checklists and self-evaluation.

Further information on methodology can be found in the National Standards Curricula and videos supplied by the Ministry of Education. There is also an accompanying Teacher's Guide to this Student's Book that helps with the setting up of activities, further background material, additional tests and answers to selected questions.

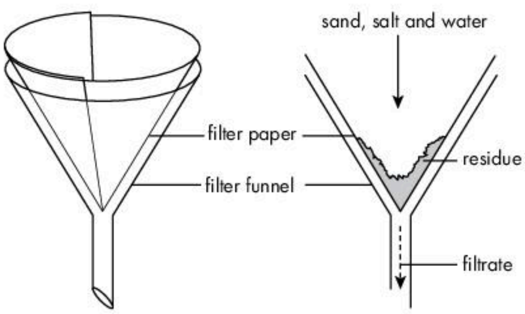
This is an exciting opportunity to guide students to learn for themselves.

Access your support website here:
www.oxfordsecondary.com/9780198426783

Introduction

Working like a scientist (2)

1 Student mixing liquids as part of a science investigation



2 Use the diagram to identify how we draw science equipment

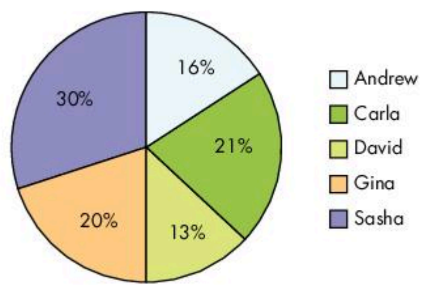
This unit will help you to:

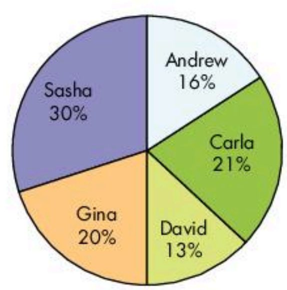
- understand and use science, technology, engineering, art and mathematics (STEAM)
- develop and use the thinking and practical skills of scientists
- use the scientific method to identify and control experimental variables
- solve practical problems using the Engineering design process (EDP)
- work safely in the laboratory
- use mathematics and ICT to present, analyse and interpret results
- prepare tables, bar charts, pie charts line graphs, and annotated drawings.

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.

Pie charts of sales of newsletters by students





3 You can use ICT and spreadsheets to prepare data such as these pie charts

STEAM and investigating

Science does not stand on its own. It is part of STEAM (Science, Technology, Engineering, Art and Mathematics).

- **Science** investigates the natural world: living and non-living things, their interactions and the forces and energy that make them work. In this book, understanding and recalling science **content** is called Knowledge and Comprehension (KC) and it is shown in magenta.

  What do scientists do? They use **process skills** (thinking and practical skills) to find out about science by using the scientific method. In this book, the Thinking skills (Use of Knowledge, UK) are shown in cyan, and Practical Skills (PS) are shown in yellow. Scientists also show **attitudes** such as being curious, creative and enthusiastic.

- **Technology** often uses and applies the content, skills and attitudes of science to design new things to solve practical problems. Technologists use additional Technological Skills (TS), shown in orange in this book.

  Both scientists and technologists use ICT (information and communication technology) for the research, analysis, presentation and sharing of information.

- **Engineering** is part of technology. Engineers design and improve models to solve problems. They brainstorm, design, test and improve their models as part of the Engineering design process (EDP). For example, there are structural engineers and also those involved with making new chemicals and also designing computers and new software programs.

- **Art** is used in several ways in science and technology. For example for making diagrams of science equipment and in the design of new models, for drawings of living things, for designing flow-charts, as part of EDP for the selection of appropriate materials and their use, and in ICT for the use of colour and design to create attractive presentations and products.

- **Mathematics** is basic to science. We need to be able to quickly manipulate numbers, e.g. by knowing the times-tables and how to add, subtract, multiply and divide. Mathematics and science also overlap when we use SI units, prefixes for large and small numbers, and standard form. We also use mathematics when we read the scales on measuring instruments, calculate area and volume, and display and interpret data in tables, bar charts, pie charts and line graphs. The binary code used in computers also depends upon mathematics.

Objectives

- Understand and use STEAM and ICT.
- Distinguish between teacher-led and inquiry-based learning.
- Develop and use the thinking and practical skills of scientists.
- Use the scientific method to identify and control experimental variables.
- Use EDP to solve practical problems and make new products.

Scientists investigate:

- atomic structure
- respiration in yeast
- properties of elements
- infectious diseases
- the parts of the solar system.

Scientists start from the natural world to find out more about how living and non-living things work. They use the scientific method to test their ideas.

Technologists design:

- nuclear power stations
- factories to produce alcohol
- solar cells to make electricity
- new antibiotics
- rockets to the Moon and planets.

Technologists make things to solve problems. They use materials and the Engineering design process to plan, design, test, improve and make things.

Scientists need technological inventions and ICT to carry out their work

Ways of working

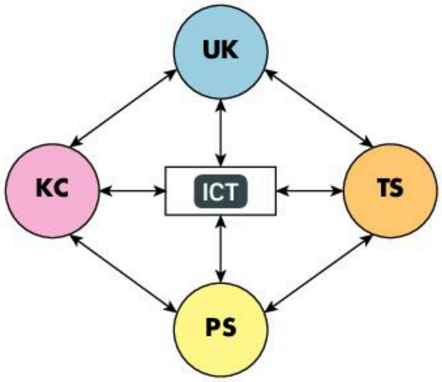
1 Teacher-led	2 Problem and inquiry-based learning
• Teacher decides on the topic and lesson to teach • Teacher gives information, e.g. by talking or writing on the board • Teacher can ask factual questions and students reply or carry out research to find the answers *Advantages* • Teacher has already planned the lesson and can present information in 'chunks' that can be attached in the mind to a framework for the topic • Useful for explaining difficult topics • Can cover a lot of work in a short time • Research is from the Textbook, other books, the Internet or other people, etc. ICT • Teacher can ask questions about opinions and the class can discuss what they think • Activities can be matched to students' abilities • Teacher can keep records of the work done *Disadvantages*: • The teacher may be too much in control • Some students may prefer to work on their own • There is less opportunity for students to interact and to develop study and cooperative skills • Students may not remember things they have been told but have not found out for themselves	• Teacher decides on the main topic, but students choose the question or problem to investigate • Students are arranged in small groups, often with different roles • Students decide on how they will answer the question or solve the problem *Advantages:* • Useful for students to find out for themselves • Students may remember more by making discoveries and decisions for themselves • Students use resources, e.g. Textbook, other books, and the Internet for information. ICT • Students discuss their findings and set up their fair tests, or make their designs and models • They discuss progress, and evaluate their results • They communicate what they have done • Students learn how to cooperate in a group *Disadvantages*: • Takes longer than for teacher-lead classes • Is not efficient for passing on a lot of basic, important information • The teacher has less control in ensuring students understand what they are doing • Students may waste time

The best solution is to use a mixture of teacher-led and problem or inquiry-based learning.

3 Scientific method (see pages 6–7 and 10)	4 Engineering design process (see pages 8–9 and 10)
Question: what is the question you want to answer?	Problem: what is the need you want to satisfy?
Research: using the Textbook, other books, people and the Internet ICT	Research: using the Textbook, other books, people and the Internet ICT
Hypotheses: make statements that can be tested	Specify requirements: decide on limitations
Predictions: suggest what might happen	Generate solutions: think of possible models to make
Identify variables: set up a fair test	Create best one: use art and design to make plans
Collect results: observe and measure	Build prototype: make your model
Analyse results: use tables, bar charts, graphs	Test and redesign: improve your model
Evaluate: have you answered your question?	Evaluate: have you solved your problem?
Communicate findings: discuss and write up your activity ICT	Communicate findings: discuss and write up your activity ICT
Use for: Science: finding out and testing: • Use the scientific method where there is a hypothesis and predictions to test by controlling variables. • Main characteristic is the 'fair test' so that the cause of the end result can be identified. • The scientific method is a step-by-step process.	*Use for*: Technology: Designing and building: • Use EDP where you need to solve a practical problem by designing and making a new product. • Main characteristic is to build a model or system that is useful in solving a problem. • EDP involves going through the steps many times.

In working with STEAM, it is useful to sometimes use the scientific method, and sometimes the Engineering design process; it depends on whether we want to test hypotheses and predictions, or to make models to solve problems.

Overview on science and technology.



KC (Knowledge and comprehension). This is the science information that you need to know and understand.

UK (Use of knowledge). These are the *thinking* skills you use for problem solving and to make use of your information.

PS (Practical skills). These are the *doing* skills you use to carry out activities and test your ideas.

TS (Technological skills). These are the skills to design and make useful new things using knowledge and materials.

ICT (Information and Communication Technology). This is to find and analyse data, and share information with others.

Knowledge and Comprehension

Information base: remembering and understanding science information

Remember ICT
- Remember information you have been taught or recorded.
- Pick out the right answers from several choices.
- Write about a given topic using ICT.

Understand
- Show you understand something by explaining it.
- Give examples to illustrate what you have learned.

Use of Knowledge

Thinking skills: applying and interpreting information, and dealing with data

Apply information
- Make use of your knowledge in new situations.
- Use mathematics in solving problems and modelling ideas.
- Show how things are related, for example in a food web.
- Say how one thing may cause another, for example when investigating a pollution problem.
- Put together information, for example parts of the water cycle.
- Make use of information to help guide you to live in a safe and responsible way without harming the environment.

Interpret ICT
- Interpret information by explaining its meaning and importance.
- Make inferences (explanations) from observations and data.
- Notice patterns in your results, and make predictions.
- Use ICT to help you find information from tables, bar charts, pie charts and line graphs.
- Draw conclusions based on your results.

Evaluate
- Say if your conclusions can be trusted. (Was there a fair test?)
- Take account of both sides of an argument.
- Make recommendations for action based on the information.
- Take account of the possible outcomes of your suggestions as they affect other people and the environment.

Practical Skills

Practical skills: planning, carrying out and reporting on activities; work and study skills

Plan / Design
- Identify a problem and ask questions about it.
- Plan an activity to test a prediction or hypothesis.
- Suggest controls where these are important.
- Identify equipment and materials to carry out a fair test.

Mnipulate/ Measure
- Handle and care for equipment, chemicals and living things.
- Use measuring instruments safely and take accurate readings.
- Carry out certain activities, such as filtering and using a Bunsen burner and microscope.

Draw
- Make large, clear drawings of living things, apparatus or models, and label them correctly.

Working methods
- Follow instructions carefully and in the correct order.
- Keep your workplace tidy and uncluttered.
- Be economical in the use of materials.

Observe / Record /Report ICT
- Use your senses, and instruments, to observe accurately.
- Repeat and take the average of several readings.
- Record your observations in tables, diagrams, bar charts, histograms, pie charts and line graphs using ICT.
- Present your findings clearly in a written or spoken report.

Study skills ICT
- Use a range of resources including ICT for research.
- Keep accurate records of what you find out.
- Be self-reliant and independent of teacher supervision.
- Carry on with a task until it is finished properly.

Group work ICT
- Express your own opinions, but also listen to and respect the different ideas of others.
- Work with others by sharing ideas, information and materials.
- Assist in coming to group decisions.
- Show co-operation and responsibility to the group.
- Show concern for the safety of other people, other living things, property and the environment.

Technological Skills

Designing and making skills: making new things to solve practical problems

Make new things ICT
- Apply scientific ideas to design and make models or machines. Make products attractive and appealing.
- Follow the Engineering Design Process (EDP) to solve a problem or make something for a particular use.

Use technology
- Investigate the use of familiar tools e.g. tin opener, egg whisk.
- Investigate the effects of inventions on people or the environment, for example the aerosol can or penicillin.

The scientific method

Now you will see how you use the thinking and practical skills of scientists. They work in a step-by-step way that is called the **scientific method**. This is a systematic method of working that allows scientists to test their hypotheses and draw their conclusions. You can also work like a scientist!

Ask, imagine and plan

ICT

- Identify the problem and ask questions about it.
- State possible solutions as statements (hypotheses) that can be tested.
- Predict answers to your questions. (What do I think will happen?)
- Identify variables and how you will control them to set up a fair test for your predictions.
- Identify the method to follow, and materials and apparatus you will need.

Carry out

ICT

- Put your plan into action, using materials safely.
- Follow good working methods on your own or in a group.
- Make observations and measurements.
- Find things out from people, books and computer sources.

Assess: Record results

ICT

- Record your observations and measurements.
- Notice and re-check any unexpected results.
- Make labelled drawings of specimens and equipment.
- Make tables, bar charts, pie charts and line graphs of your results.

Assess: Interpret

ICT

- Discuss your results with others.
- Look for patterns in your results.
- Decide what your results might mean. (Interpret them.)
- Draw conclusions based on your results.

Report

ICT

- Write up your report to show what you did and what you found out. You can use ICT.
- Record the aim or hypothesis, equipment and materials, method, results and conclusions.
- Show and talk about what you did.
- Find out if other people understand you, and answer questions.

Evaluate

- Do your results support or disprove your prediction or hypothesis?
- Decide if you have solved your original problem or achieved your aim.
- Do you need to repeat or change any part of your experiment?
- Are there new questions you want to discuss or test?

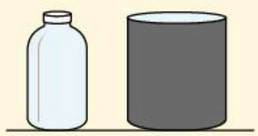
Using the scientific method

Some students chose materials, set up Activity 0.1 and wrote their report. In a small group, discuss and criticise their method and conclusion, and then answer the questions in Activity 0.2.

0.1 Comparing the heat absorption of white and black objects

Materials: A small white bottle with a lid, an empty tin can painted black, tap water, thermometer

Method: Tap water at the same temperature was used to fill both containers, and the lid replaced on the small bottle. The small bottle was left outside in the Sun and the tin inside in the shade. Is this fair test?



After ten minutes, the new temperatures of the water were taken using the same thermometer.

Result: No difference in temperature was found between the water in the two containers.

Conclusion: White and black surfaces heat up to the same amount.

0.2 Improving Activity 0.1

1 Read the report above and make a list of all the things that were done incorrectly.
2 (a) What is the manipulated or independent variable?
  (b) Why is the activity incorrect?
3 (a) What should be the responding or dependent variable?
  (b) Why is the activity incorrect?
4 (a) What should be the controlled variables?
  (b) For each one, say why the activity is incorrect.
5 (a) Can a proper conclusion be drawn from this experiment?
  (b) Explain your answer.
6 In your group, redesign the experiment as a fair test. Identify:
  (a) the one variable (independent) that you change
  (b) how you control all other variables, and
  (c) the dependent variable you measure.
7 Find equipment and materials, set up and carry out a fair test and report on your results and conclusion.
8 When your report is completed, exchange it with a another group. You check each other's work.

What does it mean?

Hypothesis: A suggested explanation for observations that can be tested.

Predictions: Outcomes that would be true if the hypothesis was correct.

Fair test: Investigation of a prediction where only one variable is changed at a time.

Variables: The conditions in the experiment, such as water and size.

Manipulated or **independent variable:** The *one* variable you change, in order to find its effect.

Controlled variables: Variables that might affect the experiment and that you should keep constant.

Responding or **dependent variable:** The result that you observe or measure.

0.3 Setting up a fair test

Observation:
- Bean seedlings have two cotyledons.

Hypothesis:
- Bean seedlings depend on food from their two cotyledons to grow.

Prediction:
- If I remove a cotyledon from a seedling it will not grow as well as a seedling with two cotyledons.

Fair test:
- You design and set this up. You carry out your test and collect your results. If your prediction is correct then this supports your original hypothesis.

Method:
1 Plan and design a fair test. Identify:
  (a) independent variable
  (b) dependent variable
  (c) control variables.
2 Find the equipment and materials you need, and set up and carry out your test.
3 Record your results and conclusions and write up your investigation.

▶ **See Workbook Introduction.**

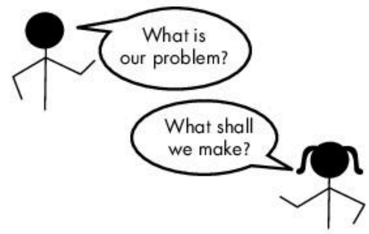
Engineering design process

Technologists, for example engineers, make new things and materials to solve practical problems. They use similar practical skills of scientists but their aim is to make something rather than to carry out a fair test. They follow steps that are called the **Engineering design process (EDP).**

Engage: Ask questions

ICT

- Identify the problem and ask questions about it.
- Describe the challenge to be solved.
- What are the design requirements and constraints?
- How have others tried to solve it?
- How long do you have, what materials might you need?



Explore: Imagine

ICT

- What are some solutions?
- Brainstorm ideas in your group.
- Write descriptions and make sketches of your ideas.
- Select the best two designs and compare them.

Elaborate: Plan

ICT

- Choose the option that is likely to be the best one.
- Make a neat and detailed drawing of your design.
- List the materials and supplies you will need.
- Gather the necessary materials.
- Find a place to work.

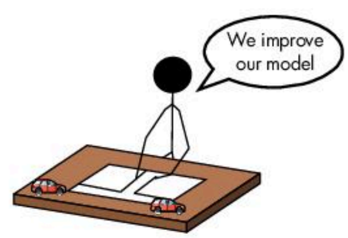
Execute: Create

- Follow your plan.
- Write any problems you have and how you changed your design.
- Make labelled drawings of your model.
- How did it work?

Explain: Assess, improve and report

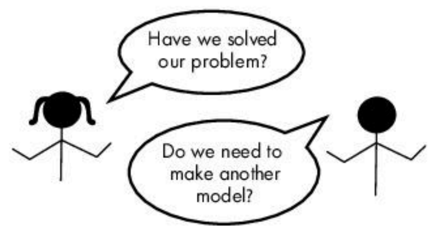
ICT

- Does your design meet the requirements?
- Does your design meet your constraints?
- Make changes to your model to improve it.
- Report to others about your model and drawings.
- Take their comments into account and make changes.



Evaluate: Have you solved your problem?

- Repeat the 'Assess' step to improve your model as many times as necessary.
- Use art to make it attractive and appealing.
- When you have your final model, decide if you have made something to solve your original problem.



Using the Engineering design process

Problem: Can you design an aid to help you convert base ten numerals into base two numerals? One idea is suggested here, but you can use that to try and make your own improved method.

1 You first need to make sure you understand all the terms you will need, e.g. place value, numeral, digit, base ten, base two, binary code, electronic circuit.

2 For example, place value means that the position of a digit in a numeral tells us its value, e.g. 6 = six units, 60 = six tens or sixty, and 600 = six hundreds.

3 Some other terms are given in the box on the right, but you may need to also check your understanding about how we change base ten into base two numerals, as below.

2^6	2^5	2^4	2^3	2^2	2^1	unit	
sixty four	thirty two	sixteen	eight	four	two	one	Value in base 10
1	0	1	0	0	1	0	(a) ?
	1	0	1	1	0	1	(b) ?

(a) Using the table above, the binary number of 1010010 means 64 + 16 + 2 = eighty two in base ten.
(b) The binary number of 101101 means 32 + 8 + 4 + 1 = forty five in base ten.

0.4 Changing between base ten and base two

Materials: Lined paper, ruler, pen, pencil, crayon

Method

1 Base two to base ten
   (a) Prepare a table like the one above, but with only the first two rows filled in with pen.
   (b) Now, starting from the 'units' column enter your base two number into a row on the table, in pencil. Then read off which base ten numerals need to be added to show the value of the whole number in base ten.
   (c) Work with a partner, to give each other questions. You can later erase the numbers and continue to use the table.
   (d) Improvements might be to use thin card, or to design and print the table using word processing skills.

2 Base ten to base two
   (a) Prepare a table like the one on the right.
   (b) Convert a number, e.g. 53. Start from the largest number inside it: 32, record this as 100000. Then 53–32 = 21: this contains 16 = 10000. Then 21–16 = 5: this contains 4 = 100. Then 5–4 = 1. So the base two numeral for 53 is 110101
   (c) Work with a partner to set each other questions, and find ways to improve your table.

What does it mean?

Base ten: A counting system that uses ten digits: 1 to 9 and 0. Each column to the left of the units is ten times bigger than the one before.

Base two or **binary:** A counting system that uses only two digits: 0 and 1. Each column to the left of the units is two times bigger than the one before.

Electronic circuits: In computer systems 0 means Off and 1 means ON. The different strings of 0 and 1 control the working of the system.

Note: Bold numbers are base ten

2^6	2^5	2^4	2^3	2^2	2^1	unit
64						
1	0	0	0	0	0	0
	32					
	1	0	0	0	0	0
		16				
		1	0	0	0	0
			8			
			1	0	0	0
				4		
				1	0	0
					2	
					1	0
						1
						1

For example:
Base ten 60

−32 = 100000
28
−16 = 10000
12
−8 = 1000
4 = 100
111100 (Base two)

Fun facts

- 0 and 1 are 'bits' (binary digits).
- 8 bits make a 'byle'.

Using the scientific method

0.5 Setting up a fair test

Work in a small group:

1 Discuss and answer these questions:
   (a) Three washing-up liquids are called 'Clear', 'Suds' and 'Froth'. The makers of 'Froth' claim that their product makes the most bubbles. Do you believe them? Explain your answer
   (b) 'Froth' manufacturers support their claim by showing a washing bowl filled with lots of bubbles. Do you believe them? Explain your answer.
   (c) You put some 'Froth' in a test tube of water and shake it. You get lots of bubbles. Now do you believe the 'Froth' manufacturers? Explain your answer.

2 A fair test
   (a) Will you need a fair test to decide which of the washing-up liquids produces the most bubbles? Give as many reasons as you can for your answer.
   (b) What will be the independent variable?
   (c) What will be the dependent variable?
   (d) List as many variables as you can that you will have to control, e.g. amount of washing-up liquid.

3 Setting up your test
   (a) Your teacher will give you three samples of washing–up liquid labelled 'Clear', 'Suds' and 'Froth'.
   (b) Make your plan and decide what equipment and materials you will need.
   (c) Write down your hypothesis. Then decide on the predictions you are going to test.
   (d) In your plan make sure you control all the variables except for the independent variable.
   (e) Decide ahead of time how you will measure your results (the dependent variable).

4 Carry out your test and write your results. Evaluate your investigation. Was it a fair test? Can you rely on your results? Were your predictions correct? Did the results support your hypothesis?

Using the Engineering design process

0.6 Designing and making a 'unitensil'

Technologists, including engineers produce new items to solve problems.

Problem: A manufacturer of picnic items wants to design a new utensil that can be used as a knife, fork and spoon: a 'unitensil'.

Engage: *Ask questions:* Specify requirements: your model should be able to:
(a) cut bread, like a knife
(b) lift up liquids, like a spoon
(c) spear food and transfer it, like a fork.

Explore: *Imagine:* What characteristics will it need? Research possible ideas. Brainstorm designs in your group. You could start from a traditional 'spork' but also explore other designs. Also take safety into account. ICT

Elaborate: *Plan:* Make sketches and accurate drawings of at least six different designs: make them as different as possible. Think about how each 'unitensil' will be used, and its advantages and disadvantages.

Execute: *Create:* Make some of your designs out of stiff paper to test out if they might work. What materials would the final models be made from? Why? What limitations do you have?

Explain: *Assess, improve and report:* Decide which of your models might work the best. Make, assess and improve your models.

Evaluate: *Have you solved your problem?:* If you have a design that fulfils the specifications, the final step is to think of a name, such as 'kniforoon' that includes parts of the words knife, fork and spoon. Have a competition in class to vote for the best name.

Quick check ☑

We study science as part of ________. Scientists use the scientific ________ to set up fair ________ so they can trust their results. Scientists manipulate the ________ variable. Technologists, e.g. ________ use ________ to make new things to solve problems.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

independent **EDP** **tests** **engineers** **method** **STEAM**

Safety and equipment

Safety in the laboratory

It is important you work in a safe way and follow safety rules.

0.7 Safety rules

Work in a group:

1 In your group, brainstorm at least ten rules for things you should do for safety in the laboratory and five things you should NOT do.
2 As you think of each rule, discuss whether it mainly relates to the safety of people (P: yourself or others), the equipment (E), or your surroundings (S).
3 After each rule write P, E or S. Note that some rules are important in more than one way. For example, 'Do clean up any spilt liquids on the floor. (P, S)'
4 Each group should draw a student behaving according to one of the safety rules you have identified.
5 Produce a class chart on card of all your safety rules and illustrate it with some of the drawings.

The SI system

'SI' is an abbreviation of Système International d'Unités, which is an international system used for measuring.

There are seven fundamental or **base quantities** in the SI system that are used to measure physical characteristics such as length and mass. Each quantity has a **base unit**, e.g. the base unit for length is the metre (see box on the right).

The base units can be used with **prefixes** to make them larger or smaller. The prefixes multiply (for larger numbers) or divide (for smaller numbers) by a power of ten, for example centimetre (cm).

The seven base units can be used to form other units that are called **derived units**, e.g. metre (m) is used to measure in one dimension and can be used to derive m^2 (area: measurement of surfaces) and m^3 (volume: measurement of solid shapes).

The base unit of temperature is K (kelvin). We have to derive °C from this (K – 273 = °C), so °C (degree Celsius) is a derived unit. But 1°C is equal to one K, so we use °C in the laboratory.

The derived units can also be used with prefixes to make them larger or smaller, e.g. cm^2 and cm^3 are derived units used with prefixes.

All derived units can be formed from the seven base units, e.g. speed is metres per second (m/s, also written as ms^{-1}). However, it is sometimes simpler to use a mixture of base and derived units in order to produce some derived units, e.g. Force = mass × acceleration, and the unit of force is the newton (N). Pressure is then N/m^2 or Nm^{-2}.

Objectives

- Classify safety rules relating to people, equipment and surroundings.
- Use scales, SI base units, derived units and prefixes.
- Use measuring, heating and filtering equipment.

0.8 Safety equipment

Work in a group:

1 List safety equipment for use in your laboratory and in the school, e.g. fire extinguisher, eye bath, fume cupboard, laboratory coat, goggles, safety symbols.
2 Find out how each item is used or what the symbol means. Make a drawing or take a photograph and produce a card (15 cm × 10 cm) with a description for each one.
3 Add the cards to your Safety chart.

SI base units

Fundamental quantity	*Base unit*
Length	m (metre)
Mass	kg (kilogram)
Time	s (second)
Temperature	K (kelvin)
Electric current	A (ampere)
Amount of substance	mol (mole)
Luminous intensity	cd (candela)

Prefixes for larger numbers

Multiple	Prefix	Symbol	Example
10^3	kilo	k	kilometre
10^6	mega	M	Megahertz
10^9	giga	G	Gigabyte
10^{12}	tera	T	Terajoule

Prefixes for smaller numbers

Multiple	Prefix	Symbol	Example
10^{-1}	deci	d	decilitre
10^{-2}	centi	c	centimetre
10^{-3}	milli	m	milliamp
10^{-6}	micro	μ	microsecond
10^{-9}	nano	n	nanometre

Measuring equipment

Measuring is using units to record the size or amount of something. The measuring equipment has scales marked with lines and numbers. As you saw on page 11, the units may be base units or derived units, and may be used with or without prefixes. In Grade 8 you will measure length, mass, time and temperature; in Grade 9 you will also measure electric current.

All measuring equipment must be handled in a safe way that does not cause harm to people, the equipment or the surroundings.

PS 0.9 Safe and correct handling

Materials: ruler, clock, stopwatch, measuring cylinder, lever-arm balance, laboratory and clinical thermometers

Method

1 Each group chooses one piece of equipment and researches how to use it safely and correctly. **ICT**
2 Write up your report and use a word processing program to make a final copy. Include an accurate, well-drawn and labelled diagram. You can also take a photograph or copy one from the Internet.
3 Collate all your reports and give them page numbers. You will then need a card cover, with an illustration, and a Contents page. You can also include the names of the students involved in preparing each report.
4 The finished booklet can be kept for reference as you work with the items of measuring equipment.

Measuring skills and expressing units

You should be able to measure using:

- Ruler or metre rule: length to the nearest 1 mm (0.1 cm)
- Ruler or metre rule: area to the nearest 1 cm^2
- Measuring cylinder: volume to the nearest 1 cm^3
- Lever-arm balance: mass to the nearest 1 g
- Clock or wristwatch: time to the nearest minute
- Stop clock or stopwatch: time to the nearest second
- Laboratory thermometer: temperature to the nearest 1 °C
- Clinical thermometer: temperature to the nearest 0.1 °C
- Write the equivalents,
  - to 1 metre, e.g. = 10 decimetre, = 100 centimetre, = 1000 millimetre, = 1000 000 micrometre, = 1000 000 000 nanometre;
  - to 1 litre (L), e.g. = 1000 cm^3, = 1000 millilitre (mL)
- Interconvert, e.g. 1 kilogram = 1000 g,
  1 g = 1000 milligram,
  1 milligram = 1000 microgram,
  1 gigabyte = 1000 megabytes,
  1 megabyte = 1000 kilobytes, 1 cm^3 = 1 mL

PS 0.10 Reading scales

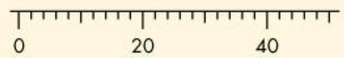
Materials a variety of measuring equipment, e.g. ruler, clock, stopwatch, measuring cylinder, lever-arm balance, laboratory and clinical thermometers

Method

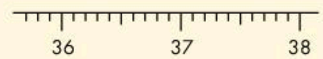
Work in a group:

1 Examine the measuring equipment and prepare a table with the names of the equipment, quantities that are measured (length, mass etc.), units that are used (cm, g, etc.) and the value of each small division.
2 The diagrams below will help you to work out the values on the scales.

(a) value of each small division = 10/10 = 1

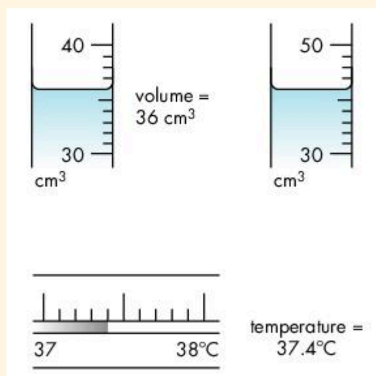


(b) value of each small division = 20/10 = 2



(c) value of each small division = 1/10 = 0.1

3 Here are some examples:

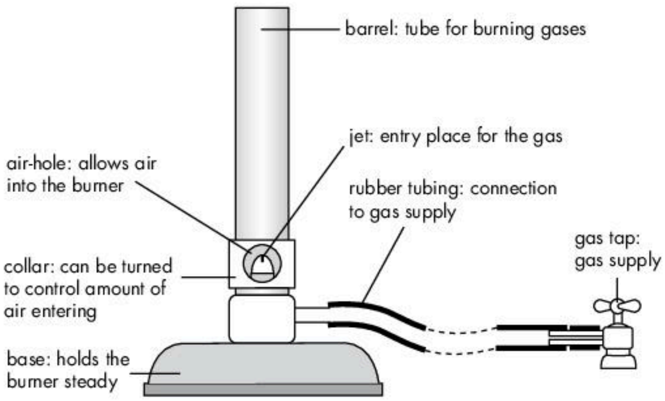


4 Your teacher will give you a worksheet to find the sizes/ values of various quantities around the laboratory. Go to each place in turn and complete the worksheet.
5 Make sure you record the amount and the unit, e.g. 28 cm^3 in each case.
6 Work with a partner. Draw a line and make a scale. Add an arrow and your partner reads the value.

▸ **See Workbook Introduction.**

Heating equipment

For heating in the laboratory we use a Bunsen burner. Look at the picture below so that you know the parts and how they work. While unlit, practise opening and closing the air-hole of the burner by turning the collar.



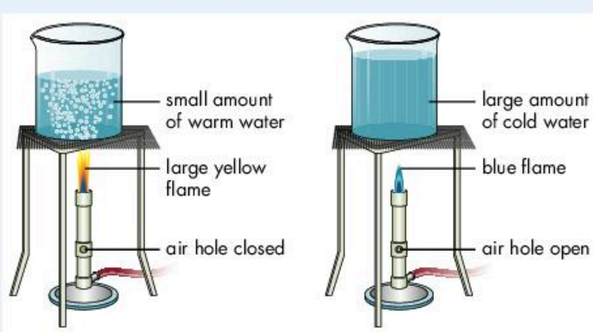
- To light a Bunsen burner, first close the air-hole. Light a match and gently turn on the gas. You will get a yellow flame. The gas is not being fully burned.
- To get a blue flame, you start with a yellow flame and slowly turn the collar. This opens the air-hole to provide more air so that the gas is now fully burned and gives a blue flame.

0.11 Setting up a fair test

Materials: Two Bunsen burners, tripods, gauzes and beakers; water, thermometer

Method

1 Eva used this set-up to test which flame was hotter.
2 Find and describe at least three things that are wrong, so that it is not a fair test.
3 Describe how you would correct each mistake.



4 Research the differences between the yellow and blue flames of a Bunsen burner.

▸ See Workbook Introduction.

0.12 Comparing flames

Design a fair test to find if the yellow or blue flame of a Bunsen burner heats more quickly.
Materials: a measuring cylinder, two similar Bunsen burners, beakers, glass rods, thermometers, tripods and gauzes
Method
Work in small groups:

1 What is your independent variable?
2 What are the control variables to be kept constant? Describe how you will control each one in your design.
3 What is your responding or dependent variable? How will you measure it? How will you make it fair?
4 Predict which flame you think is hotter and will heat the water quicker.
5 Carry out your activity and record your results. Was your prediction correct?
6 Can you improve your design?

0.13 What happens to my sweets?

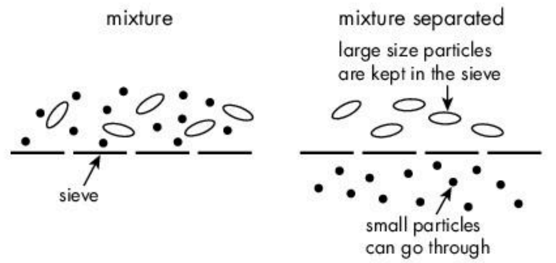
Materials: coloured sweets such as M and M's, two containers, ice, warm water, tap water, measuring cylinder
Method

1 Plan and design a fair test to find out what happens to the coloured layers on the sweets in warm and cold water.
2 Identify all the variables, make your prediction and then carry out your test.

3 Was your prediction correct?
4 Write down and explain all the observations you can of the two containers.
5 What do you think the liquid in the containers would taste like? Why?

Filtering equipment

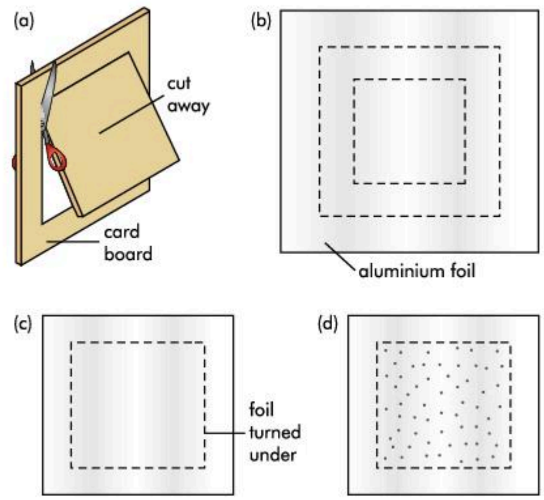
Filtering is a way to separate parts of a mixture where the parts have particles of different size. The mixture is passed through a sieve or filter paper that only one of the parts goes through (see diagram on the right).



0.14 Designing a sieve

Use the Engineering design process to research, plan, design and test a sieve to separate a mixture of salt and rice.

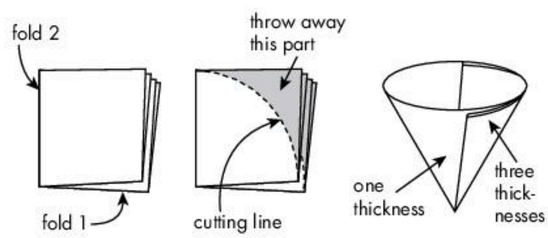
1 One idea is shown on the right. But you should also do research and think of your own design. **ICT**
2 Your teacher will give you the mixture. Test your sieve to see if it is successful. Improve and re-test.
3 Explain how your sieve works. What must be true about the two substances in the mixture and the sieve?



0.15 Identifying improvised filter paper

Use the Engineering design process and the scientific method to test a variety of different papers to see if you can find an improvisation that can be used to separate sand from water.

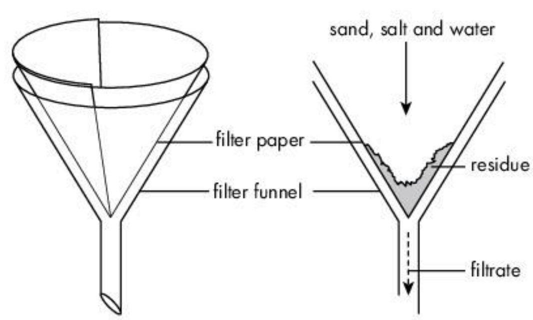
1 Some papers you can test are: proper filter paper, magazine paper, kitchen towel, brown paper, newspaper, newsprint, and tissue paper. You will also need scissors, ruler, filter funnel, beakers, spoon, measuring cylinder, watch and the sand and water mixture.
2 Examine and predict the best and worst improvised filters.
3 Make your 'filter papers', either by using proper filter paper as a guide, or by folding and cutting (see diagram).
4 Test the papers by seeing how well they separate the sand and water. Report and explain your results.



pull top layer up to form a cone

0.16 How can you separate salt and sand?

Plan and design how to separate a mixture of salt and sand. You will need to use filtering and heating equipment. Set up and carry out your investigation.



Quick check ☑

We need ________ rules to protect people, ________ and surroundings. Measuring ________ has ________ with different values. The main heating ________ is the ________ burner. For filtering we use special ________ paper that acts like a ________ to separate substances.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

scales **sieve** **Bunsen** **safety** **equipment** **filter**

Presenting and interpreting data

Data we display can be words (qualitative) or numerical (numbers: quantitative). Displays can organise the data and help us see any incorrect (anomalous) results and any patterns, which can then help to explain or interpret it.

- Tables are used to group words and numbers in rows and columns. They are quick and easy to prepare.
- Bar charts show amounts (by bars) of different named groups of things. Only one variable is numerical.
- Pie charts show the parts out of the whole.
- Line graphs show the relationship between two numerical variables recorded on two axes.

Preparing tables

These are used to record words and numbers.

1 Set up your table before you begin your work.
2 Decide what you are going to observe and the measurements you are going to record.
3 Columns are the vertical spaces down the table.
4 Add a heading to each column to say what will be recorded, e.g. Temperature. If it will be numbers, then add the units that are used, e.g. (°C)
5 Rows are the horizontal spaces across the table. Here you record the results you make, one per row.

TABLE SHOWING THE INCREASE IN TEMPERATURE OF WATER WHEN HEATED

column

heading

row

Time (min)	Temperature (°C)
0	21
2	25
4	30
6	35
8	40

6 Your records may be words or numbers, e.g. you could set up a table to compare similar characteristics of two organisms.
7 Add a heading, in capital letters to describe your data.

For example, 'ABSORPTION RATES OF TWO LIQUIDS, A AND B, BY THE SAME PAPER STRIPS'

		Time (min)					
	Height	0.0	0.5	1	1.5	2	2.5
A	cm	0	1	2	3	4	5
B	cm	0	1.5	3	4.5	6	7.5

Objectives

- Present data in appropriate formats.
- Draw and interpret tables, bar charts, pie charts and line graphs.
- Use Excel® to prepare a table, bar chart pie chart and line graph.
- Prepare accurate labelled and annotated drawings of equipment and living things.

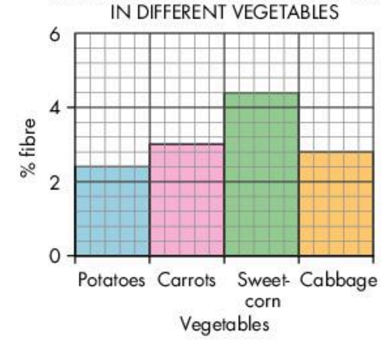
Preparing bar charts

Use these when one variable is numerical, and record the amounts of the different things as bars.

1 Use graph paper and a ruler.
2 Choose enough space to record your results.
3 Choose a scale for the upright (y) axis that is easy to use. It should start from zero and be a little taller than the largest reading.
4 Draw small lines up the y axis and add numbers to label their amounts.
5 Evenly space the names for the items to be described along the horizontal (x) axis.
6 Use a ruler to draw the bars of the correct height for each item. Bars can be separate or touching.
7 Use several clear, light colours on the bars. You should still be able to see the graph lines.
8 Label the y-axis with what is being measured, e.g. Percentage fibre, and the x-axis with a name that describes all the items, e.g. Vegetables.
9 Write a title in capital letters, to describe the bar chart.

Table of % fibre in various vegetables			
Vegetables	% fibre	Vegetables	% fibre
Potatoes	2.4 %	Sweet corn	4.4 %
Carrots	3.0 %	Cabbage	2.8 %

BAR CHART SHOWING THE % OF FIBRE IN DIFFERENT VEGETABLES



A bar chart of % fibre in different vegetables

Preparing pie charts

A pie chart is like a pizza cut into various parts or sectors. The sectors show the relative sizes of the parts that make up the whole.

1 The angle at the centre of a circle is 360°. In a pie chart this is divided up to make the sectors.
2 The angle for each sector is worked out as

$$\frac{\text{number or percentage in the group}}{\text{total number or percentage}} \times 360°$$

% constituents in edible food				
P = protein, F = fat, C = carbohydrate, W = water				
Rice	P 8%	F 2%	C 76%	W 14%
Sweet potato	P 2%	F 1%	C 27%	W 70%
Beef	P 22%	F 8%	C 0%	W 70%
Coconut flesh	P 4%	F 38%	C 12%	W 46%

3 Calculate the angles for the sectors, and make sure they add up to 360°

$$\frac{\text{Percentage of constituent}}{100} \times 360° = \text{angle of sector}$$

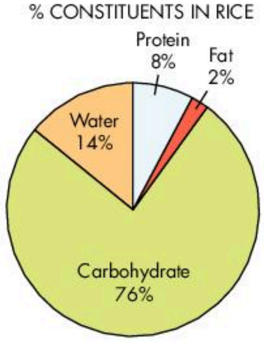
Rice Protein $= \frac{8}{100} \times 360° = 28.8°$

Fat $= \frac{2}{100} \times 360° = 7.2°$

Carbohydrate $= \frac{76}{100} \times 360° = 273.6°$

Water $= \frac{14}{100} \times 360° = 50.4°$

4 Use a pair of compasses to draw a circle.
5 Use the ruler to draw a line for the radius, and use a protractor to enter the first sector. The angle is the one that you worked out. Label the sector.
6 Draw and label sectors for the other parts.
7 Use different light colours to show the sectors.
8 Write a title, using capital letters.



Note: If you are given a pie chart and want to know the amount or percentage of a constituent:

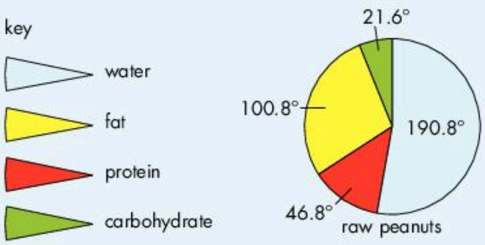
- Measure the angle, divide by 360° and × 100; e.g. Rice protein = 28.8°/ 360° = 0.08 × 100 = 8 g

0.17 Tables, bar charts and pie charts

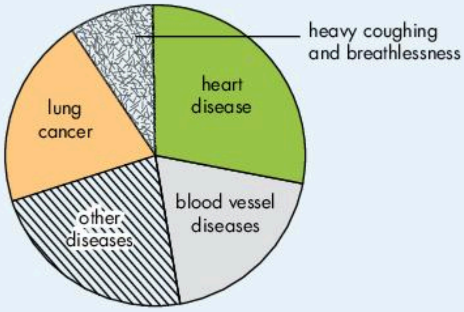
1 (a) Make a table from the following information. % in edible food of P = protein, F = fat, C = carbohydrate, W = water.
Bread: P = 8, F = 1, C = 49, W = 42;
Raw peanut: P = 13, F = 28, C = 6, W = 53;
Red pea: P = 24, F = 2, C = 48, W = 26;
Soya bean: P = 35, F = 18, C = 12, W = 35.
(b) Prepare a pie chart for each food.
(c) Use the pie charts to make bar charts.
(d) How do rice and red peas complement each other?

2 Look at the table in column 1.
(a) Make pie charts for each food.
(b) Use the pie charts to make bar charts.

3 Angles for the sectors are given in the pie chart. Calculate the % of the parts in the original food.



4 The pie chart shows causes of death before age 65 due to smoking.
(a) Measure the angles on the pie chart and calculate the percentage for each cause.
(b) Make a table for the % for each cause.
(c) Make a bar chart for % for each cause.



5 The amount of water in certain organisms is: Human = 65%, herring = 70%, chicken = 75%, earthworm = 80%, jellyfish = 98%, sunflower seed = 8% and tomato = 95%.
(a) Which is the best way to display this data?
(b) Prepare your answer.

Preparing line graphs

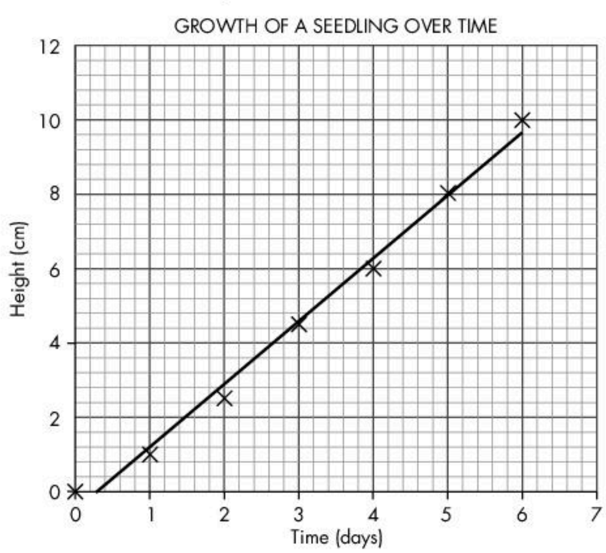
Line graphs are used to show the relationship between two numerical variables. The experimenter changes the independent variable and finds the effect on the other, the dependent variable.

1 Your data is entered on graph paper.
2 Draw two lines at right angles on the graph paper, one large square in from the edges of the paper.
3 The independent variable is entered on the horizontal (x) axis. These are the values the experimenter has decided, e.g. times at which readings are taken.
4 The dependent variable, e.g. height or mass is entered on the vertical (y) axis. These are the results and readings that you make.
5 Look at your range of results for both axes and decide on the scales you will use (usually but not necessarily starting from zero).
6 Make small marks and numbers evenly along each scale for each axis.
7 Write the names near the x- and y-axes to show what the readings are, e.g. time and height.
8 Now refer to your table of results, for example:

GROWTH OF A SEEDLING OVER TIME

Time (days)	0	1	2	3	4	5	6
Height (cm)	0	1	2.5	4.5	6	8	10

9 Make a dot inside a circle, or a cross, where an imaginary line up from day 1 meets an imaginary line across from 1 cm. This is your first point.
10 Make dots or crosses for the other readings.
11 Then draw a straight line with a ruler, or a curved line that goes through most of the points (line of best fit). Ignore any unusual (anomalous) results.
12 Add a title, in capital letters.



0.18 Tables, bar charts and line graphs

1 Scientists collected a new kind of mammal, but they noticed that it was losing its hair very quickly:
Age 0 days, hair loss 0.0 mg, 4 days: loss 1.8 mg, 8 days: loss 3.5 mg. 12 days: 5.2 mg, 16 days: 5.9 mg, 20 days: 8.5 mg.
(a) Prepare a table to show these results.
(b) Prepare a line graph.
(c) Identify an anomalous result. What might have caused this?

2 Peter recorded his patty sales.
Monday: 50, Tuesday: 30, Wednesday: 45, Thursday: 35, Friday: 20 and Saturday: 10.
(a) Prepare a table to show these results.
(b) Prepare a bar chert.
(c) From the data where do you think Peter's Patties is located: in the town centre, or near the beach? Give as many reasons as possible for your answer.

3 A chemist reacted powdered chalk (calcium carbonate) with hydrochloric acid to produce carbon dioxide. He recorded the amount of carbon dioxide produced each minute:
0 minute: 0 cm^3 gas; 1 minute: 4.3 cm^3 gas; 2 minutes: 7.7 cm^3 gas; 3 minutes : 10.2 cm^3 gas; 4 minutes: 12.0 cm^3 gas; 5 minutes: 13.4 cm^3 gas; 6 minutes: 14.5 cm^3 gas; 7 minutes: 15.4 cm^3 gas; 8 minutes 16.0 cm^3 gas.
(a) Prepare a table to show these results.
(b) Prepare a line graph.
(c) Describe how the rate changes with time.

4 Samantha set up her electrical circuit containing resistance wire and measured the current (in amps: A) for each reading of voltage (in volts: V) which she adjusted.
Voltage 0 V: current: 0 A; voltage 2 V: current 0.10 A; voltage 4 V: current 0.20; voltage 6 V: current 0.30 A.
(a) Prepare a table to show these results.
(b) Which other way will be useful to display the data: bar chart or line graph? Why?
(c) Which is the independent variable and which the dependent variable? Explain your answer.
(d) On which axes should the variables be shown?
(e) What is the relation between amps and voltage?
(f) Prepare the display.

Making displays using Excel®

It is important you can draw tables, bar charts, pie charts and line graphs for yourself, but also be able to use ICT to help prepare them for you. Make copies of your work, clearly labelled, in a folder.

Preparing tables

1 Open Excel® and see that the columns are headed A, B, C, D, E etc., and the rows 1, 2, 3, 4, 5 etc.
2 We describe 'cells' by the intersection of a column and a row. So the top left cell is A1, and the cell below it A2. Work with a friend to name some other cells.
3 First give your table a title: 'Sales of school newsletter'. This is too long to fit into A1, so we need to extend the space. At the bottom corner of A1, you will see a small square: select it with your mouse and pull it across B1 and C1 **(a)**.
4 To remove the small lines between cells, use the 'Merge' command in the tool bar. Select and pull down the small arrow to select 'Merge cells'. This gives you a clear space (A1 to C1).
5 Now position the + cursor in the title space and type 'Sales of school newsletter'. Notice how your typing is also recorded in the space above the table. When we add information to a table we can either type it into the cell, or in the space above (after having selected where we want it to go).
6 Our table would look better if we centre the heading and other things in the columns. Select the white arrow at the extreme left corner to select all the cells. Find and select the icon for 'centre text'.
7 Column A is names of students. Click on A2 and enter 'Students' (the title of that column). Then in A3–A7 add the other names. Column B is for 'Sales'. Enter the data in cells B2–B7 **(b)**.
8 In A8 type TOTAL. We can ask for this to be calculated; we want the sum of cells B3 to B7. We choose cell B8 and type: '=sum(B3:B7)' and press the Enter key on the key-board **(c)**. The answer appears! Check if it is correct.
9 Now add lines to the table: position the + cursor at the top left and hold down as you pull to make a shape over A1 and down to C8. Select the 'Borders' icon and from the arrow drop-down choose and select 'All Borders' to add lines **(d)**.
10 On the spreadsheet click and pull from the top left corner to select the table and use 'Copy' command.
11 Then use 'Paste' command to put the table in a new file Table of sales of newsletter.
12 Name and save the Excel® document as 'Table'.

Table (a)

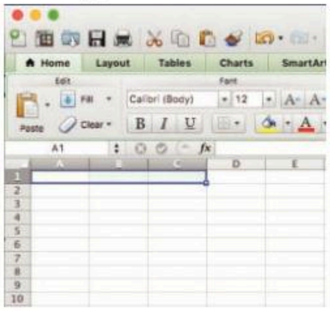


Table (b)

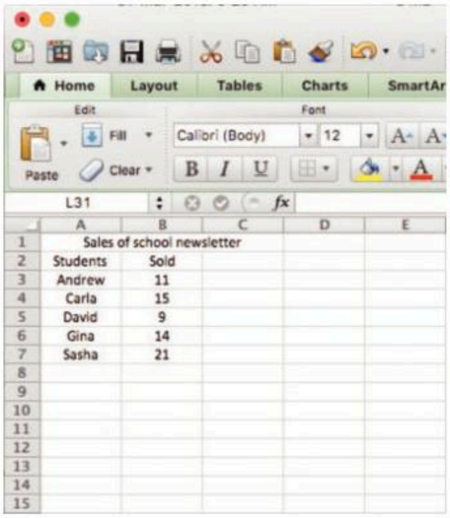


Table (c)

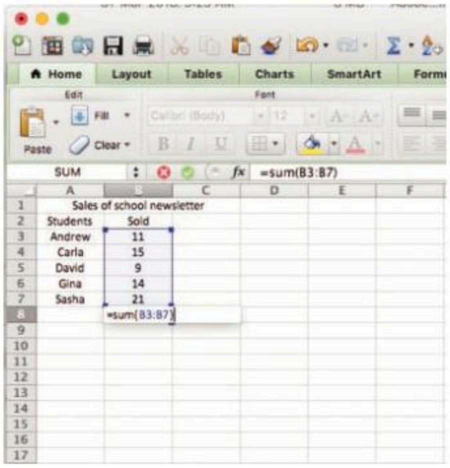
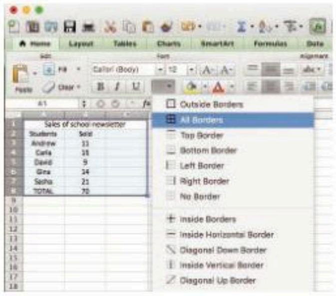


Table (d)



Preparing bar charts

1 Use graph paper and a ruler to prepare a bar chart of the information shown in the table (page 18).
2 Label the axes and the bars, and colour them different pale colours.
3 Duplicate and open the previous Excel® document.
4 Select the readings you want in a bar chart (A2 to B7). Then look above the tool bar to find and select the option 'Charts'. Pull down the little arrow at the side and select 'Clustered columns' **(a)**.
5 A basic bar chart is made, and you can finish it yourself.
6 Above the toolbar select 'Chart Layout' and then pull down the arrow near to 'Chart Title'. Type 'Bar chart of sales of newsletters' in the 'Chart Title'. Then choose 'Home' and make the title smaller.
7 Now return to 'Chart Layout' and choose the arrow near to 'Axis title.' Choose the 'Horizontal axis title' and 'Vertical axis title' in turn to add your labels **(b)**.
8 The bars would look nicer with different colours, so do that next. Above the toolbar select 'Format' and identify the icon called 'Fill' **(c)**.
9 Click on a bar, then on the little arrow by the side of 'Fill' and choose a colour. Do all the bars by selecting and filling them with different colours **(d)**.
10 Click on and change the title, e.g. add 'by students'. To delete any unwanted text on the bar chart, select it and then use the delete command on the keyboard.
11 Click on part of the bar chart to select it and use the 'Copy' command. Then use 'Paste' command to put the bar chart into a new file document.
12 To make any changes to the bar chart, first select it (it will get a border). Adjust the sizes of any of the writing to produce a neat result.
13 Also practise clicking in the bottom right corner and pulling or pushing to change the size.
14 When you are satisfied, print out a copy.
15 Name and save the Excel® and file documents in labelled folders.

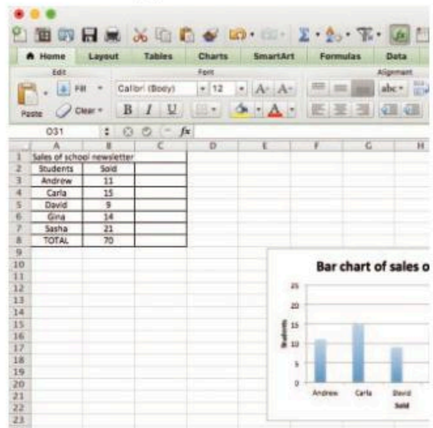
0.19 Tables and bar charts

Your teacher will provide you with tables of data.

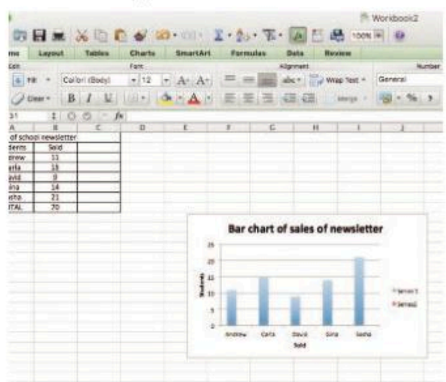
1 Choose two that would be appropriate to show as bar charts (one variable is words, e.g. descriptions of things, and the other is numerical, the amounts).
2 Open a new Excel® document for each one and prepare the tables and bar charts.
3 Save and name the Excel® documents and copy and paste your work into new labelled files in a folder. Display images of your work in class.

Bar chart (a)

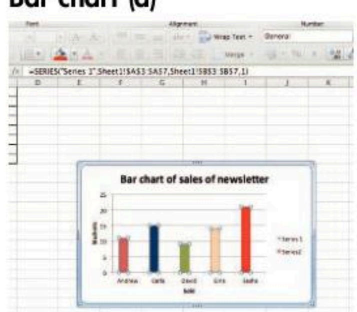
Bar chart (b)



Bar chart (c)



Bar chart (d)



Preparing pie charts

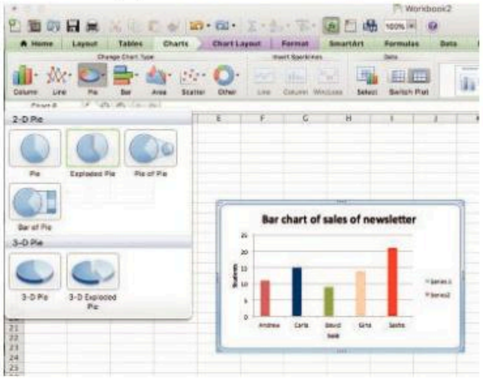
1 Duplicate the previous Xcel® document labelled 'Bar chart', and work with one of the copies.
2 First convert data in the table to the sectors in a pie chart. Label C2 'Sectors'. You calculate these by the (number/total number) × 360°.
3 In C3 type =(11/70)*360 and press Enter (the * stands for 'multiply' and is made by pressing the shift key and key '8' at the same time).
4 Similarly in C4 type = (15/70)*360 and press Enter. Complete C5, C6 and C7 in a similar way.
5 To get the total, in C8 type =sum(C3:C7) and press Enter. It will give you 360.
6 Now you round off the numbers and use these angles to prepare your own pie chart (see page 16).
6 Save, name and close the document.
7 Excel® can also be used to make a pie chart directly from a bar chart. Open the copy of the version you saved with the table and bar chart.
8 Click inside the bar chart area to select it; it will get a border. Then click to select 'Charts' and then click on the arrow near to 'Pie'. Choose and select '2-D Pie: Pie' **(a)**.
9 The bar chart is changed to a pie chart! Select the title and change the word 'Bar' to 'Pie' in the title.
10 Now click on 'Chart Layout' and pull down the arrow near to 'Data Labels' to select 'Percentage'. Labels will appear on the pie chart **(b)**.
11 To add a key or legend, pull down on the arrow near the 'Legend' and choose 'Legend at right' **(c)**.
12 If instead, you would like the names in the sectors, then choose the pie chart area and undo the last two actions.
13 Now, when you pull down the arrow near 'Data Labels', select 'Category Name and Percentage'. You will get that information on the pie chart **(d)**.
14 Select your pie chart, Copy it and then Paste it into a Word document.
15 Save the Excel® document and label it Excel® 'Table + Pie chart'.

0.20 Pie charts and line graphs

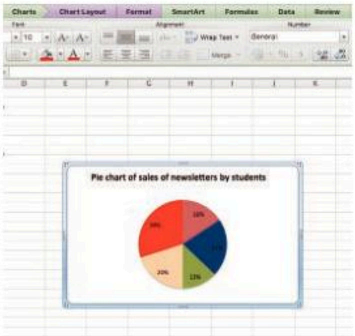
Your teacher will provide you with tables of data.

1 Choose two that would be appropriate to show as pie charts and two as line graphs.
2 Open new Excel® documents for each one and prepare them. Copy and paste your work into new labelled files in a folder.

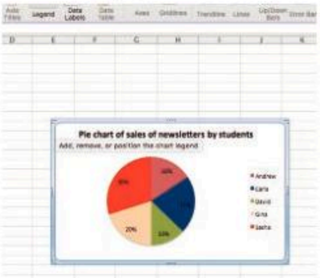
Pie chart (a)



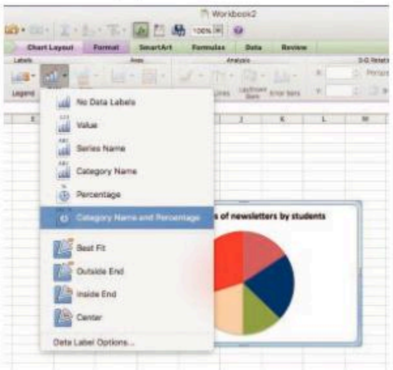
Pie chart (b)



Pie chart (c)



Pie chart (d)

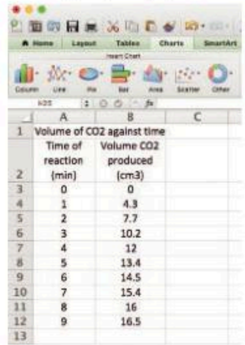


Preparing line graphs

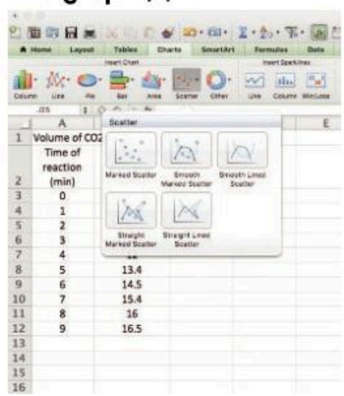
You use these when the two variables are numerical and are entered along the axes on graph paper; the corresponding points are plotted and the best-fit line shows the relationship between them.

1 You prepared a table and line graph for the production of CO_2 in a reaction (page 17). Now you will use Excel® to extend and prepare them.
2 Open a new Excel® document. The full data for time and the production of CO_2 are below: 0 minute: 0 cm^3 gas; 1 minute: 4.3 cm^3 gas; 2 minutes: 7.7 cm^3 gas; 3 minutes : 10.2 cm^3 gas; 4 minutes: 12.0 cm^3 gas; 5 minutes: 13.4 cm^3 gas; 6 minutes: 14.5 cm^3; 7 minutes: 15.4 cm^3; 8 minutes: 16.0 cm^3; 9 minutes: 26.5 cm^3.
3 First prepare the table. In Excel®, pull A1 across B1 and merge the cells to make space for the title (see page 18): ' Volume of CO_2 against time'.
4 Also widen the columns a little. To widen column 'A', position the cursor in the top row, between A and B. It will make a line with two small arrows on it. Select and pull this to the right to see the effect.
5 In a similar way choose the line between 'B' and 'C' and pull to the right to widen column B.
6 Add titles to columns A and B. Select A2 and type: 'Time of reaction (min)'. This is too long for the space so choose 'Wrap Text' from the tool bar above and from the little arrow choose 'Wrap text'.
7 In B2 type 'Volume CO_2 produced (cm^3). It will automatically wrap itself into 3 lines.
8 Enter the data into the correct cells (**a**).
9 Now you need to choose the correct chart to make. First chose 'Charts'. You will recognise 'Column ' and 'Pie' that you have used before. Select the button called 'Scatter' (**b**).
10 Select your table by selecting and pulling across from A2 to B13 and select 'Scatter' and then the option 'Smooth Lined Scatter'. A graph will be made with a smooth line (**c**).
11 If you want to enter the points corresponding to the readings, delete what you did. Now select the table again, and pull down the arrow by the side of 'Scatter'. Choose 'Smooth Marked Scatter'.
12 Your line will now also have the points entered and the line drawn (**d**).
13 Change the title, add labels to the axes and remove the legend (see page 18).
14 Copy and Paste your line graph into a new file document. Save, label and close Excel®.

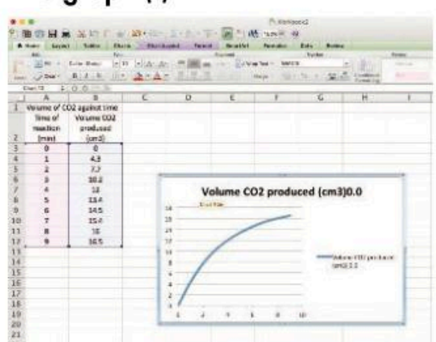
Line graph (a)



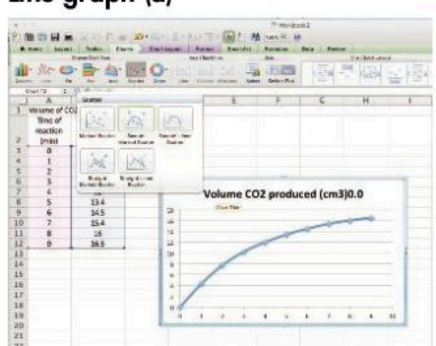
Line graph (b)



Line graph (c)



Line graph (d)



Analysing and interpreting data

Analysing: reading values and calculating new ones.
Interpreting: explaining results, finding patterns and relationships, making predictions, evaluating and drawing conclusions.

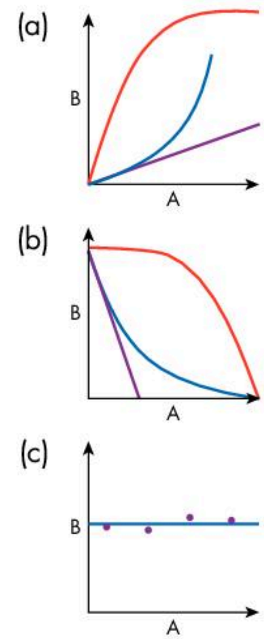
0.21 Analysing and interpreting data

Your teacher will give you examples of tables, bar charts, pie charts and line graphs, and you can use the ones you have produced during this unit.

1 Use them to practise the skills described below.
2 Write a report on four different displays of data and how you analyse and interpret them.

- Read values, e.g.
  - decide the value of each small division on graph paper so you can read the heights on a bar chart or points on a line graph
  - identify the value of any particular reading
  - find values that differ in some way, e.g. one is twice another
  - use a protractor accurately to read the angles of the sectors on a pie chart
  - add the units, e.g. cm^3 when describing a measurement.
- Calculate values, e.g.
  - be able to add, subtract, multiply and divide
  - use prefixes correctly to multiply or divide numbers by powers of ten, and convert them from one to another
  - convert numbers into sectors of a pie chart, and vice versa
  - find the average of a set of numbers.
- Explain results, e.g.
  - understand and explain why and how the particular display has been used for a particular set of readings
  - observe results carefully and relate them back to the material being measured, e.g. living things are variable
  - suggest reasonable explanations for what is recorded, e.g. living things get taller over time.
- Find patterns and relationships
  - identify errors and anomalous results in the data: results that are not lying on the best line of fit
  - describe how one variable changes in relation to another, e.g. on a line graph notice how the line is drawn (see diagrams)
  - notice if the angle of slope on a line graph is not all the same. Realise that a steeper slope means the growth or reaction or speed is faster than where the slope is less steep.
- Make predictions, e.g.
  - realise you cannot predict from a bar chart as all the readings (columns) are independent
  - on a line graph you can continue the line as a dotted line as a prediction, and answer a question based on this.
- Evaluate, e.g.
  - consider the value (the usefulness) of what you have done and the records you have made
  - evaluate if a fair test was set up or if it was not set up
  - realise that only if all the control variables were kept constant can you rely on the results
  - identify possible sources of error, or alternative causes of the results.
- Draw conclusions, e.g.
  - decide if your results support or disprove your hypothesis
  - sum up whether you have found out what you set out to do.

Interpreting line graphs



(a) B is proportional to A: as A increases so does B, e.g. growth over time
(b) B is inversely proportional to A: as A increases, B decreases, e.g. size of potato tissue left in strong salt solution
(c) Changes in A do not affect B: as A increases, B stays the same, e.g. any variables that are not related

▶ **See Workbook Introduction.**

Drawing

A drawing of living things is a picture made to look like the 'real thing'. It depends upon careful observation and usually has curved lines drawn without a ruler.

A drawing of equipment is drawn with a ruler as an imagined cut surface.

A diagram is simpler than a drawing, and does not need to look like the real thing. It shows parts, e.g. of the water cycle, and how they are related; it often has arrows and colour.

0.22 Drawing and annotating

Materials: A leaf, a filter paper folded in a filter funnel, ruler, pencil, eraser

Method

1. Research the names and functions of the parts of a leaf.
2. Make an accurate drawing of the leaf, following the hints below. Include the magnification.
3. Add annotations (brief descriptions of the functions) after each label.
4. Examine the filter paper and funnel. Discuss how you will make a scientific drawing.
5. Make and label your drawing and add annotations.

Hints for making drawings

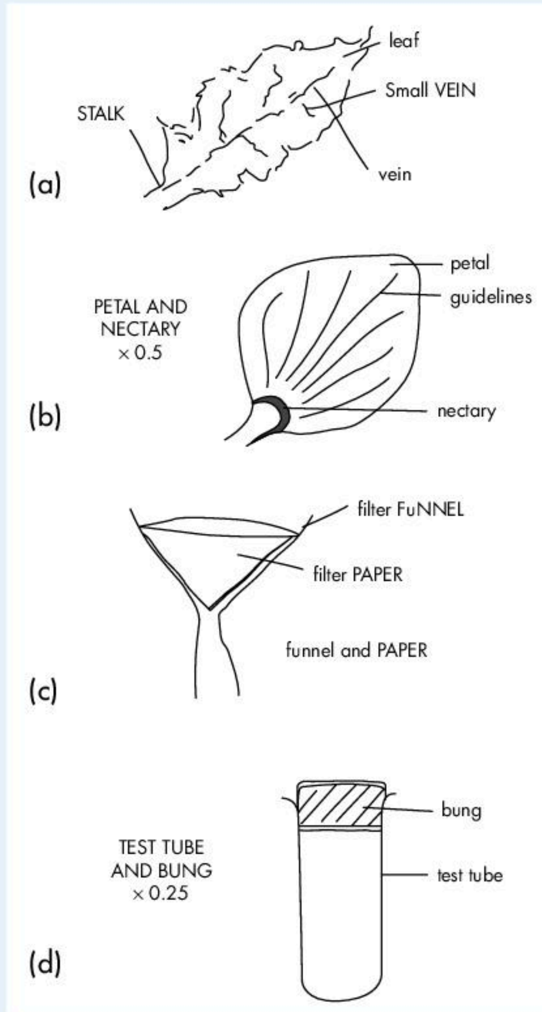
- Make very careful observations.
- Use a sharp pencil and make a rough outline.
- Check that the shape and proportions are accurate.
- Erase this outline as you add the details.
- Keep your pencil on the paper to make a smooth line.
- Show the important details; do not add colour.
- Label lines should be ruled and straight.
- Label in lower case script; do not shade drawings.
- Magnification = $\frac{\text{length of drawing}}{\text{length of specimen}}$ e.g. $\frac{10\text{ cm}}{5\text{ cm}}$

  Magnification = ×2
- Give a title to your drawing in capital letters.

0.23 Bad and good drawings

Work in a small group:

1. Discuss the following four drawings. and then mark them (each out of 10). Give reasons for your marks.



2. How many marks out of 10 would you give yourself for each drawing you made in Activity 0.22?

▸ **See Workbook Introduction.**

Quick check ☑

Data in words is __________: numerical __________ is __________. A bar chart has only one __________ variable.
A line __________ shows the relation between two __________ variables. A __________ chart shows the parts of a whole.
We can use __________ to make displays of __________.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

quantitative **pie** **Excel®**
qualitative **data** **graph**

Questions

Answer these questions in your notebook

For questions **1–33** answer **A**, **B**, **C** or **D**.

1 What does the T in STEAM stand for?
A Temperature **B** Technology
C Technologists **D** Technical

2 Which of these is NOT usually part of Art?
A drawing **B** design
C textures **D** numbers

3 Which way of working would be best to use to develop a new product?
A problem-based work in a group using EDP
B inquiry-based group using the scientific method
C teacher-led group
D individual work

4 Which way of working would be best to use to explain a new topic?
A teacher-talking lesson
B teacher-led class with practical activities
C inquiry-based group
D individual work

5 Use of knowledge (UK) skills are most concerned with
A thinking skills **B** practical skills
C comprehension **D** technological skills

6 Which of these is NOT a useful study skill?
A use a range of resources including ICT
B keep an accurate record of what you do
C copy an assignment from the best student
D carry on and finish an assignment properly

7 A main characteristic of the scientific method is
A setting up a fair test
B using measuring equipment
C describing what we did
D writing a final report

8 In a well-setup experiment which of these variables does the experimenter NOT control?
A dependent variable
B manipulated variable
C independent variable
D control variable

9 Which of these is a general statement that can be tested?
A guess **B** prediction
C hypothesis **D** conclusion

10 What is the value of the binary number 11101 in base ten?
A twenty four **B** twenty five
C twenty eight **D** twenty nine

11 What is the binary number for 54 base ten?
A 111110 **B** 101010
C 110110 **D** 111100

12 What do base ten and base two have in common?
A number of digits they use
B importance of place value
C their use in computer code
D all of the above

13 Safety rules in the laboratory help to keep which of these safe?
A people **B** equipment
C surroundings **D** all of the above

14 Which of these is a derived unit?
A cm^3 **B** m
C s **D** kg

15 How many g in a kg?
A 10 **B** 100
C 1000 **D** 10000

16 By what do we divide g to get mg?
A 10 **B** 10^{-2}
C 10^{-3} **D** 10^{-4}

17 When first lighting a Bunsen burner the
A air-hole is closed to get a yellow flame
B air-hole is closed to get a blue flame
C air-hole is open to get a yellow flame
D air-hole is open to get a blue flame

18 Which of these is the odd one out?
A filter paper **B** Bunsen burner
C support stand **D** filter funnel

19 Which of these could NOT be separated by from water by filtering?
A coffee dregs **B** tea leaves
C sand **D** salt

20 Which are the main parts of a table?
A rows and axes
B rows and columns
C horizontal and vertical axes
D x- and y-axes

21 When making a bar chart, what is the most important part?
A the heights of the columns
B the widths of the columns
C whether or not the columns touch each other
D the colours of the columns

22 You make a bar chart to show
A two quantitative variables
B two qualitative variables
C a quantitative and a qualitative variable
D any two variables

23 In a pie chart the angles are calculated out of?
A 10 **B** 100
C 360 **D** any appropriate number

24 Which of these things do you NOT need to draw a pie chart?
A pair of compasses **B** protractor
C ruler **D** graph paper

25 On a line graph, on the horizontal axis we record
A the dependent variable
B the manipulated variable
C the responding variable
D any appropriate variable

26 On a line graph, the line we draw to connect the points
A is always a straight line
B can be drawn with a ruler
C is always a curve
D is any smooth line of best fit

27 Which of these would you use to make a pie chart?
A Google®
B Excel®
C CSEC®
D Microsoft Word®

28 On a spreadsheet, the cell A1 is found
A at the top right corner
B at the top left corner
C anywhere in the top row
D anywhere in the first column

29 Which of these is important when making display charts?
A record your steps as you work
B use buttons and icons to make necessary changes
C save your work in a named file and folder
D all of the above

30 On a line graph of B against A, if the line rises to the right it means that
A B is increasing in proportion to A
B B is decreasing in proportion to A
C B is not related to A
D the experimenter has made a mistake

31 On a line graph a fast rate is shown by a
A steep slope
B gentle slope
C flat line
D zigzag line

32 When drawing science equipment we make
A a 3D drawing
B any 2D drawing
C a drawing of the cut surface
D a freehand sketch without a ruler

33 Which of these is important when drawing?
A make it look like the real thing
B draw with clear, continuous lines
C add a magnification and a title
D all of the above

For questions **34–45** write the answers in your notebook.

34 Describe three ways in which STEAM helps you better understand your science work.

35 (a) Describe in your own words three differences between teacher-led and inquiry-based learning using groups. (b) When is it most useful to use each one?

36 (a) Give two ways in which the scientific method and Engineering design process are similar. (b) Describe a problem that could be solved by using the scientific method. (c) Identify a product you use that was designed by EDP.

37 (a) Describe to a 10 year-old student, the difference between numbers in base ten and base 2. (b) How do we use powers of ten when measuring? (c) How do we use base two in computer programing?

38 Identify three laboratory rules, one each that is mainly for the safety of people, the equipment or the surroundings.

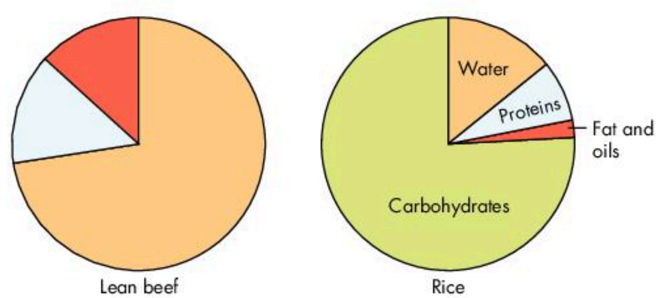
39 Describe what is meant by each term and give an example: (a) fundamental quantity, (b) base unit, (c) prefix, (d) derived unit.

40 (a) List four measuring instruments and the quantities they measure. (b) Describe one safety procedure for the use of each one.

41 Describe the steps you follow in lighting and then preparing a Bunsen burner for heating.

42 Describe the principles behind the use of filter paper to separate two substances.

43 (a) Convert the pie charts below to show the tables from which they were prepared.
(b) What is the main difference between the composition of lean beef and rice? (c) Why do you think the data has specified 'lean' beef?



44 Describe when you would use each of a table, bar chart, pie chart and line graph.

45 Write down the steps you use to present the data in a table as (a) a bar chart, (b) a pie chart and (c) a line graph.

Key ideas

- We learn science as part of STEAM (science, technology, engineering, art and mathematics).
- Scientists find out about the natural world by using the scientific method.
- Technologists, including engineers, design and improve models to make new processes and items using EDP to solve practical problems.
- Art is used in making drawings and in EDP.
- Mathematics is the use of numbers to calculate and to display results.
- ICT uses base two (binary code) and is important in science, technology and everyday life.
- We can work in teacher-led classes or by inquiry-based learning.
- In the laboratory, rules help us to keep people, equipment and the surroundings safe.
- The SI system has seven fundamental quantities each with a base unit.
- Prefixes (representing powers of ten) are used to multiply or divide the base units.
- Base units are used to produce derived units.
- Measuring equipment has scales with lines and units marked on it for measuring different quantities.
- Before lighting a Bunsen burner, we close the air-hole and get a yellow flame. The collar is then twisted to open the air-hole and give a blue flame.
- Sieves and filters can separate two substances if their holes will allow only one of the substances to go through.
- Tables are used to enter qualitative and quantitative data in columns and rows.
- Bar charts show one qualitative variable in the form of bars of different height.
- Pie charts show the parts out of a whole as sectors in a circle.
- Line graphs show the relationship between two qualitative variables entered on axes. The corresponding points are connected by lines.
- Science equipment drawings are of the cut surface and made using a ruler.
- Drawing of living things are made freehand, to look like the real thing.
- We can analyse (describe) and interpret (explain) tables, bar charts, pie charts and line graphs.

▸ **See Workbook Introduction.**

Problems

1 Your class is going to prepare charts to show, step-by-step, the way in which you carry out certain activities. The reports should be prepared by hand and then word-processed into a neat copy. **ICT**

This is pasted to the card and illustrated with appropriate labelled drawings, artwork from the Internet, or photographs. **ICT**

Use this book and research on the Internet.

Here are some ideas of topics:

- The scientific method
- The Engineering design process
- Safety rules for the laboratory and their reasons
- Using base ten and base two systems
- Using the SI system, prefixes and powers of 10
- Making and interpreting tables
- Making and interpreting bar charts
- Making and interpreting pie charts
- Making and interpreting line graphs
- Making labelled drawings of scientific equipment
- Making labelled and annotated drawings of living material

When finished, display your material in class.

2 Your younger friend wants you to show them how to use spreadsheets and Excel® to make tables, bar charts, pie charts and line graphs.

Work in a group:

(a) Discuss how you will introduce the problem, by showing examples of finished displays and describing to your friend when you need to use each of them.

(b) Arrange a time when you can work with a computer (it may be in an ICT class and you will need to ask permission from your teacher). **ICT**

(c) Begin with the steps needed to make a table. Make sure you record notes of what you do so you can keep it for later. Copy the final result into a labelled Word document and print it out.

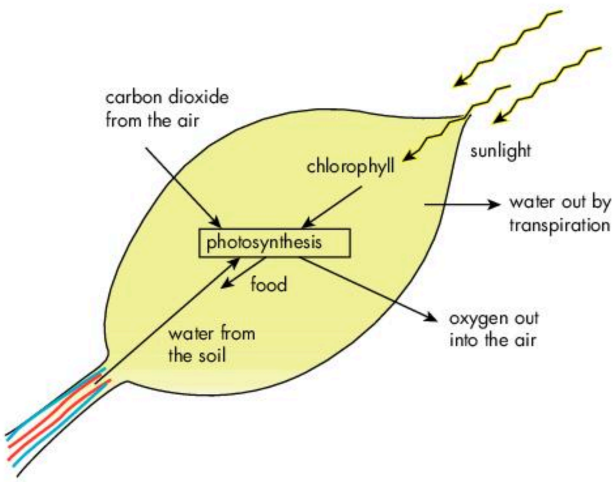
(d) Repeat this process for a bar chart, a pie chart and a line graph.

3 Work on your own. Which do you think you would like to be: (a) scientist (b) technologist (c) engineer (d) artist (e) mathematician (f) something else? Give three reasons for your answer. (All answers can be correct; what is important is that you explain your reasons.)

Unit 8

Photosynthesis and energy relationships

1 How do organisms on a coral reef depend on each other?



2 Use the diagram to write the equation for photosynthesis

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.

This unit will help you to:

- understand that energy from the Sun sustains all living things
- investigate the process of photosynthesis
- recognise the modifications of leaves to carry out photosynthesis
- collect living things and identify producers and consumers
- trace the flow of energy through food chains and webs
- recognise that energy is lost in the transfer between trophic levels
- describe how humans are part of food webs and can have a positive or negative effect on them.

3 Identify the thickened inner edges of the guard cells in this photograph of the lower epidermis of a leaf

Photosynthesis

In Grade 7 you studied the main parts of flowering plants: roots, stems, leaves and flowers. You will now find out how parts of the plant are involved in photosynthesis.

8.1 Looking at leaves

Materials: plants growing outside, hand lens, scissors, paper, wax crayon, hot water, cotton thread, prepared slides of leaf section and epidermis, microscope

Method

Work in a small group:

1 Look at how leaves are arranged on a variety of plants. Are the leaves lying on top of one another? How are they arranged so that each one can get the most sunlight?

2 Look at five different shapes of leaves. Are there any rounded leaves? Are there any flat leaves? Are the leaves thick or thin? Describe the leaves.

3 Look at and describe the top surfaces of a leaf. Is it shiny or dull? Why do you think this is? Look in the middle of the lamina (main part) to find the mid rib (main vein).

4 How is the lamina supported? Look on the underside of the leaf and use your hand lens to look at the pattern of veins from the mid rib. Feel a vein and feel the lamina. What do you think supports the lamina?

5 Now your group can use the scissors to cut two leaves from a plant. Cut at the base of the leaf stalk or petiole.

6 In the laboratory make accurate labelled drawings of your leaves, the top surface and the underside.

7 Lie the leaf underside upwards. Lay paper on top of it and use a wax crayon to rub over the paper. You will get a leaf print that shows the veins.

8 Attach thread to the petiole and dip the leaf into hot water. What happens? Do you see any bubbles? Where do most of them come from? Why?

9 Look at the section of a leaf your teacher has set up on the microscope. What do you notice close to the top surface of the lamina? Explain how this is useful for photosynthesis.

10 Look at the cells closer to the underside. Are they more spread out and with spaces between? How is this useful for the movement of carbon dioxide and oxygen?

11 Gases travel in and out through holes called stomata. Can you find any stomata on the lower surface?

12 Look at the prepared slide of the lower epidermis. Identify a stoma and the two guard cells each side. These can change their shapes to open and close the stoma so that carbon dioxide and oxygen diffuse in and out during photosynthesis, and water vapour diffuses out in transpiration.

Objectives

- State that photosynthesis by plants (using chlorophyll to trap the Sun's energy) forms the basis of life.
- Carry out fair tests to identify raw materials as carbon dioxide and water and products as oxygen and glucose.
- Perform the test for starch.

Fun facts

- All animals on Earth depend on plants for their food and oxygen.
- Leaves coloured red or brown can carry out photosynthesis, as long as they also contain chlorophyll.

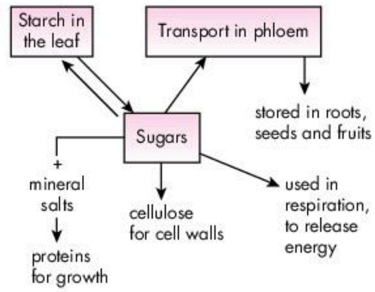
Leaf adaptations

- There is a main vein and branching veins to support the lamina.
- Leaves are held at an angle, and overlap as little as possible to get a lot of sunlight.
- The leaf is thin, so it has a high surface area for its volume. Gases can diffuse easily in and out.
- Cells near the top surface contain very many chloroplasts.
- Cells near the underside have large air spaces between them, so gases can diffuse easily.
- The veins contain xylem (brings water and salts from the root) and phloem (to take food away).
- The lower epidermis has holes called stomata. The guard cells on each side control how they open and close to control movements of carbon dioxide, oxygen, and water vapour.

Raw materials and products

Plants build up food using light energy during photosynthesis. You will design and carry out fair tests to find:

- Substances combined: Carbon dioxide and water
- Conditions necessary: Light energy and chlorophyll
- Substances produced: Sugars (and starch) and oxygen



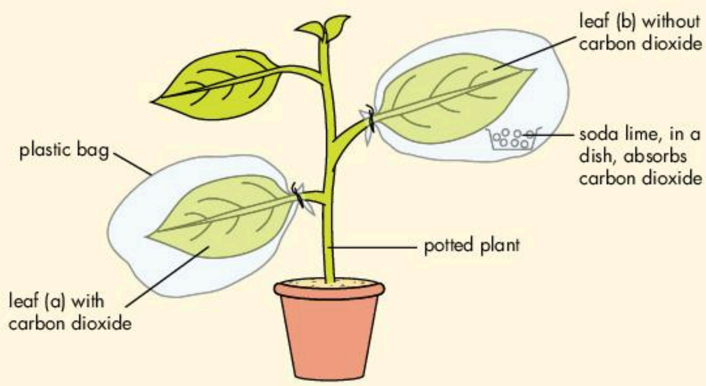
8.2 Is carbon dioxide used in photosynthesis?

Materials: potted plant, two plastic bags, dish with soda lime, starch-testing materials.

Method

1 You have to be sure the plant does not have starch at the beginning. Why is this? Put a potted plant in the dark for two days. Any starch in the leaves will be sent to other parts of the plant. Test a leaf to be sure (see Activity 8.3).

2 You need a fair test with one leaf with, and another leaf without, carbon dioxide. The diagram shows one idea but you can also try your own design. Inside one of the plastic bags is a dish with soda lime. This will remove carbon dioxide from around that leaf. Label the leaves (a) and (b). Leave the plant in the sunshine for four hours.



3 Test each leaf for starch and explain your results.

8.3 Testing a leaf for starch

Materials: potted plant, beaker, heating apparatus, forceps, test tube, ethanol, Petri dish, dropping pipette, iodine solution

Method

Work in groups. Use a potted plant that has been in the light for three hours.

1 Heat a beaker of water on a tripod and gauze. Cut and dip a leaf in the boiling water to kill and soften it.

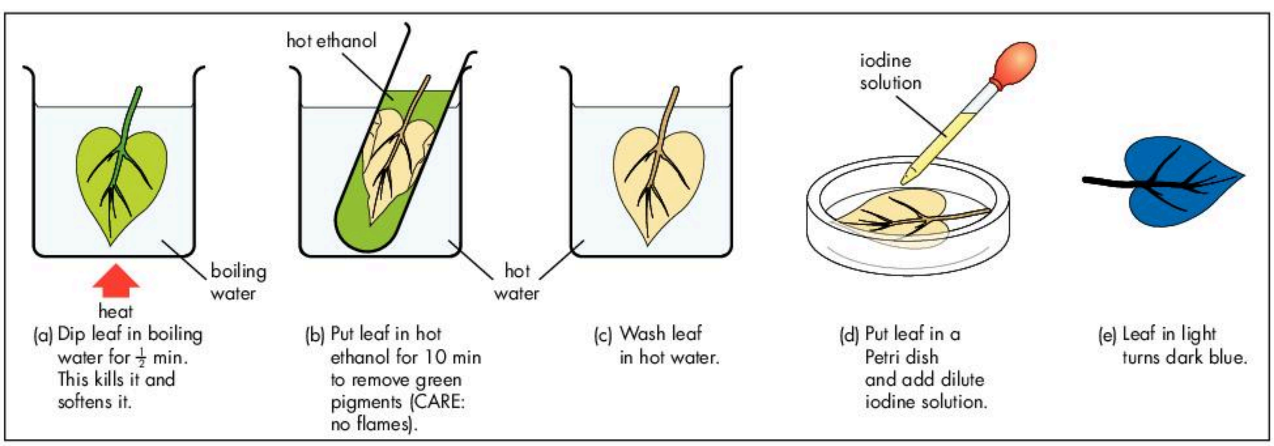
2 Turn off the Bunsen burner. This is because the ethanol you are going to use can easily catch alight.

3 Three-quarters fill a test tube with ethanol. Push the leaf inside and put the test tube in the beaker of hot water for 10 minutes to remove the chlorophyll.

4 Take out the leaf, and wash off the ethanol by dipping it in the water.

5 Put the leaf in a Petri dish. Use the dropping pipette to add a few drops of Iodine solution. If starch is present, the leaf will turn dark blue.

Do you think carbon dioxide is needed for photosynthesis?



How to test a leaf to see if the sugar produced in photosynthesis has changed to starch

8.4 Is light necessary for photosynthesis?

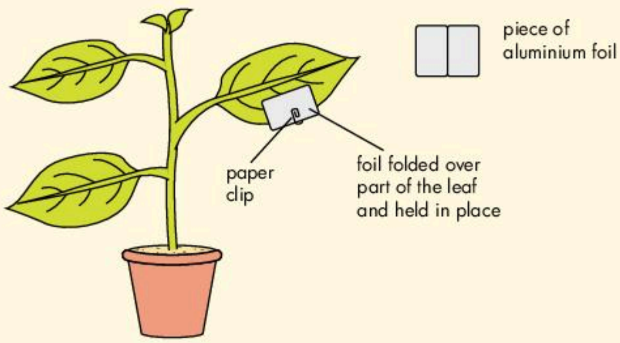
Materials: potted plant, scissors, aluminium foil, paper clip, starch-testing materials

Method

1 Collect a potted plant that has been in the dark for two days. This produces a de-starched plant. Why is it important to start with a plant without starch? Could we set up a fair test without doing this first?

2 Brainstorm how to set up a fair test to find the effect of light on photosynthesis. The diagram shows one idea.

3 Cut a piece of aluminium foil to cover about half a leaf. Fold the foil and attach it to a leaf with a paper clip.



4 Put the whole potted plant into the sunshine for four hours. Then take off the leaf and sketch the area that had been covered. Why is this important?

5 Test the leaf for starch. Sketch the areas that have and have not made starch. What do you notice?

6 Record and explain your results.

Do you think light is needed for photosynthesis?

8.5 Is chlorophyll necessary for photosynthesis?

Materials: leaves that are partly green and partly white (e.g. variegated leaves of hibiscus), starch-testing materials

Method

1 Remove and draw a variegated leaf. Sketch the areas that are green (chlorophyll) and white (no chlorophyll).

2 Test the leaf for starch. Sketch the areas that have and have not made starch. What do you notice?

3 Record and explain your results.

Leaf before testing   Leaf in iodine solution

Do you think chlorophyll is needed for photosynthesis?

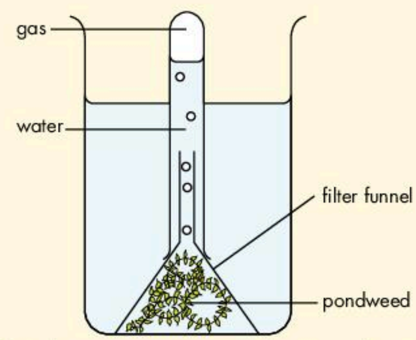
8.6 Is oxygen produced in photosynthesis?

Materials: water plant such as pond-weed (*Elodea*), beaker, filter funnel, test tube, glowing splint

Method

1 Place the pondweed in a beaker of water under the filter funnel. (We use a water plant as this makes it easier to collect the gas produced.)

2 Make sure the water level is above the end of the funnel. Fill the test tube with water, and, keeping your thumb over the end, upturn it over the end of the funnel. Rest it on the funnel.



3 Put the apparatus in the sunshine for several hours. You should see bubbles of gas being produced as the plant carries out photosynthesis. Collect as much of the gas as you can.

4 Your teacher will carefully remove the test tube, and test the gas with a glowing splint. The test for oxygen is that it relights a glowing splint.

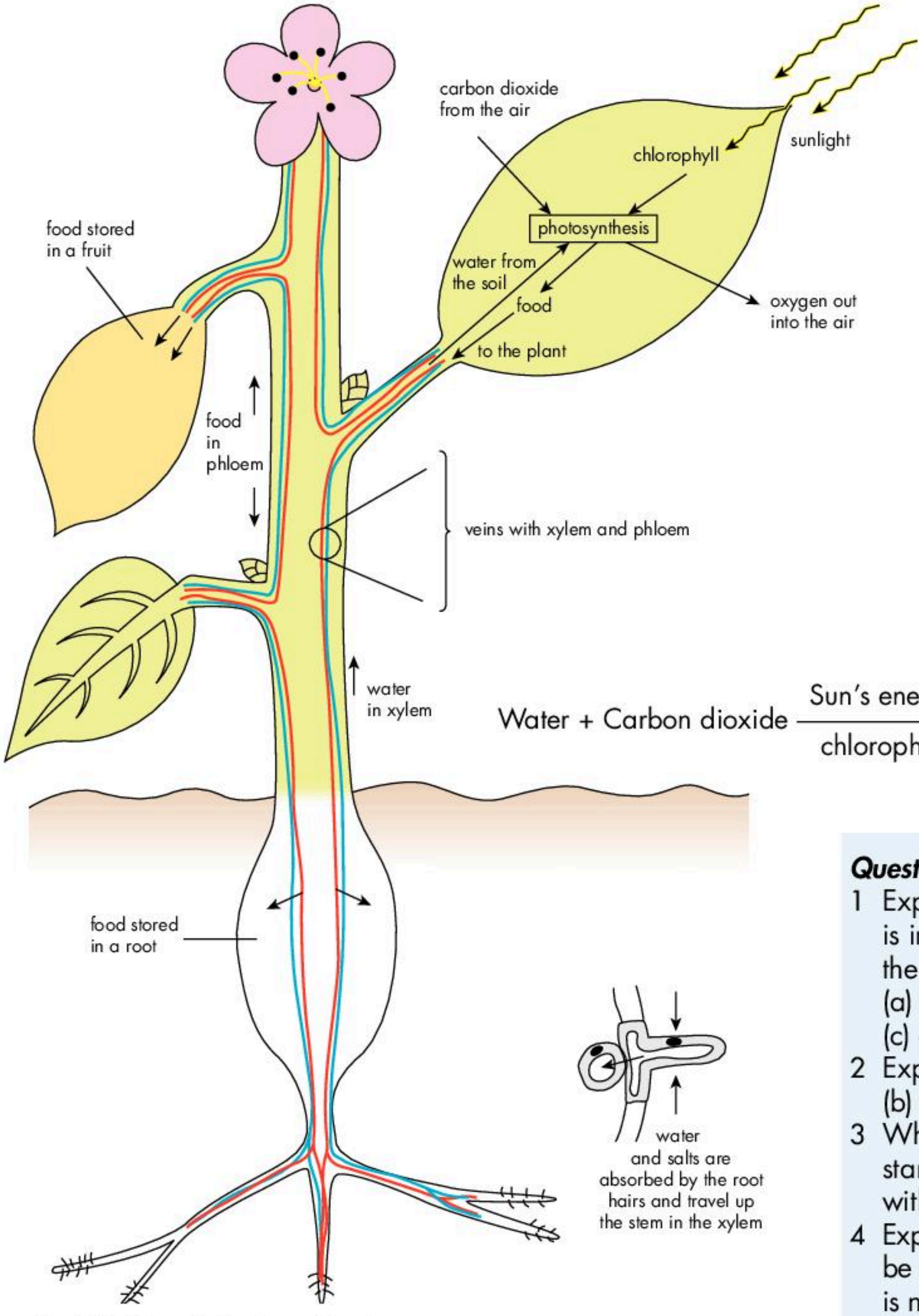
Has oxygen been produced in photosynthesis?

Writing a word equation for photosynthesis

Use the results of your experiments on page 29 and this page to write a word equation for photosynthesis. Don't forget to add the conditions that are necessary.

The food produced are sugars such as glucose, but these are quickly changed to starch. This is why we can test for starch to show that photosynthesis has occurred.

How a flowering plant makes and uses food



$$\text{Water} + \text{Carbon dioxide} \xrightarrow[\text{chlorophyll}]{\text{Sun's energy}} \text{Sugars} + \text{Oxygen}$$

water and salts are absorbed by the root hairs and travel up the stem in the xylem

▸ **See Workbook Photosynthesis.**

Questions

1 Explain how each of the following is important for photosynthesis or the use of the food that is made:
(a) root hairs (b) xylem
(c) chloroplast (d) phloem.

2 Explain how (a) carbon dioxide and (b) water get to the cells of the leaf.

3 Why does a plant have to be de-starched before doing experiments with photosynthesis?

4 Explain how variegated leaves can be used to help us understand what is needed for photosynthesis to occur.

Quick check ☑

__________ in the chloroplasts absorbs light energy, and makes it available for __________. __________ gvas is taken into the leaves, and __________ and mineral salts enter by the roots. Sugars are made that quickly change to __________. __________ gas is released that passes out of the leaf.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

water chlorophyll photosynthesis oxygen carbon dioxide photosynthesis starch

Food chains and webs

The main difference between living and non-living things is that living things can control their own energy needs. If a living thing can no longer do this, then it dies.
These are the characteristics of living things (**Reminder**):

- **Respiration**: This is the release of energy from food. It happens inside all living cells all the time
- **Excretion**: Living things produce wastes as they carry out their activities, e.g. respiration produces waste carbon dioxide, water and heat.
- **Movement**: Living things can move parts of themselves, on their own. Animals can move from place to place.
- **Irritability**: This is being sensitive to the surroundings, and responding to any changes.
- **Nutrition**: This is making food (plants) or eating food (animals). This is the 'fuel' that releases energy.
- **Development**: Living things grow by becoming bigger, and develop by becoming more complex.
- **Reproduction**: When living things become mature they can reproduce to make new organisms like themselves.

8.7 Grouping living things

Work in groups:

1 Look at the list of characteristics of living things. Discuss them in your group and identify:
   (a) which are done by plants and animals in a similar way, e.g. respiration. Make a list of these characteristics.
   (b) which are done by animals and plants in a different way, e.g. nutrition. Make a list of these characteristics.

2 Take the characteristics you listed under step 1 (b) above.
   (a) Prepare a table to describe how plants and animals are different in these characteristics.
   (b) How many of these differences are related to differences in the cells of plants and animals, and in their systems?

3 Prepare definitions of 'Plant' and 'Animal'.

Objectives

- Identify living and non-living things, and plants and animals.
- Realise plants (producers) are the ultimate source of oxygen, food and energy for all other organisms.
- Prepare food chains and webs.
- Classify levels of consumers and describe how part of the energy is lost along food chains.

Plants and animals

- **Feeding**: Only plant cells contain chlorophyll, and so only plants can make their own food and release oxygen. Animals have to eat plants for their food, or eat animals that have eaten plants or other animals.
- **Moving**: Because animals have to find their own food, they must move from place to place. Animals have muscular and skeletal systems to allow this. Plants need to be rooted in the soil to get water and minerals for photosynthesis and making other foods. Plants can move parts of themselves as they need to grow and turn towards the Sun.
- **Reacting**: Animals catch food and escape from enemies by reacting quickly. If they could not do these things they would die. They have nervous systems and also muscles and skeletons. Plants cannot move to escape being eaten, but they can grow more leaves to replace the ones that they lose.

Fun facts

- The most massive tree ever was a coastal redwood: 3299 tonnes.
- The tallest sunflower was 7.7 m.
- The biggest animal is a female blue whale: up to 33 m long. Babies at birth are 8 m long.
- The smallest animal is a fairy fly. It is only 0.02 mm long.

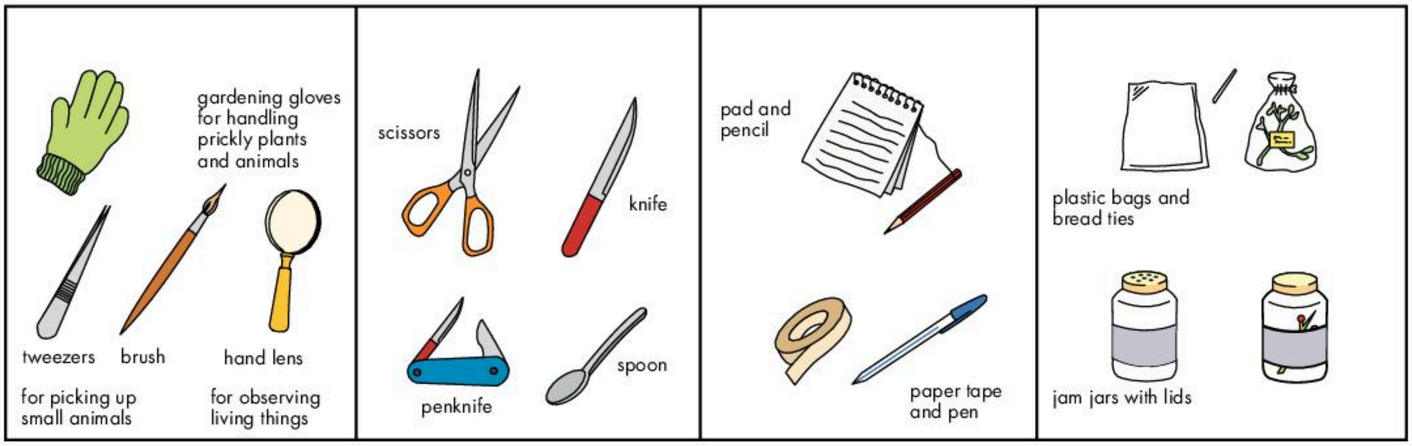
Observing and collecting plants and animals

PS 8.8 Observing and collecting living things

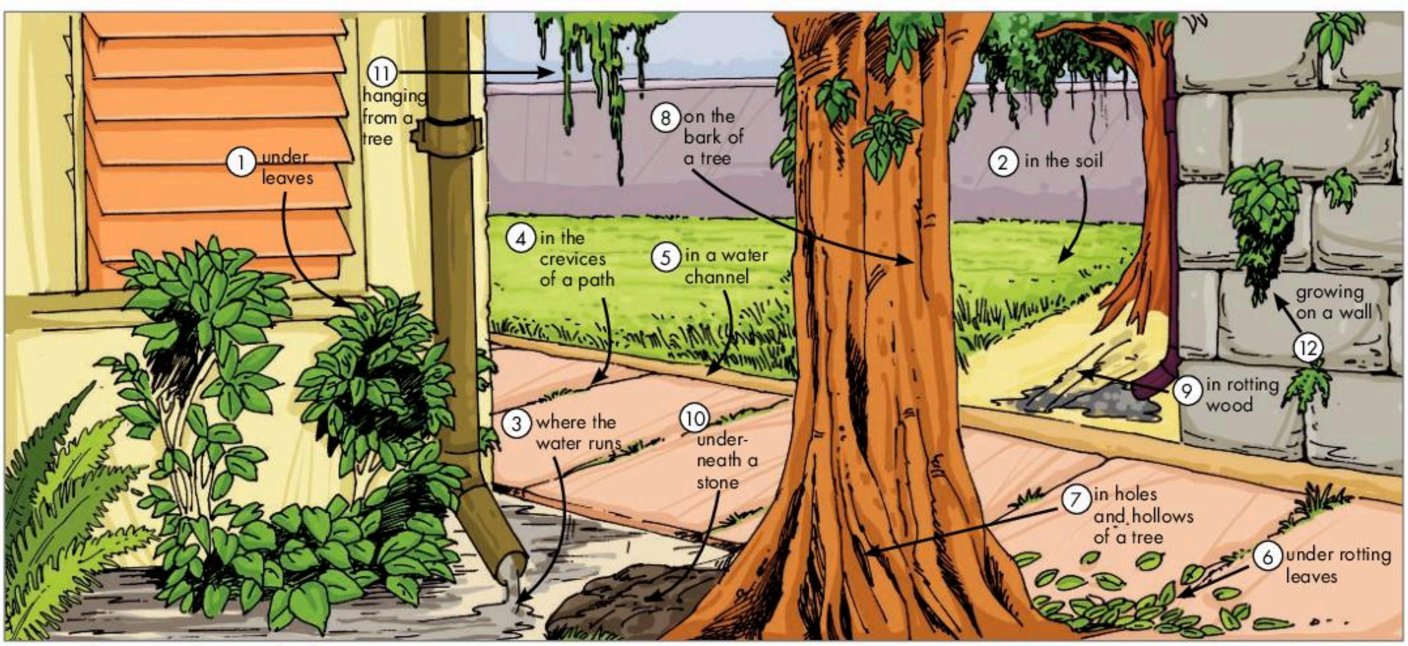
1 Collect together the things shown in the top picture. Take them outside and use them for observing and collecting plants and animals.
2 Look for small animals in some of the places shown in the bottom picture.
3 Cut off small pieces of plants, and collect one flower from each plant. Also look carefully for small plants without flowers.
4 Observe the environment and write down the names of other animals and plants that you see around you.
5 Collect some leaves from the plants on which your animals were feeding. Take your living things back to the classroom.

How to behave

- Protect yourself. Wear gloves to handle plants with spines. Also be careful when feeling under stones, in case there is a biting or stinging animal hiding there.
- Protect plants. Only take small pieces from the plants, and only as much as your group needs. Make clean cuts with a sharp knife, these are easier for the plant to heal than breaking the plant by hand.
- Protect animals. Pick them up carefully with gloved hands or a brush. Put them in containers with small holes to provide air. Return them to the habitat afterwards.



Things to take with you



Some ideas of where to look

Exploring a habitat

Green plants use simple raw materials: water and carbon dioxide, to make sugars such as glucose. Sugars can be changed to starch, fats and oils. With mineral salts, they can form proteins. All these foods contain trapped energy from the Sun. In the process of photosynthesis, oxygen is also released.

Plants break down some of the foods during respiration to release energy for their own activities. The energy trapped in photosynthesis is released in respiration. The excess food the plants store in roots, stems, leaves, seeds and fruits. Some of this is for the plant to use later for its own growth, but animals also use it as their food.

No animal can make its own food, nor can it make oxygen. All animals depend ultimately on plants for oxygen, food and energy. Animals feed on plant parts, or on other animals. Respiration then releases energy for their activities. You can make a list of activities that use energy.

PS 8.9 What eats what?

Materials: hand lens, glove, notebook, pencil

Method

For this activity, just observe and record. Do not collect.

1 Record the different plants you see, and any animals that are feeding on them.

2 Look for organisms feeding:
   (a) on leaves (caterpillars, slugs)
   (b) in dirty water (mosquito larvae and pupae)
   (c) in mounds of earth (ants and earthworms)
   (d) under rotting leaves (cockroaches and woodlice)
   (e) in tree crevices (ants and termites)
   (f) in tall grass (grasshoppers and praying mantises)
   (g) on flowers (insects and birds)
   (h) on rotting wood (termites and mushrooms).

3 Make and fill in a table like the one below.

Name of organism	Where do you find it?	What was it eating? or It makes its own food?	What eats it?

4 Look carefully at what you have recorded, and identify
- producers (plants on land or water that make food),
- consumers (animals that eat food), and
- decomposers (live on decaying material and make useful things available again).

5 Look at the consumers. Can you divide them into three groups: those that eat plants (**herbivores**), those that eat animals (**carnivores**) and those that eat plants and animals (**omnivores**)?

6 To which group of consumers do humans belong? What about vegetarians and vegans?

What does it mean?

Producers: Plants that produce energy-containing foods and oxygen.

Consumers: Animals that have to eat energy-containing foods.

Primary consumers: These are herbivores that eat plants.

Secondary consumers: These are carnivores that eat herbivores.

Tertiary consumers: These are carnivores that eat carnivores.

Omnivores: These animals eat both plants and animals.

Decomposers: These organisms, e.g. fungi and bacteria bring about decay and release mineral salts into the soil to be taken up again by plants.

Interdependence

Animals depend on plants for

- Food. Only plants photosynthesise, and all animals eventually depend on plants for their food and source of energy.
- Oxygen. Only during photosynthesis, is oxygen released. This is needed for respiration in all living things.
- Shelter. Many animals depend on plants, e.g. birds to build their nests.

Plants depend on animals for

- Carbon dioxide. From animal respiration and burning fossil fuels: used in photosynthesis.
- Pollination. Insects and birds pollinate some flowers.
- Dispersal. Animals disperse fleshy and sticky fruits.

Questions

1 List the parts of a flowering plant. For each part, try to identify an animal that uses it for food, for example: flower (nectar) butterfly.

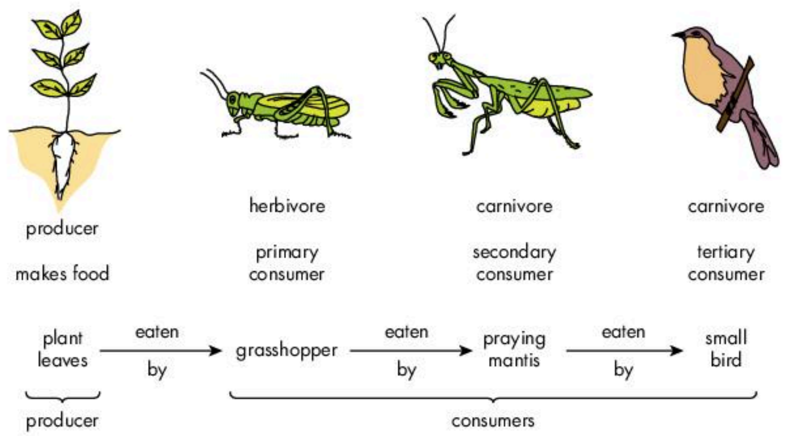
2 Do you think green protists are also producers? Why?

3 How do aquatic animals get food?

Food chains

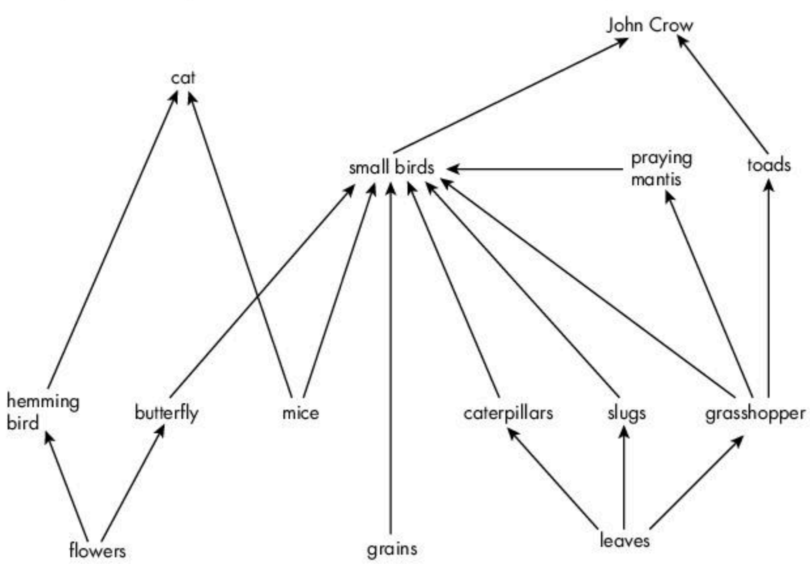
We can show the feeding relationships between organisms by drawing a **food chain**. This shows the producer and consumers, and has arrows to show how each organism is eaten by the next one. Within the group of consumers we can identify different feeding or **trophic levels**, depending upon what they eat.

- Primary consumer, e.g. a grasshopper (a herbivore) eats producers.
- Secondary consumer, e.g. a praying mantis (a carnivore) eats animals that have eaten plants.
- Tertiary consumer, e.g. a small bird (also a carnivore) eats animals that have eaten animals.
- Omnivore, e.g. humans eat both plants and animals, and so they are both herbivores and carnivores.



Food webs

In a particular habitat, the animals will eat more than one kind of food. We can link together the food chains to form a **food web**, for example that found on the school compound.



▶ See Workbook Food chains and webs.

How do food chains work?

- Green plants only need water, carbon dioxide, the Sun's energy and mineral salts to make all their food.
- The plant uses some of this food for its own needs, by respiration. This releases carbon dioxide and water (for photosynthesis) and energy (for life processes). The plant stores excess food.
- A herbivore eats the plant's excess food. This is digested and some is then respired to release carbon dioxide, water and energy. Excess substances are used for growth.
- A carnivore eats the herbivore (and its stored food). This is digested and some is then respired to release carbon dioxide, water and energy. Excess substances are used for growth.
- All the organisms in the food chain eventually die. Their remains become the food for decomposers. These break down the remains to release carbon dioxide, water and mineral salts, which are recycled for the plants to use again.

How do food webs work?

- The animals in a habitat eat more than one thing. If one kind of food runs out, they may be able to survive by eating something else.
- Each plant is a source of food for several different animals, so the animals will compete with each other.
- Each herbivore is a source of food for several different carnivores, so the carnivores will compete with each other.
- Animals that are killed and eaten by others are called **prey**. Caterpillars are the prey of small birds. The small birds are called **predators**.
- The small birds in turn become the prey of the larger predator, John Crow. So small birds have to be looking for food at the same time that they are avoiding becoming the food for another animal.

8.10 Make some food chains

1 The photographs below show parts of six different food chains. Discuss in small groups, what is shown in each photograph. Then suggest at least two other steps in that food chain.
2 Write out your food chain, and label each organism as a producer, primary consumer, secondary consumer etc.

Falcon eating a small bird

Bees eating a mouldy fruit

Limpet eating algae

Cows eating grass

Bird eating nectar

Human eating beans on toast

8.11 Mr Cherian's fish farm

Mr Cherian's fish farm contains a lot of pondweed. Tadpoles and mosquito larvae feed on it. Each month Mr Cherian puts in new small Tilapia fish that eat some tadpoles and mosquitoes and keeps down the numbers. He also adds some fertiliser and fish food supplements. At the end of the month he takes out the biggest fish, which he sells in the market. He and Mrs Cherian also eat some for themselves.

He removes any diseased fish from the pond, but lets other wastes fall down to the bottom of the pond where they are decayed with other dead materials by bacteria.

Questions

1 Identify the producer, herbivores, carnivores and decomposers. Draw food chains and then a food web to show the organisms. Include the humans who buy and eat the fish. Label each organism (e.g. primary consumer: herbivore) to show its position in the food web.
2 Why does Mr Cherian add fertiliser to the water?
3 How does Mr Cherian make sure that the fish get enough food?
4 How do the fish get oxygen to breathe?
5 How are raw materials recycled in the pond so that the pondweed can keep growing?
6 Where does the energy come from that the pondweed needs for photosynthesis?
7 How is the trapped energy in the food used by (a) the pondweed, (b) the tadpoles and (c) the fish?
8 What might happen if:
   (a) The frogs did not come to the pond to lay eggs?
   (b) Mr Cherian went on holiday for two months and no-one looked after the fish farm?
   (c) The pondweed died?

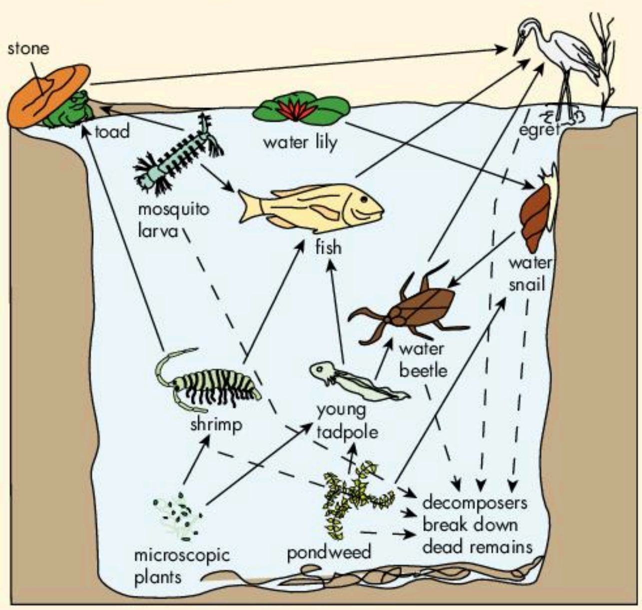
▸ **See Workbook Food chains.**

8.12 Feeding relationships in a pond

Materials: net, plastic dish, notebook, pencil, plastic bottles, microscope, glass slide, cover slip

Method

1. Observe the surroundings of the pond. Look for frogs, toads and wading birds such as herons or egrets.
2. Look into the water and see if you can observe small and large fish and water beetles.
3. Use the net to collect any small animals. You may find mosquito larvae and pupae, shrimps, tadpoles and water snails. Put the water and specimens in the dish and ask your teacher to help you with identification.
4. Look for plants. You may find water lilies on the surface and different kinds of pondweed in the water. Take some of the pondwater back to school as it will contain microscopic organisms that can be used as food by the small animals.
5. In the laboratory, observe some of the pond water for microscopic plants. Record all your observations and then return the organisms to the pond.
6. The picture below shows the feeding relationships in a pond. Use it to write out ten different food chains, each containing three organisms.



Questions

Based on the feeding relationships in the pond:

1. Which animals compete to eat (a) microscopic plants? (b) shrimps?
2. What are two foods of (a) water snails? (b) water beetles?
3. Name (a) a herbivore, (b) a primary consumer, (c) a secondary consumer, (d) a tertiary consumer.
4. What are (a) the prey and (b) the predator of the fish?

Recycling of raw materials in a pond

Green plants trap energy from the Sun using chlorophyll in their chloroplasts. The raw materials that they need to make food are water, carbon dioxide and mineral salts.

Where do these come from?

- Water is all around the plants. The plants have thin walls and take in water by osmosis.
- Carbon dioxide is dissolved in the water. It is produced as all the organisms respire, and as decomposers break down the wastes and dead remains of organisms in the pond. Carbon dioxide also diffuses into the water from the air, so it can then diffuse into the plants that carry out photosynthesis.
- Mineral salts are used by plants to build proteins. The proteins are part of the food eaten by animals along the food chain, and digested and rebuilt into the proteins of different animals. When the plants and animals die, these remains become the food of decomposers. These organisms break down the remains into carbon dioxide, water and mineral salts. These are then in the water for the producers.

So the raw materials needed for photosynthesis are recycled. The energy is **not** recycled: it is used up for growth and life activities, and some of it is 'lost' as heat at each stage of feeding. But the Sun still shines, so producers can continue to trap more energy into food and keep the food chains working.

Fun facts

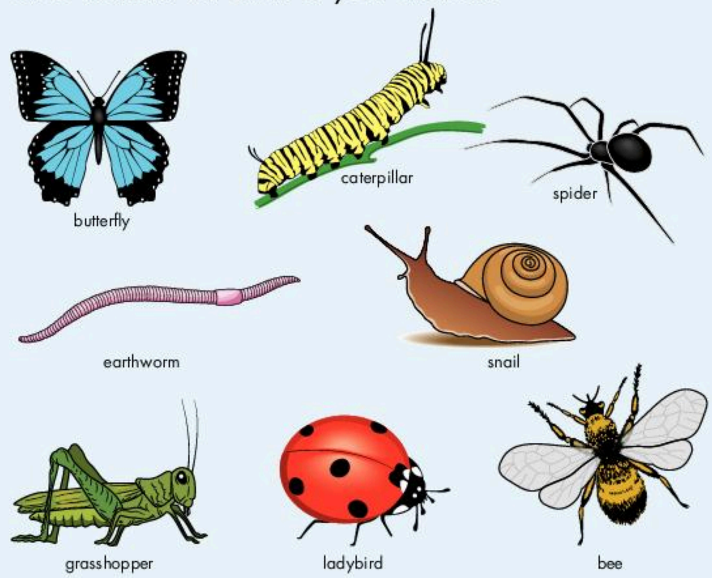
- Shrimps are 'filter-feeders'. They take in water containing microscopic plants that they filter out for food.
- Young tadpoles are herbivores, older tadpoles and frogs are carnivores.
- Mosquito pupae are eaten, but do not eat.

8.13 Good or bad in the garden?

The organisms living in a habitat compete with each other and with humans for food. As an example, a caterpillar eats leafy vegetables. But some animals, such as bees may be useful to pollinate flowers and make honey.

ICT

1 Research and identify which of the following organisms are good or bad in the garden.
2 Give reasons for each of your choices.



3 Prepare two food chains, starting from green plants, using the organisms shown above.

What does it mean?

Habitat: The place where a plant or an animal lives.

Sample: Small part that represents the whole, e.g. part of the habitat.

Feeding level: The position of a plant or animal in a food chain, e.g. producer or primary consumer. Also called an energy level or a trophic level

Biomass: The amount of living material, e.g. at one energy level in a food chain.

Ecosystem: All the organisms in a habitat as they are affected by the environment (soil, weather etc.)

Energy levels

We can arrange the organisms in a habitat into their feeding or energy levels (see right).

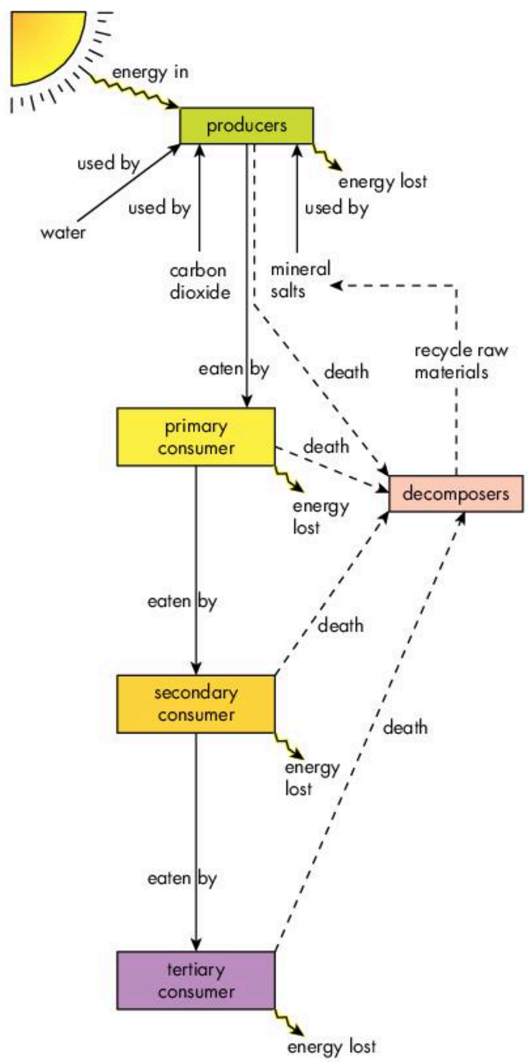
Plants occupy the first energy level in each food chain and in the food web. They trap the energy from the Sun and produce energy-containing food and release oxygen. An example of a producer is vegetable crops.

The next energy level is the herbivores or primary consumers that eat the producers. Examples are caterpillars, snails, grasshoppers and aphids. These organisms directly compete with humans for food.

The next level, the secondary consumers (carnivores) eat the herbivores. So, for example, birds eat caterpillars and snails, praying mantises eat grasshoppers, and ladybirds eat aphids. These animals help humans to protect their food.

In turn the tertiary consumers (also carnivores) eat smaller carnivores. So, for example, spiders eat both small herbivores and carnivores, and larger birds eat smaller birds.

The decomposers then decay all the wastes and dead remains and release the mineral salts again for the plants.

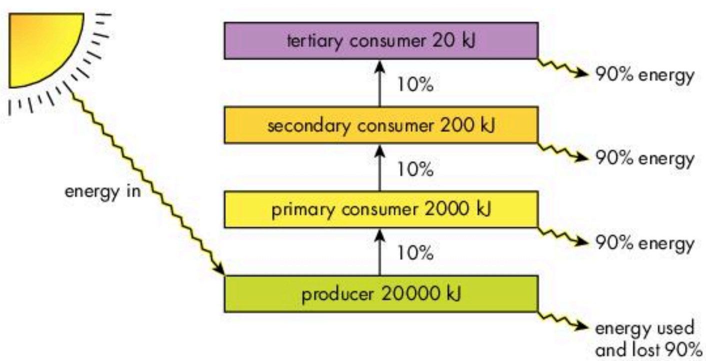


Energy or trophic levels in an ecosystem. Notice how the decomposers recycle the raw materials for plants to reuse

Raw materials and energy

- Raw materials are water, carbon dioxide and mineral salts. They can only be used as a source of food by producers (green plants, plant plankton and green protists) because only they can build them into energy-containing food. You have seen how food passes along the food chains, with each organism feeding on others. When the organisms die, the decomposers decay their remains. The raw materials are released and return to the soil, air or water, depending on the food web. Raw materials are recycled to be used again by the producers.
- Energy passes one-way through a food chain. It is not recycled. The arrows that show which organism eats another also represent the flow of energy along the food chain. Food chains only have four or five links in them. This is because energy is used, and lost, along the way.

  At each level, about 90% of the energy is used for staying alive and moving, and lost in urine and faeces and as heat. Only about 10% becomes new flesh for food for the next level. Also, the food material at one level is not all eaten, and so not all the energy is passed on. This loss of energy means that the numbers of organisms usually get less at each level, and there is less living material as we go up the food chains.



How energy is lost as it goes up the food chain

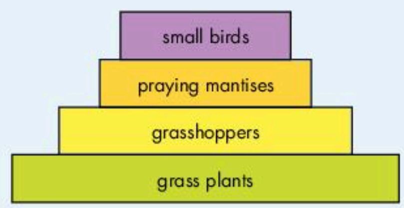
Questions

1 Is it more 'energy-efficient' for humans to eat a vegetable patty rather than a meat patty? Explain.
2 Identify all the ways in which energy is used (a) by a plant and (b) by an animal such as a human.

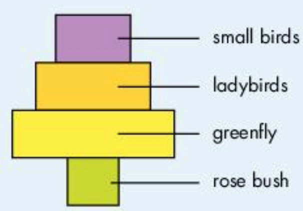
8.14 Pyramids of numbers

Materials: notebook, pencil, net
Method
Work in small groups to investigate the numbers of organisms at each level.

1 Go outside and choose area **(a)**: a sample representative of the habitat, e.g. an area of grass.
2 Make a rough estimate of the numbers of grass plants, grasshoppers, praying mantises and small birds.
3 Choose area **(b)**: a sample centred around one large shrub or tree. Identify the producer and try to find primary, secondary and tertiary consumers.
4 The diagrams below show two pyramids of numbers:
   (a) Which one corresponds to your sample **(a)**? Explain your answer.
   (b) Which one corresponds to your sample **(b)**? Explain your answer.
   (c) Which pyramid might also be used to show a pyramid of biomass?



(a) Pyramid of numbers



(b) Pyramid of numbers

Quick check ☑

Living things need ________ to stay alive. Food ________ and webs are how organisms ________ on others. ________ are at the beginning of all food ________. Various levels of ________ depend on them. Raw materials are ________ in a food web. ________ is not recycled.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

energy **producers** **feed** **recycled** **consumers** **chains**

Humans and food webs

8.15 Humans and other living things

Materials: magazines and newspapers, scissors, paste, card

Method

1 Collect pictures of plant parts that humans eat, e.g. beans, callaloo, yam, and sort them into plant organ, e.g. roots.
2 Make a display chart and add annotations.
3 List other ways in which we use plants, and find examples, e.g. for timber for building and fuel.
4 How do humans change the environment to (a) grow crops, (b) rear animals and (c) for housing and development?

Humans affect a food web by changing the environment, e.g. removing forest trees or by killing one kind of organism, e.g. rats. These changes upset the balance in the food web.

8.16 What happens if ...?

In small groups, discuss and report on the following.

1 The person who owns the pond (page 37) decides to remove all the water lilies. The water snails, which eat the water lilies, would have to eat more pondweed or they would die. But if the snails ate more pondweed, there would be less for the tadpoles. Find two other effects that might occur.
2 The egrets are not visiting the pond this year. What will be the effect of this on (a) water beetles (b) water snails and (c) the fish in the pond. What other things might happen?
3 The owner lets the pond become very dirty, and little light can reach the microscopic plants and pondweed. What will happen to the plants? What effect will this have on (a) the shrimps, (b) the tadpoles and (c) the fish?
4 Work with a partner. Use the food web on page 35. Choose an organism and ask your partner to give three results that would happen if that organism were removed, e.g.
   (a) Which organisms would get eaten less, and so increase in numbers?
   (b) Which organisms would get eaten more, and so decrease in numbers?
   (c) Which organisms would go hungry as their food has gone?
   (d) Which organisms would now have to compete for other food sources?
   (e) Which other organisms in the food web would be affected, and how?
5 Research an endangered species of your choice. Consider the food sources, natural enemies and habitat. Were any of these upset by humans or natural disasters to cause the species to become endangered? ICT

Mrs Brown's cabbages

Mrs Brown was proud of her cabbages. They grew well and all her family enjoyed eating them. She had even won a prize with her best one!

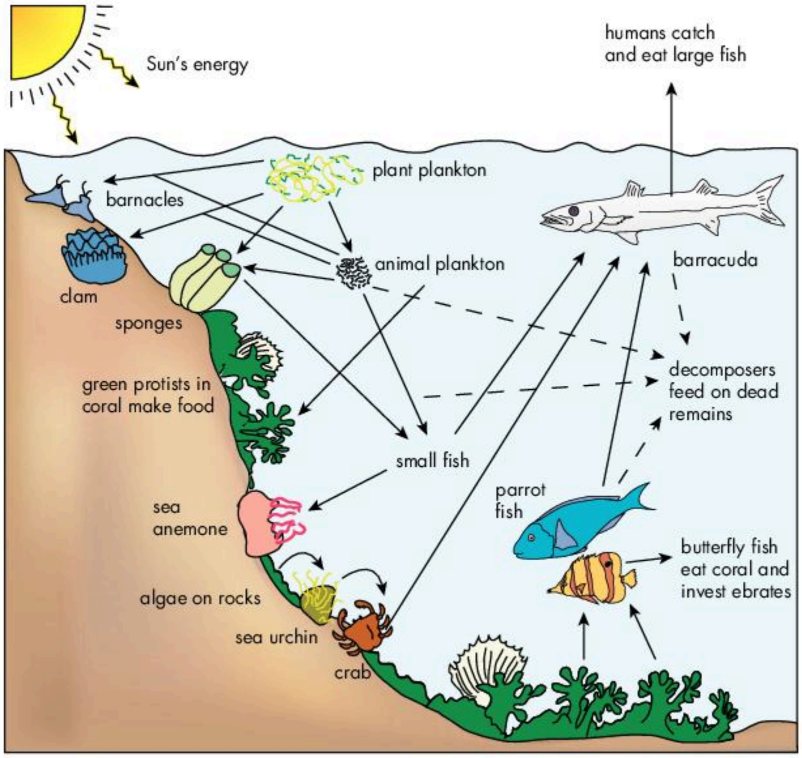
Mrs Brown went to stay with her sister in Mandeville, who was ill. She was away for some time. When she returned, she was dismayed to see her cabbages.

Questions

1 What might have caused the damage to Mrs Brown's cabbages?
2 Draw a food web showing all the organisms involved.
3 What will happen if Mrs Brown did each of these things?
   (a) Eating the cabbages when they were younger
   (b) Washing off the caterpillars with soapy washing-up liquid and killing them.
   (c) Encouraging more birds to come to the garden.
   (d) Covering the young cabbages with a net.
   (e) Letting a cat chase away any birds.
   (f) Spraying the cabbages with insecticide.

Food chains and web on a coral reef

The diagram shows the feeding relationships on a coral reef.



- Corals are of many kinds and are related to sea anemones. Coral is made up of many individual polyps, living together in a colony inside a common skeleton. The tentacles of the polyps come out to feed on plant and animal plankton in the water.
- The coral also contains small algae in its tissues. These carry out photosynthesis, and the coral uses the food that is produced. The algae in the coral are eaten by parrot fish.
- Butterfly fish eat the coral and invertebrates.
- These fish become the food for larger fish, e.g. barracuda.
- Humans also take some larger fish for food.
- Dead organisms are eventually decayed by decomposers to release carbon dioxide, water and mineral salts into the water for the plant plankton and small algae to use.

▶ **See Workbook Humans and food webs.**

8.17 Humans and coral reefs

Work in small groups:

1. Research a coral reef and describe how at least six organisms, from varied feeding levels, live and eat, and are eaten. **ICT**
2. On a certain coral reef, the fishermen have caught large numbers of barracuda Explain the effect of this on (a) parrot fish, (b) coral, (c) crabs and (d) plankton.
3. It has been a clear sunny season, and the plant plankton have increased to large numbers. What effect will this have on (a) the animal plankton, (b) the sponges, (c) small fish and (d) the barracuda?
4. Research how each of these actions affect a coral reef. Prepare an illustrated report. **ICT**
   (a) Climate change (see Grade 7, Unit 7), is causing an increase in temperature. This is destroying green protists inside the coral.
   (b) Higher sea temperatures also mean disease-causing organisms of coral can grow more quickly.
   (c) Excess carbon dioxide in the air is dissolved in seawater, making it more acidic. Coral skeletons are made of chalk.
   (d) Overfishing (removal of so many fish so that the population cannot be re-stabilised) is occurring either with or without the extra problems of use of cyanide and dynamite.
   (e) Pollution from the land in the form of sewage and fertiliser run-off from agricultural land.
   (f) Items from the reef are collected, e.g. for personal use or aquariums.

Quick check ☑

A food web in nature stays in ________. If a certain ________ increases in numbers it will be ________ by another one. Humans and natural ________ can upset the ________. It may take many ________ or it may be impossible to ________ the damage, e.g. to coral reefs.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

balance **organism** **reverse**
eaten **disasters** **years**

Questions

Answer these questions in your notebook.

For questions **1–28** answer **A, B, C** or **D**.

1 Which of these is a modification of leaves for photosynthesis?
A a thin flat shape with large surface area
B a lot of air spaces near the lower epidermis
C arrangement of leaves on the plant
D all of the above

2 Which of these is NOT important for photosynthesis?
A shiny top surface of a leaf
B lower surface of leaf with many stomata
C many chloroplasts inside the leaf cells
D mid rib and veins in the leaf

3 Which of these do the veins of leaves NOT carry?
A water **B** carbon dioxide
C mineral salts **D** food

4 Which cells in a leaf have the most chloroplasts?
A cells in the veins
B closely packed cells near the top surface
C spongy layer of cells near the lower surface
D cells in the upper and lower epidermis

5 Which of these statements is correct? Photosynthesis is carried out only by
A land plants
B flowering plants
C plants containing chlorophyll
D green plants

6 Which things are combined in photosynthesis?
A carbon dioxide and chlorophyll
B carbon dioxide and water
C carbon dioxide, water and energy
D oxygen, water and energy

7 What gas is given off in photosynthesis?
A oxygen **B** carbon dioxide
C water vapour **D** all of the above

8 If the leaf from a de-starched plant is tested with Iodine solution, it will
A stay the same colour
B all turn blue-black
C partly turn blue-black
D all turn a pale blue

9 Water is taken to the leaves by the
A root hairs and cells in the root
B root hairs, cells in the root and xylem
C root hairs, cells in the root, xylem and phloem
D stomata in the lower epidermis

10 Which of these is NOT a function of xylem? To transport
A water **B** mineral salts
C food **D** all of the above

11 What happens to the sugars produced during photosynthesis? They can be
A changed to starch in the leaf
B transported in the phloem
C combined with mineral salts to make proteins
D all of the above

12 In the daytime, which gas or gases enter the leaves of the plant from the air?
A carbon dioxide alone
B oxygen alone
C oxygen and water
D carbon dioxide and water

13 In the night-time, which gas or gases leave the leaves of the plant and go into the air?
A carbon dioxide alone
B oxygen alone
C oxygen and water
D carbon dioxide and water

14 What is a difference between plants and animals?
A only animals need to take in oxygen
B only animals need to carry out respiration
C only plants can make their own food
D only plants lose water vapour

15 Which of these is important to use when observing and collecting organisms?
A a hand lens
B a collecting bag
C notebook and pencil
D all of the above

16 In which of these places are you LEAST likely to find small invertebrates?
A under leaves **B** in the open on a rock
C in dirty water **D** in cracks in a wall

17 What kind of organism is found at the beginning of each food chain?
A consumer **B** herbivore
C producer **D** decomposer

18 An organism that eats plants and animals is
A an omnivore only
B a consumer and an omnivore
C a consumer only
D a decomposer

19 An organism that decays plant and animal remains to release raw materials is
A an omnivore **B** a decomposer
C a carnivore **D** a herbivore

20 An animal that eats herbivores for food is a
A producer **B** primary consumer
C secondary consumer **D** tertiary consumer

21 Which is the correct order of organisms in a food chain?
A producer, herbivore, carnivore
B producer, carnivore, herbivore
C herbivore, producer, carnivore
D carnivore, producer, herbivore

22 What is the local area where plants and animals live
A community **B** population
C habitat **D** environment

23 If a carnivore is removed from a food web, which organisms may be affected?
A another carnivore that eats it
B a herbivore that is eaten by it
C an animal in competition for the same food
D all of the above

24 In most food chains, the numbers of which organisms will be greatest?
A producers **B** primary consumers
C secondary consumers **D** tertiary consumers

25 In most food chains, the biomass of which organisms will be least?
A producers **B** primary consumers
C secondary consumers **D** tertiary consumers

26 Which statement is correct about food chains?
A Both raw materials and energy are recycled
B Neither raw material nor energy is recycled
C Energy is recycled, but not raw materials
D Raw materials are recycled, but not energy

27 From where do corals get most of their food?
A from the green protists in their tissues
B from the rocks on which they grow
D from the fish that swim amongst their tentacles
D they can carry out photosynthesis

28 How do humans affect coral reefs?
A through global warming that raises sea temperature
B through rise in carbon dioxide that makes seas more acidic
C by using dynamite to stun fish and overfishing
D all of the above

For questions **29–50** write full answers.

29 List and explain four (a) external and (b) internal features of a leaf suiting it for photosynthesis.

30 (a) Why is photosynthesis so important? Give three reasons. (b) How do the raw materials get to the leaf cells? (c) Write a word equation for photosynthesis.

31 Describe the steps you would take to show that photosynthesis has occurred.

32 (a) What conditions are necessary for photo-synthesis to occur? (b) Describe a fair test to show the importance of one of the conditions.

33 How can brown and red seaweed and variegated leaves carry out photosynthesis?

34 Outline four things that can happen to the sugars produced in photosynthesis.

35 Describe three storage organs of plants that are used as food by humans.

36 What are the roles of (a) xylem and (b) phloem in the feeding process of plants?

37 Explain three ways in which (a) animals depend on plants, (b) plants depend on animals.

38 Explain these words and give an example of each:
(a) producer, (b) herbivore, (c) omnivore,
(d) consumer, (e) carnivore, (f) decomposer.

39 Write four imaginary accounts of what would happen in a world without: (a) producers, (b) herbivores, (c) carnivores, (d) decomposers.

40 What are (a) food chains and (b) food webs?

41 (a) Prepare three food chains from these organisms: lettuce, humans, cat, grass, praying mantis, small birds, slugs, grasshopper. (b) Combine the food chains to make a food web. (c) Give three results of killing all the slugs.

42 Outline how the Sun's energy can be made available to you to answer this question.

43 Why is it sometimes difficult to say why a particular animal, e.g. caterpillar or spider is good or bad for the garden?

44 What happens to (a) the raw materials and (b) the energy in a food chain?

45 (a) Why is the energy trapped at one food level not all transferred to the next food level? (b) About how much of the energy is 'lost'? (c) What do we mean by 'lost'?

46 How are the pyramids of numbers and of biomass (a) similar and (b) different?

47 Explain why food chains only have four or five levels.

48 Describe four ways in which humans upset the balance of nature in order to (a) use food chains to supply them with food (b) use the land in other ways.

49 Describe four ways in which humans are harming the coral reefs.

50 Write three sentences to explain the importanceof this Unit 'Photosynthesis and energy relationships'.

Key ideas

- The leaf blades (lamina) are held to catch the sunlight, are thin and flat, and supported by the veins and leaf stalks (petioles).
- Inside, the leaf has many chloroplasts, veins, large air spaces and stomata.
- Chlorophyll traps light energy, which is used in the chemical reactions of photosynthesis.
- Water (from the soil) and carbon dioxide (from the air) are combined in photosynthesis.
- The products are oxygen (passed out into the air) and sugars (changed into starch, fats and oils).
- Mineral salts (from the soil) are combined with sugars to make proteins.
- Photosynthesis can be shown by killing and softening the leaf and adding Iodine solution; this turns blue-black if starch is present.
- Plants use sugars and combine them with oxygen to release energy in respiration. The other products are water and carbon dioxide.
- Plants store sugars, starch, fats, oils and protein for day-to-day use for energy release and growth and for storage for reproduction.
- Some plant food stores can become a source of food for animals.
- Plants are called producers. They produce food and oxygen for all living things.
- A food chain shows, by using arrows, which organism eats another.
- Food in plant roots, stems, leaves, fruits and seeds is eaten by herbivores (primary consumers).
- Then the secondary consumers (carnivores), eat herbivores and consumers eat them.
- Omnivores eat both plants and animals.
- In the habitat there are several interconnected food chains that produce a food web.
- Decomposers feed on dead organisms and return raw materials for the re-use of producers.
- Energy is not recycled; it is used up along the food chain. More sunlight is needed for plants.
- The numbers of organisms at each feeding or energy level is called the pyramid of numbers.
- Humans can upset the balance in a habitat by removing or adding new organisms.
- Human activities, e.g. climate change and overfishing can have a bad effect on coral reefs.

▶ **See Workbook Photosynthesis and energy relationships.**

Problems

1 For photosynthesis to occur a plant needs:
- carbon dioxide and water as the raw materials
- chlorophyll and light energy as the conditions.

Oxygen and sugars (quickly changed to starch) are produced.

In order to determine the rate at which photosynthesis occurs under different conditions you are going to use the experiment with pondweed (*Elodea*) from page 30. The rate of photosynthesis can be measured by the rate at which bubbles of oxygen are released.

Work in a small group:

(a) Discuss how you will set up a fair test to find out the effect of changing the amount of light falling on the plant. Hint: one idea would be to use a lamp at different distances and also to find the rate in a shaded place.

(b) Work out the details of your plan and check it with your teacher.

(c) How will you make sure that the plant has become used to each new light condition before you start to count the bubbles?

(d) For how long will you take readings of the number of bubbles for each light condition?

(e) How will you record your results?

(f) Carry out your experiment and record your results in a table and line graph.

(g) Another student criticizes your experiment and says that, as the lamp is hot it may be the higher temperature, rather than the extra light that is the reason for any differences. What do you think? Is this an uncontrolled variable? How could you change your experiment?

(h) Try the adjusted experiment and see if you get similar results to before.

2 Carbon dioxide is a raw material for photosynthesis. How could you increase the concentration of carbon dioxide in the water to find its effect?

(a) Discuss your ideas in the group.

(b) Work out the details of your plan and check it with your teacher.

(c) Carry out your experiment and record your results in a table and line graph. You can draw your own, or use Excel(R).

Unit 9

Physical and chemical changes

1 Do you think the reaction of calcium with water is a physical or chemical change? Give reasons for your answer.

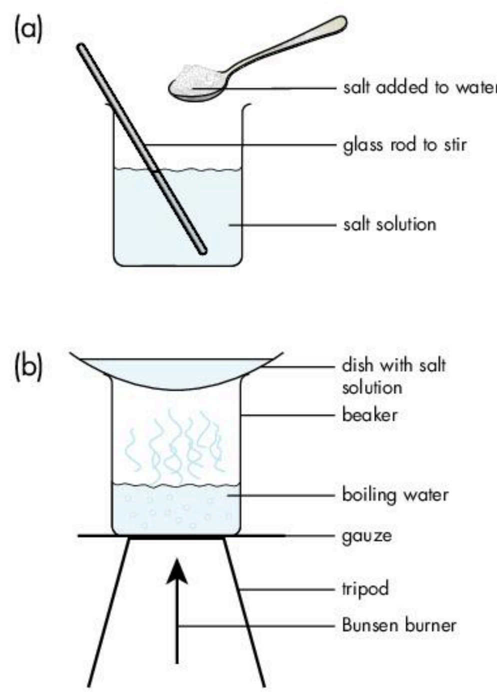
2 The samples are iron, iron sulphide and sulphur (but not necessarily in that order). Identify elements and a compound.

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.

This unit will help you to:

- *classify matter as pure and impure*
- pure substances are single substances (elements and compounds), and impure substances are mixtures
- state that elements are made of atoms or molecules of one element and compounds of molecules of two or more elements
- investigate, compare and give examples of physical and chemical changes
- match the differences in properties of the parts of a mixture to the method used to separate them
- design and explain their investigations.



3 Are the two reactions: (a) dissolving of salt and (b) evaporation of water, physical or chemical changes? Give reasons for your answer.

Pure and impure substances

We can describe substancces as pure or impure.

- A pure substance is a single substance; it has particles that are all the same. Pure substances are either elements (e.g. carbon) or compounds (e.g. carbon dioxide).
- An impure substance is a mixture of substances; it has particles of more than one kind (e.g. seawater).

9.1 Looking at substances

Materials: samples of gold, copper, carbon (soot, charcoal, graphite), sodium chloride (common salt), sugar, distilled water, salt solution, sugar solution, dirty water, bread.

Method

1 Look at each of your items. Discuss in your group if you think it contains one or more substances.

2 Do the same thing for the items shown in the artwork.

3 Prepare a table listing pure and impure substances. Add to the table other items from the classroom and outside.

9.2 Comparing melting points

Materials: ice made from distilled water, ice made from salt solution (distilled water plus salt), beakers, thermometer.

Method

1 Crush the ice made from distilled water and put it in a beaker. Put in the thermometer.

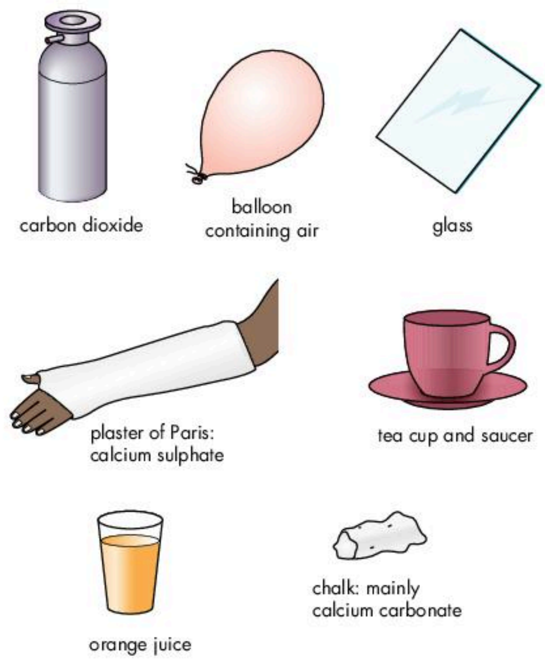
2 Observe and record when the ice melts.

3 Repeat steps 1 and 2 with the ice made from the salt solution. What difference do you notice?

The distilled water should melt at 0 °C. This is a characteristic of pure water. Everyone should get the same result. However, the ice from the salt solution melts at a lower temperature. This is because of the impurity of the salt. Results in different groups may also vary.

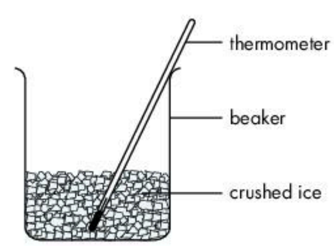
Objectives

- Classify and list examples of pure substances (elements and compounds) and impure substances (mixtures).
- Show that pure substances have fixed boiling and melting points, whereas impure substances do not.
- Describe elements as made of atoms and molecules, and compounds as only made of molecules.



Fun facts

- Soot, graphite and diamond are all pure forms of carbon.
- Chemists have produced tables showing all the fixed boiling and melting points of pure substances.



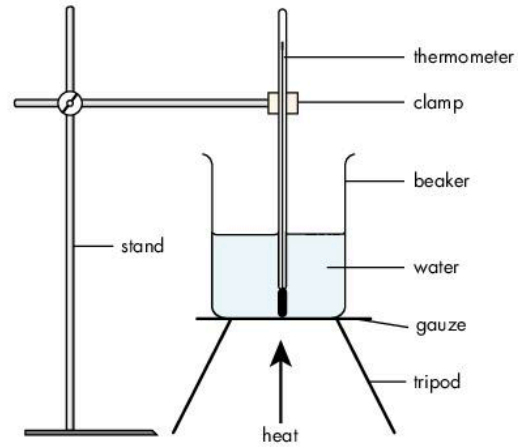
Record the temperature at which pure and impure ice melts. What causes the difference?

9.3 Comparing boiling points

Materials: distilled water, salt solution (distilled water with salt dissolved in it), beakers, heating apparatus, support stand, thermometer.

Method

1. Half fill a beaker with distilled water. Place it on a tripod with a Bunsen burner underneath. Support a thermometer in the water, using a stand and clamp.
2. Heat the water and record the temperature at which it boils.
3. Repeat steps 1 and 2 using the salt solution. What difference do you notice?



Record the temperature at which pure and impure water boils. What causes the difference?

The distilled water should boil at 100 °C. This is a characteristic of pure water. Everyone should get the same result. However, the salt solution boils at a higher temperature. This is because of the impurity: salt. Results in different groups may also vary.

Questions

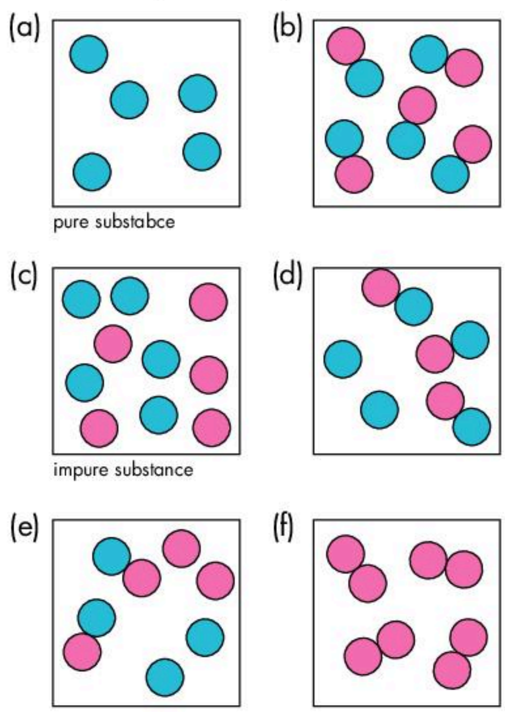
1. What name would you give to the salt that is dissolved in the water: solution, solute or solvent?
2. What is the effect of the salt on (a) the melting point and (b) the boiling point?

Are the particles the same or different?

The diagrams below, (a) and (b) show models of pure substances. All the particles are the same. Model (a) shows an element and model (b) shows a compound. Elements and compounds are pure substances.

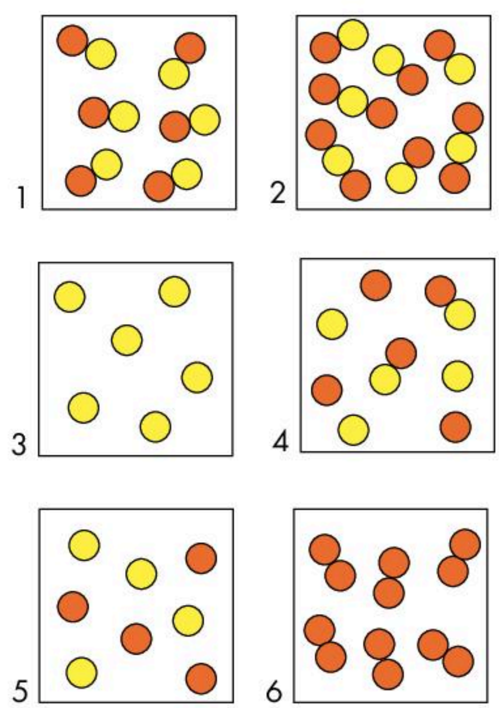
The diagrams (c) and (d) show models of impure substances. The particles are of two or more different kinds. These are models of mixtures. Mixtures are impure substances.

Now look at diagrams (e) and (f). For each one write down whether it contains a pure or impure substance.



▶ See Workbook Pure and impure substances.

Now, for each of the diagrams (1–6) write down whether it shows a pure or impure substance. In each case, also write down whether it contains an element, compound or mixture.



What are the particles made of?

Atoms are the building blocks of matter. Each kind of matter (the elements) has atoms that have special characteristics (see Unit 11 'More about matter').

- Some elements exist as atoms, e.g. carbon and sulphur.
- Other elements, especially gases, exist as molecules, e.g. oxygen and hydrogen.

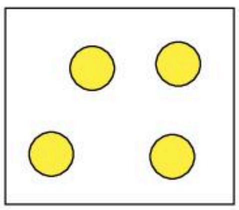
The atoms of different elements can join to make molecules: these are compounds, e.g. carbon dioxide and iron sulphide.

Elements and compounds are pure substances as all the particles are the same as each other, whether they are made of atoms, or molecules.

Fun facts

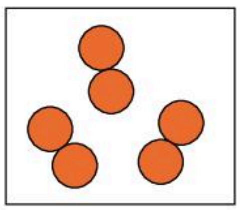
- It was not until 1808 that John Dalton showed that atoms exist.
- An atom is only a few hundred millionths of a centimetre across.
- If an atom was the size of your fingernail, your hand could hold the Earth!
- There are 21 atoms in each lemon juice (citric acid) molecule, and over 1500 in a starch molecule.

An element made up of atoms



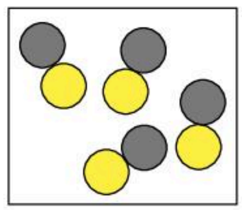
e.g. sulphur

An element made up of molecules with one kind of particle



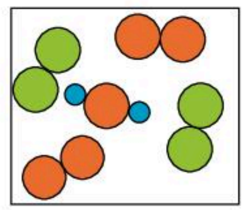
e.g. oxygen

A compound made up of molecules with different kinds of particles



e.g. iron sulphide

A mixture of elements and compounds

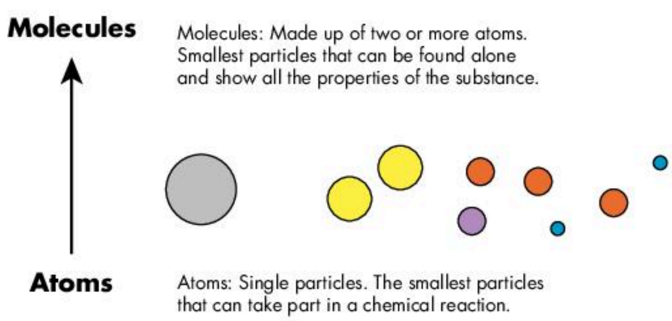


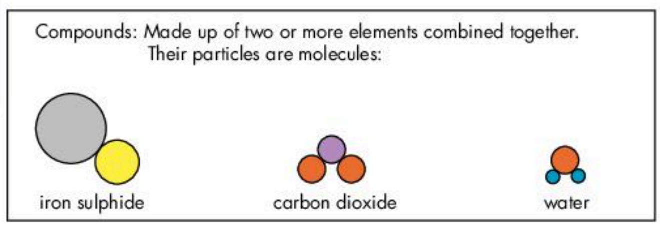
e.g. air

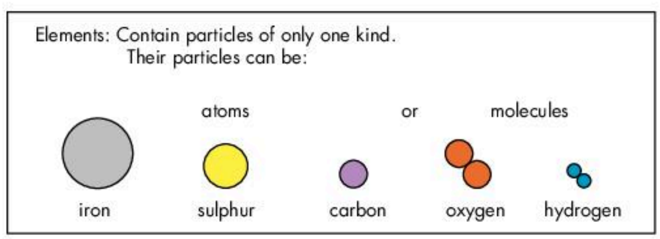
9.4 Making models of atoms and molecules

ICT

Choose modelling clay of different colours to make balls to represent atoms of different elements. Research which elements are needed to make oxygen, hydrogen, carbon, water and carbon dioxide. Make your models.







Quick check ☑

Only pure substances have ________ melting and boiling points. Pure substances have one kind of particle and are ________ and compounds. They are made of ________ or ________. Impure substances are ________; they have ________ or more kinds of particle.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

elements **two** **atoms**
molecules **fixed** **mixtures**

Physical and chemical changes

We can describe the changes that occur in matter as either physical or chemical changes.

- Physical changes can be easily reversed. A physical change can occur in a substance, for example expansion or change of state. No new substance is formed. Mixing substances together can also be a physical change if no new substances are made.
- Chemical changes cannot be easily reversed. A chemical change can occur when we heat some substances. We can also mix and heat substances together. New substances are made. An example is lighting a match or baking a cake.

Objectives

- Investigate and distinguish between physical and chemical changes.
- Explain and give examples of physical and chemical changes.
- Realise that physical changes make mixtures, and chemical changes make compounds.
- Investigate the conditions necessary for rusting.

How many physical and chemical changes occur when a candle burns?

PS 9.5 Physical and chemical changes

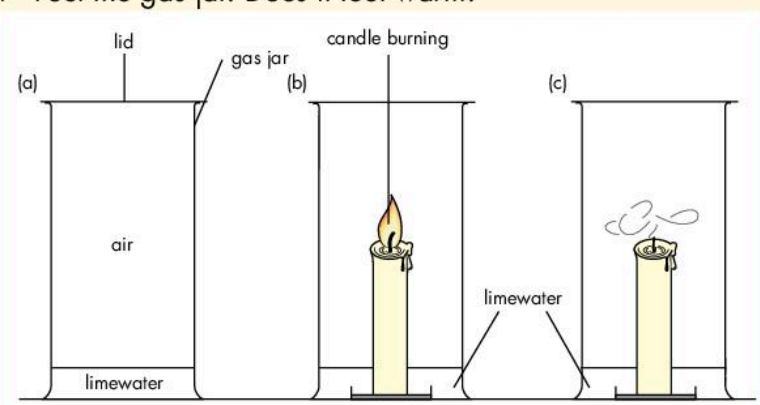
Materials: matches, candle attached to a small lid, gas jar with a lid, limewater.

Method

Work in small groups:

You are to observe every change that occurs. List them and identify which ones are physical and which are chemical changes. Give a reason in each case.

1 Pour a cm of limewater into the gas jar. Put on the lid and shake the jar around. Does the limewater change?
2 Lower the candle and its support into the limewater. Light a match. Record the changes.
3 Use the match to light the candle. Record the changes.
4 Add the lid to the gas jar and let the candle burn.
5 List all the changes you observe in the candle. See how many changes of state you can observe.
6 When the candle goes out, remove it from the gas jar. Put back the lid and shake the jar around. Does the limewater change? What might account for this?
7 Feel the gas jar. Does it feel warm?



8 Your teacher will set up other activities for you. Record your observations and whether the changes are physical or chemical.

▶ **See Workbook Physical and chemical changes.**

Physical changes

- Expansion, e.g. metals in a bimetallic strip, mercury in a thermometer.
- Change of state, e.g. ice, chocolate or butter melting, water boiling.
- Making solutions, e.g. dissolving salt or sugar in water.
- Mixing, e.g. mixing rice and salt.
- Separating, e.g. filtering.

Chemical changes

- Heating to make new substances, e.g. cooking a cake or baking bread, heating iron and sulphur together.
- Mixing certain substances to make new ones, e.g. mixing an acid and alkali to make a salt, adding vinegar to baking soda, putting calcium into water.
- Combustion, such as burning candle wax, and respiration in living things.

9.6 Research, videos and jingles

ICT

Work in small groups:

1 Use a variety of resources to research what is meant by physical characteristic, chemical reaction, physical change and chemical change.
2 View pictures and videos that show physical and chemical changes and prepare your own definitions for these.
3 Compose a jingle, using audio-recording software to distinguish physical and chemical changes. Record it on a CD-ROM. Perform it for the other groups.

9.7 More physical and chemical changes

Your teacher will set up activities with apparatus and materials around the classroom. In groups, go to each place, carry out the investigations to determine which ones are physical and which chemical changes. Then wash up the things you used and leave everything tidy for the next group.

Tabulate your observations on change in composition, properties, reversibility, and change in mass. Give reasons for classifying each reaction and draw conclusions.

Investigation 1

(a) Add one spatula of salt into a beaker, add 5 cm^3 of water and stir. Wait 15 seconds (do not taste). Record observations.
(b) Heat solution to dryness and record observations.
(c) Draw conclusions.

Investigation 2

(a) Add one spatula of baking soda into a beaker, add 15 cm^3 of vinegar and stir. Wait 15 seconds (do not taste). Record observations.
(b) Draw conclusions.

Investigation 3

(a) Add three raisins to a cup of soda water or Sprite®. Record observations.
(b) Draw conclusions.

Investigation 4

(a) Place two ice cubes in a dish and leave for five minutes. Record observations.
(b) Draw conclusions.

Investigation 5

(a) Half fill a test tube with copper sulphate solution and add a 2 cm strip of magnesium ribbon. Record observations.
(b) Draw conclusions.

Summary

Combine your findings and make a chart that compares physical and chemical changes, with examples of each one. Illustrate it with artwork or photographs.

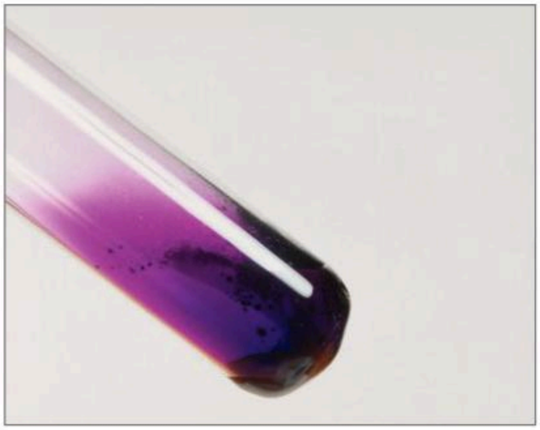
Heating crystals

Your teacher will demonstrate two reactions. Everyone should wear protective clothing and eye goggles.

- Heating iodine crystals

You should observe and record the appearance of the solid crystals. Your teacher will then heat some of these gently in a test tube with cotton wool in the neck. Observe and record.

The test tube is then rested in a beaker. Observe after ten minutes.



- Heating ammonium dichromate crystals

You should observe and record the appearance of the solid crystals. Your teacher will then heat some of these on aluminium foil supported on a tripod stand. Observe and record what happens.

Are the reactions physical or chemical changes? Give reasons for your answers for heating (a) iodine crystals and (b) ammonium dichromate crystals.

Prepare a table for your observations: record the colour and appearance of the chemical(s) before, during and after heating. In which case were new compounds made?

The rusting of iron

Objects made of iron often form a reddish brown covering called **rust**. A new compound is formed, so this is a chemical reaction and it corrodes the surface. Now plan fair tests to investigate the causes and possible prevention of rusting.

PS 9.8 The rusting of iron

Materials: ten iron nails, sandpaper, dry calcium chloride, cotton wool, kettle, test tubes, two bungs, water, oil or Vaseline, paint, paint brush, aluminium foil, scissors

Method

Conditions necessary for rusting

1 To make sure they are clean, begin by rubbing the nails with sandpaper to remove any other surface chemicals.
2 You should design and plan fair tests to find out if (a) air and (b) water are needed for rusting.
3 Here is some information to help you.
   – Dry (anhydrous) calcium chloride can absorb moisture from the air in a test tube.
   – A bung in the neck of a test tube can stop air from getting in or getting out of the test tube.
   – Boiling water in a kettle will drive out any air that was dissolved in the water. Leave the water to cool in a test tube with the bung on (to stop air dissolving in it again).
   – Use six nails for this investigation.
4 Set up your test tubes. What are the conditions present in each one? What prediction is each one testing? Leave for a week and then record your results.

How to prevent rusting

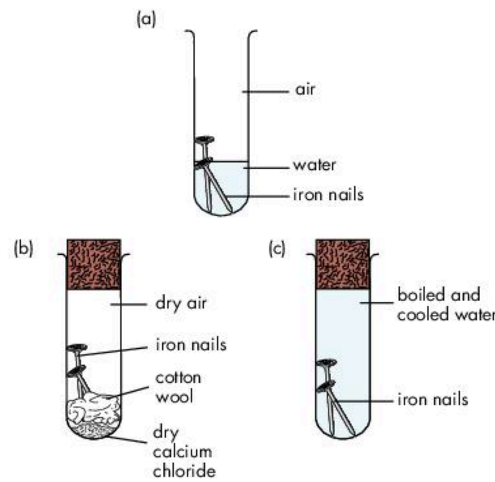
5 Use the other four nails.
6 You should brainstorm, design and plan fair tests to find out how to prevent rusting. Research possible causes and set up your investigation. ICT
7 Here is some information to help you.
   – You need to cover the surface of a nail to keep it away from the atmosphere. Try out your own ideas.
   – Prepare one set-up that you expect to rust.
   – Make sure to control all other variables.
8 What method of prevention against rusting are you testing in each test tube? What prediction is each one set up to test? Leave for a week and then record your results. Were your predictions correct or not? Did they support or disprove the hypothesis on which they were based?

Questions

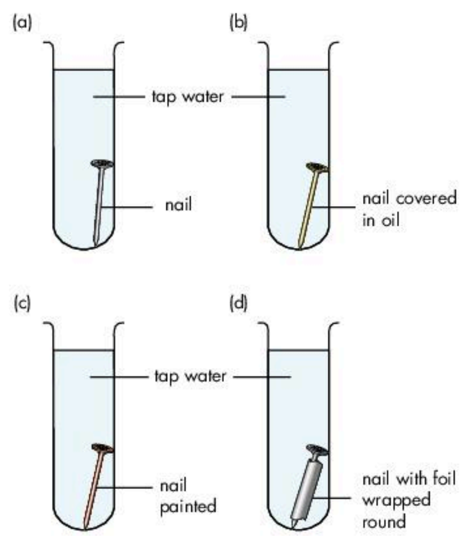
1 What are the conditions necessary for rusting?
2 What methods have you tested to prevent rusting?
3 What other preventative methods can you suggest?

▸ **See Workbook Physical and chemical changes.**

This car has rusted near the shore. How could you find out if salt causes iron to rust more quickly?



What are the conditions in each of the test tubes? Where will rusting occur?



How can we prevent rusting?

Prevention of rusting

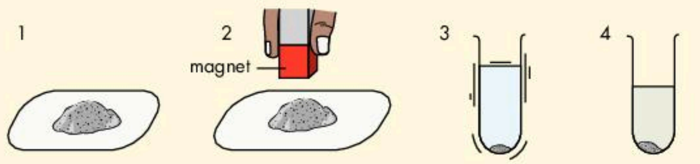
1 Cover with oil or grease.
2 Paint with undercoat and top coat.
3 Cover with a layer of another metal.

9.9 Iron and sulphur

Materials: iron filings, sulphur, test tubes, small dishes, magnet, teaspoons, dilute hydrochloric acid, test tubes, test tube rack, Bunsen burner, tin lid, tongs, pestle and mortar

Method

(a) Properties of the elements: iron and sulphur. Carry out each test on iron and sulphur separately. Record your results.
1. Describe the colour and texture.
2. Test the element with a magnet.
3. Shake a little with half a test tube of water.
4. Add a little to half a test tube of dilute hydrochloric acid.



(b) Properties of the mixture: iron and sulphur. Mix together a teaspoonful each of sulphur and iron. Repeat the tests as for (a) and record your results. What do you notice?

(c) Properties of the compound: iron sulphide.

Your teacher will mix 10 g of iron filings with 7 g of sulphur, and give you some of the mixture. Heat this mixture on a metal lid until it is red hot. This will make the elements combine into the compound iron sulphide. Let this cool and break it up in a pestle and mortar to make a powder. Repeat the tests as for (a) and record your results.

Questions

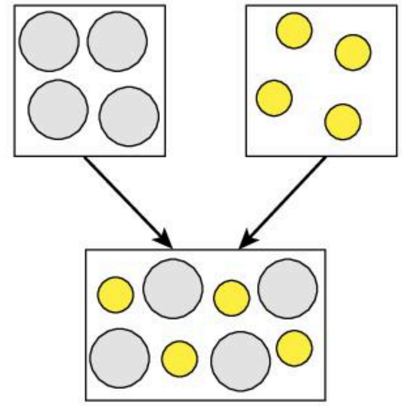
1. Did the elements retain their separate properties in (a) the mixture and (b) the compound?
2. What differences were there in the making of a mixture and a compound? Explain your answer.
3. List all the reactions you have carried out. For each one record if it was a physical or chemical change and give your reasons.

▶ **See Workbook Physical and chemical changes.**

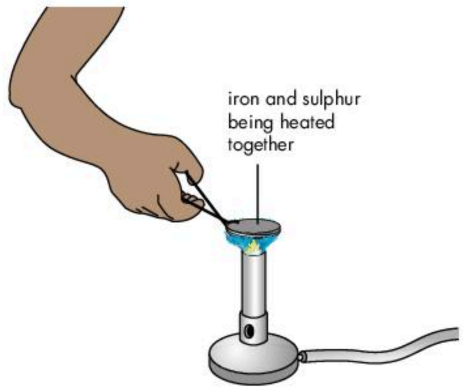
Research on compounds

ICT

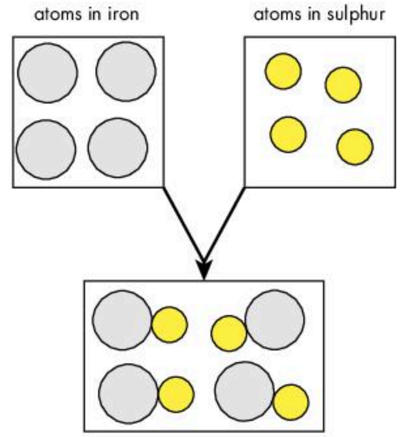
1. Definite a compound and how it is formed.
2. Name three compounds used in the laboratory and their chemical elements.
3. Examine 10 labels of substances found in the home. From the ingredients name two compounds in each.
4. Prepare appropriate displays of your findings.



In a physical change to make a mixture, do the elements keep their own properties? Why do you think this is?



Making the compound: iron sulphide



In a chemical change to make the compound, do the elements still show their properties? Or has a new substance been made with new properties?

When iron and sulphur combine, they are called the **reactants**. They combine to form iron sulphide, which is called the **product**.

Comparing physical and chemical changes

(a) **Composition:** In physical changes the substance stays the same, e.g. a substance can be heated, but it is still the same substance when it cools. In chemical changes, new substances are made, e.g. a candle burns to produce carbon dioxide.
(b) **Properties:** In physical changes only physical properties such as colour, size, appearance, density or state, are changed. In chemical changes, the particles are changed. So the chemical properties of how the substances interact are changed.
(c) **Reversible or not:** Physical changes are usually easily reversed, e.g. steam can be cooled to make water. But chemical changes cannot be easily reversed, e.g. you cannot get the match back after it has been lit.
(d) **Mass of substances:** In physical changes, the masses do not change, e.g. 10 g of ice will melt to give 10 g of water. But in chemical changes, a new substance may have a greater or smaller mass than one of the original ones.
(e) **Heat involved:** In physical changes little heat is usually used or produced, e.g. making a salt solution. In chemical changes, the heat change may be large, e.g. the burning a candle.

Fun facts

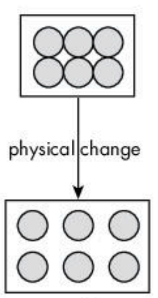
- When the very reactive sodium is combined with the poisonous greenish gas, chlorine, a harmless compound, common salt, is made.
- When the hydrogen and sulphur are combined they make hydrogen sulphide, a poisonous gas.

Questions

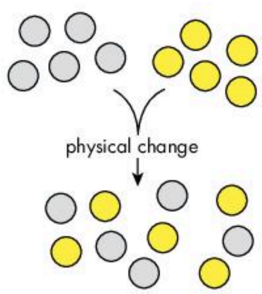
1 (a) A chemical change usually produces or absorbs heat, shows a colour change, produces a gas or forms a precipitate. Describe one chemical change for each of these things. (b) Find out the names of the new substances produced.
2 Make a flowchart to show the physical and chemical changes occurring when dumplings are prepared and cooked.

Physical changes

(a) The composition is not changed.
(b) Only physical properties are changed.
(c) The change is usually easily reversed.
(d) The mass of the substance is not changed.
(e) Usually little heat is used or produced.



e.g. expansion, particles move apart

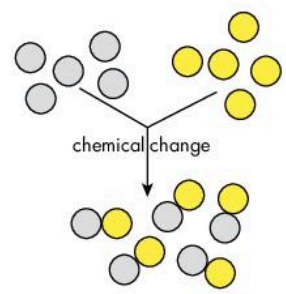


e.g. mixture of iron and sulphur or a solution of salt in water

Chemical changes

(a) New substances with different composition.
(b) Chemical and physical properties are changed.
(c) The change is not easily reversed.
(d) The mass of the substance is changed.
(e) Usually a lot of heat is used or produced.

carbon dioxide (gas)
+
limewater (clear liquid)
↓ chemical change
cloudy liquid of calcium carbonate in water



e.g. making compound of iron sulphide

Quick check ☑

A physical change does not produce ________ substances; it only affects ________ properties. A ________ change produces ________ substances with ________ properties. A change in ________ is a ________ change. The formation of ________ is a ________ change.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

state **different** **new**
chemical **rust** **physical**

Elements, mixtures and compounds

9.10 Investigating properties

Materials: iron, sulphur, mixture of iron and sulphur, powdered iron sulphide, magnet, dishes, test tubes, carbon disulphide solution, dilute hydrochloric acid

Method

Work in a small group:

1 Plan how you will use the materials provided to carry out tests on the elements iron and sulphur, the mixture of iron and sulphur and the compound iron sulphide. You may use any previous results you made.

2 Your tests should help you to prepare a table that compares the properties of elements, mixtures and compounds in general.

3 Compare your table to the one below.

9.11 Classifying substances

Materials: examples, pictures, names and formulae of elements, mixtures and compounds

Method

1 Classify the substances, pictures, names and formulae into a table of elements, mixtures and compounds.

2 Be able to explain why you classified each thing as you did.

Objectives

- Distinguish amongst elements, mixtures and compounds, and give examples in non-living and living things.
- Identify different kinds of mixture, and how we can use the properties of their parts to separate them.

Fun facts

- It is rare to find separate elements in nature. Elements are reactive and combine with others to make compounds.
- Gold is fairly unreactive and it is found as the element.
- Iron and aluminium are mainly found as their oxides. They have to be treated to get the pure elements.

Questions

1 Are the properties of elements shown in (a) the mixture (b) the compound?

2 Does a compound show properties not seen in the elements that made it?

mercury

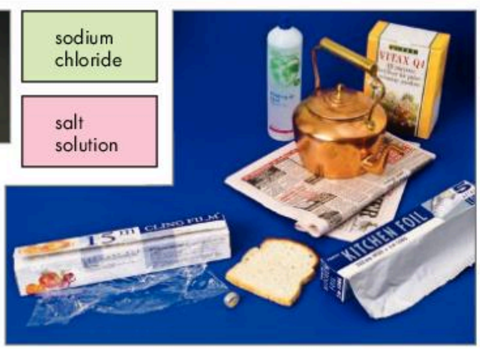
sodium chloride

salt solution

CO_2

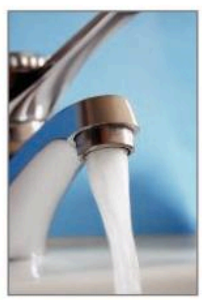
O_2

S

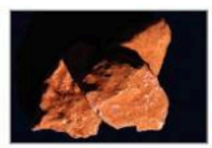


sulphur and iron

hydrochloric acid



Fe



bauxite

iron sulphide

gold

Cl_2

Elements	Mixtures	Compounds
Made of one kind of atom or molecule only.	Made of two or more substances mixed together.	Made of two or more kinds of atom joined together.
Contain only one element.	Variable composition.	Fixed composition.
Each has its own special properties.	Properties are the same as the substances that made them.	Properties are different from the elements in the compound.
Exist on their own.	Made in a physical change.	Made in a chemical change.
Are already separate elements.	Substances can be separated by physical means.	Substances cannot be separated by physical means.

Elements, mixtures and compounds in living things

Flowering plants

- Carbon dioxide from the air and water from the soil provide the plants with **carbon**, **oxygen** and **hydrogen** for building carbohydrates and fats.
- Mineral salts taken in by the roots are the source of the elements needed to make proteins. Minerals may be naturally in the soil, or added as fertilisers. **Nitrogen** is needed to make all proteins; a lack causes stunted growth. **Sulphur** and **phosphorus** are also needed for some proteins. **Magnesium** is part of the chlorophyll molecule, and **iron** is needed for its formation. So lack of either element causes yellow leaves and poor growth.
- Plants also contain hormones that control growth, and enzymes, for use in photosynthesis and respiration. These are all made from proteins, which contain carbon, oxygen, hydrogen, nitrogen and some other elements.

Humans

- We need certain trace elements for healthy growth. We take these in with the minerals in our food, e.g. **iron** (to prevent anaemia) and **calcium** and **phosphorus** (for healthy bones and teeth). We also need iodine (as part of the hormone, thyroxine), and **sodium** and **potassium** (for keeping the correct composition of body fluids).
- We need certain vitamins for healthy growth, e.g. vitamin A (for healthy skin and eyes) and vitamin B1 (for respiration and a healthy nervous system). We also need vitamin C (for healthy teeth and gums) and vitamin D (for healthy bones and teeth). Lack of any of these vitamins cause deficiency diseases.
- All the hormones and digestive enzymes in our bodies are also built up from elements, mainly **carbon**, **oxygen**, **hydrogen** and **nitrogen** with small amount of other ones.
- We get all our needs from what we eat and drink.

9.12 What is in our food?

Materials: labels on boxes, tins and packaged foods.

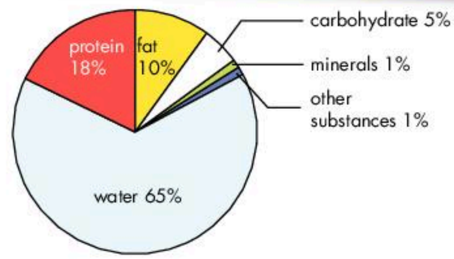
Method

1. Examine the labels. (Do not remove labels from food still being used.) Make a table to record the food constituents, e.g. carbohydrates, fats and proteins and also the amounts of each one.
2. Identify as many elements as you can. For example, if salt is an ingredient, then you can record sodium and chlorine.
3. Are any parts of a healthy diet poorly represented? Would it be important to also include fresh foods? Which nutrients would the fresh foods provide?
4. Use the information you have collected to plan healthy meals for breakfast, lunch and dinner.

Fun facts

An average adult contains about:

- 4.5 litres of water (a sinkful).
- 13 kg of carbon (a sackful).
- 250 g of calcium (enough to make a large box of chalks).
- enough phosphorus for the heads of 2000 matches.
- two teaspoonfuls of sulphur.
- enough iron to make a 2.5 cm nail.



The percentages of substances that make up the human body

What are the elements?

- **Water:** hydrogen and oxygen: H_2O.
- **Carbohydrates:** carbon, hydrogen and oxygen. The hydrogen and oxygen are in the same proportion as in water (2:1). Building block is glucose: $C_6H_{12}O_6$. Also important: sucrose (cane sugar): $C_{12}H_{22}O_{11}$, starch and cellulose.
- **Fats and oils:** carbon, hydrogen and oxygen. But they contain less oxygen than carbohydrates do. Building blocks are glycerol and fatty acids. Different kinds of fatty acids make different kinds of fat.
- **Proteins:** carbon, hydrogen, oxygen and nitrogen. Some also contain phosphorus and sulphur. Building blocks are amino acids. Muscles and the digestive and respiratory enzymes are proteins.
- **Minerals:** in addition to the elements mentioned, our bodies contain small amounts of calcium, potassium, sodium, chlorine, magnesium, iron, zinc, copper, iodine, fluorine and manganese: mainly combined into various compounds.

Different kinds of mixture

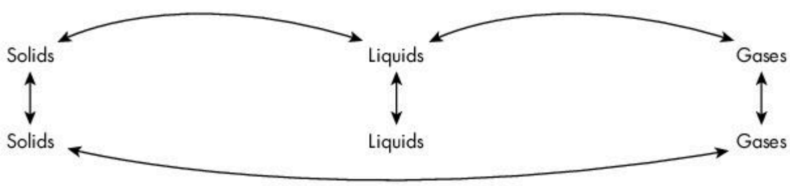
You know mixtures contain two or more different substances The substances are mixed (physically combined), and can be separated by physical means, e.g. filtering. Mixtures have a variable composition, e.g. rice and peas, the air, and soil. The substances making up the mixture can be elements or compounds and can be present as solids, liquids or gases.

Mixtures are divided into two main kinds:

Homogeneous mixtures

These are **solutions**. They look the same throughout. You cannot see the separate substances that make up the solution. Liquid solutions are transparent, e.g. a solution of sugar (the solute) in water (the solvent). Solutions can be:

- a solid and a liquid, e.g. salt dissolved in water,
- a gas and a liquid, e.g. fizzy drinks, oxygen in water,
- a mixture of liquids, e.g. alcohol and water,
- a mixture of solids, e.g. alloys of different metals,
- a mixture of gases, e.g. the air.

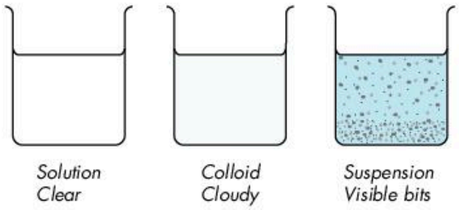


Heterogeneous mixtures

These are not the same throughout. There are two kinds based on the sizes of the particles they hold.

Suspensions have large enough particles for us to see. The particles are suspended in the liquid, but they can settle to the bottom when left, e.g. mud or powdered chalk in water. There are also some medicines that are suspensions: they have a label that says 'shake well before use'.

Colloids have particles of a size between those of solutions and suspensions. The particles are too large to dissolve, but too small to settle out. For example: jelly and white of egg. An **emulsion** is a special example of a colloid where the two substances are liquids. Examples of emulsions are milk (fat in water) and oil and water salad dressing.



The different kinds of mixture

9.13 Classifying mixtures

1 Your teacher will give you some mixtures. Classify each mixture as a solution, colloid or suspension.
2 Be able to explain why you classified each mixture as you did.
3 Prepare a table in which to record your findings.

Questions

1 Give examples of solids, liquids and gases dissolved in water.
2 What kind of mixture is (a) air, (b) seawater, (c) mayonnaise?
3 How are colloids and suspensions (a) similar and (b) different?
4 Give two examples each of solutions, colloids and suspensions.

▶ **See Workbook Elements, mixtures and compounds.**

What do we mean by 'pure'

In science by 'pure' we mean all the particles are the same, as in a single element or compound.

In everyday life, 'pure' means there is nothing else mixed in with it, e.g. 'pure' orange juice is a mixture squeezed from oranges: it may be a solution, colloid or suspension.

Solutions	**Colloids**	**Suspensions**
Homogeneous mixture. Solute dissolved in a solvent.	Heterogeneous mixture. Colloid particles are often charged.	Heterogeneous mixture. Separate parts can be seen.
Solute particles very small.	Colloid particles in-between size.	Suspended particles are large.
Particles are not visible under a microscope.	Particles are visible under a microscope.	Particles are visible to the naked eye.
Solute and solvent do not separate or settle out.	Particles do not separate or settle out.	Particles are suspended, but they settle out when left.
Solute cannot be separated by filtering.	Particles cannot be separated by filtering.	Particles can be separated by filtering.
Examples: sugar and oxygen dissolved in water, alloys.	Ink, glue, paint, dust, smoke. Also emulsions: milk, salad cream.	Mud, powdered chalk or sulphur in water, some medicines.

Mixtures in everyday life

Solutions: solutes (gas, solid or liquid) in a solvent (gas, solid or liquid)

Solutions: Alloys: solid in solid. These are unusual mixtures as the alloy has new properties.

Colloid: Emulsion: liquid in liquid

Suspension: solid suspended in a liquid

Suspension: solid suspended in a liquid

Colloid: Aerosol: tiny drops of liquid in a gas

Colloid: Solid foam: Gas trapped inside a solid

Colloid: Liquid foam: Gas trapped inside a liquid

Questions

1 Identify other examples of solutions important to plants and animals. In each case list if a gas, liquid or solid is dissolved.
2 Identify other examples of suspensions in everyday life. Suggest ways in which their parts could be separated.
3 How are aerosols and foams (a) similar and (b) different?

Separating mixtures into their parts

The methods we use depend upon the properties of the parts.

- Suspensions can be separated by using sieves, colanders and filter paper. These can be used where the parts are of different sizes, and only one of them goes through the 'filter'.
- Solutions cannot be separated by filters. We can use evaporation, distillation and chromatography.
- Colloids, such as emulsions, can be separated using a separating funnel, if one liquid is less dense than the other.

What kind of mixture is this?

Separation methods

The method we choose to separate the parts (components) of a mixture depends upon how the components are different. For example, we cannot separate a solution by filtering, as the particles are all small and will go through the filter paper. But we can use a filter or sieve if the particles of the components differ in size.

As mixtures can be separated by physical means, these differences will be, e.g. differences in size, attracted by a magnet or not, solubility, density, and boiling points of the parts of the mixture.

9.14 Using sieves

Materials: uncooked rice and salt, percolated coffee with coffee grinds, instant coffee in water, tea with tea leaves, cooked macaroni in water, small sieve, colander, salt cellar

Method

1 Try to separate each mixture into its parts using each of the 'sieves' in turn. Record your results in a table.

2 Draw conclusions about what makes a sieve useful in relation to the sizes of the different parts of the mixture.

Questions

1 Were you able to separate all the mixtures? If not, then what was the reason?

2 What kinds of mixtures can be separated using sieves?

9.15 Using filter paper

Materials: dirty water or sand and water, powdered chalk and water, orange juice with bits in it, instant coffee and water, salt solution, filter funnel, filter paper, beakers

Method

1 Set up filter paper in the filter funnel. Support the funnel over a beaker. In turn, use filter paper to try and separate the parts of each mixture. Record your results in a table.

2 In each case describe what remains on the filter paper (the residue) and what comes through (the filtrate).

Questions

1 (a) Which mixtures can you separate by filtering? What do they have in common?

(b) Which mixtures can you not separate by filtering? What do they have in common?

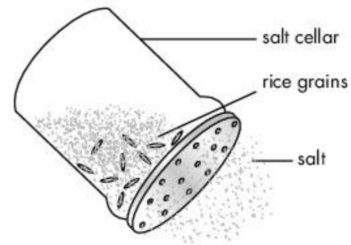
2 How is using filter paper (a) similar to and (b) different from using a sieve? Give two examples of mixtures in the home you would separate with each method.

▸ **See Workbook Elements, mixtures and compounds.**

Questions

1 List the physical properties of the components of a mixture that are used to separate them.

2 For each property, identify a mixture and the name of the separation method.



Why does the rice not come through the holes in the salt cellar?

Applications of sieves and filters

- Sink strainers and drain grates stop unwanted materials getting through.
- Window screens and mosquito netting stop insects from getting through.
- Our nose, kidneys and small intestines all filter useful from non-useful things.
- Coffee filters. We can make coffee by putting boiling water over coffee grains.
- Car filters. Fuel and air filters remove impurities from the gasoline or air.
- Air conditioning units have a filter to take dust out of the air.
- A water purification plant has several filters for purifying dirty water.
- Set of soil filters with holes of different sizes to remove stones or gravel.
- Kitchen sieve for sieving floor before using it in cooking.

How does this filter coffee maker work?

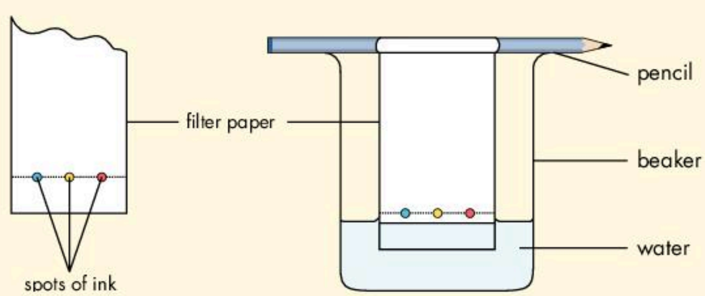
9.16 Using a magnet

Materials: iron filings and sand, salt and sand, iron nails and brass screws, aluminium and 'tin' cans, magnet
Method
Use the magnet to try and separate each mixture. Record your results in a table.

Questions
1 Which mixtures can you separate using a magnet? Why?
2 How are magnets used commercially for separating mixtures?

9.17 Using chromatography

Materials: coloured markers, filter paper, water, container, scissors, pencil.
Method
Used to separate dyes that differ in solubility in a solvent.
1 Cut a strip of filter paper.
2 Make spots of the marker ink (each about 2 mm wide) on the filter paper, and allow them to dry.
3 Put a little water in the beaker (it must be below your spots of ink). Set up the apparatus as shown below.
4 Observe what happens as the solvent goes up the strip.
5 Allow the paper to dry and use it in your report.



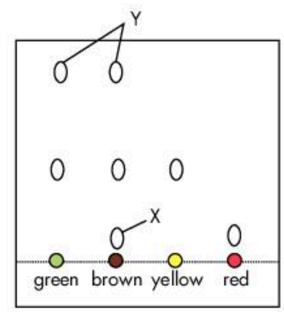
Questions
1 What happens to the original colours?
2 Is the colour that travels the furthest, the least or the most soluble in the solvent?

9.18 Using a separating funnel

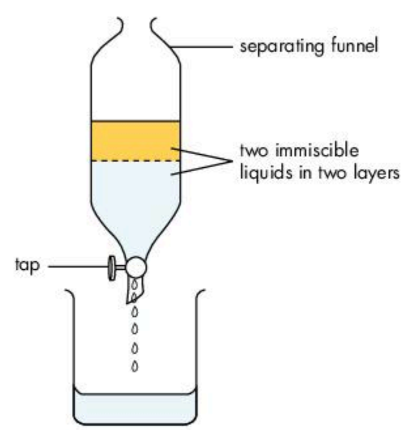
Materials: oil and water mixture, beaker, separating funnel.
Method
Used to separate two non-mixing (**immiscible**) liquids that form two layers as they also differ in density.
1 Pour the mixture into a separating funnel.
2 Open the tap and let the lower liquid run out.
3 Observe and record your results.

Applications of using magnets
- Magnets are used to take out any useful iron items from domestic rubbish.
- Electromagnets are used for moving iron objects around in a scrap yard.

Applications of chromatography
- Used in forensic work to separate and identify blood samples.
- Used in dye making to separate different pigments.
- Used to identify different amino acids in proteins.



(a) Which inks contain only one dye?
(b) Which ink contains three dyes?
(c) What colour would spot X be?
(d) What colour do you predict the spots labelled Y will be?



A separating funnel being used to separate two immiscible liquids

Applications of separating funnel
- Oil can be separated from soups.
- Lavender and other oils can be separated from denser liquids.

9.19 Using evaporation

Materials: salt solution, food colouring solution, filtering apparatus, sand from the shore, evaporating dishes, heating apparatus

Method

You have been given two solutions. The solute in a solution cannot be recovered by filtering. You will need to use evaporation.

1 Put some of the solution in the evaporating dish. Use the apparatus shown on page **45** to heat it.
2 Observe and record what happens.

Questions

1 What is driven off from the solution?
2 What remains in the evaporating dish? Have you been able to use evaporation to get the solute from the solution?
3 You have also been given some sand from the sea shore that you expect has salt and other substances mixed with it. Draw a flow chart of the steps to take to get dry sand a dry sample of whatever else is in the original mixture.

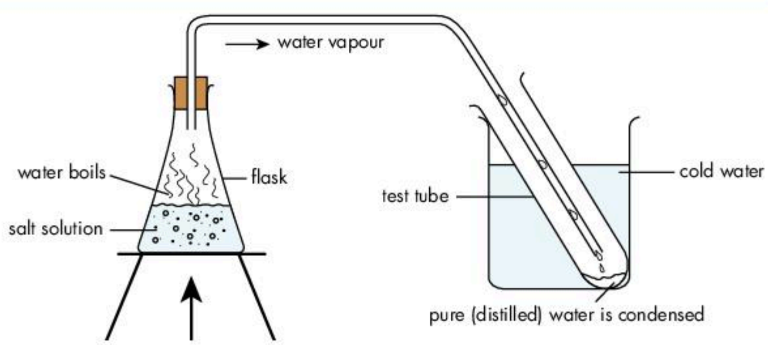
9.20 Using simple distillation

Materials: salt solution, food colouring solution, flask, rubber bung, delivery tube, test tube, beaker, water, Bunsen burner, ice

Method

In this case we collect and condense the water vapour to collect the solvent.

1 Set up the apparatus for simple distillation shown below. Use it with the salt solution or food colouring solution. Put ice in the water in the beaker to make it cold.
2 Observe and record what happens.



Questions

1 What is collected in the test tube? Where did it come from? What changes in state are involved?
2 What stays behind in the flask? Have you been able to separate the solvent from the solution?

Salt pans. The seawater evaporates to leave the salt. This is collected and cleaned

Applications of evaporation

- Collecting salt from seawater.
- Collecting the solute from any solution.

Solutions

- Water dissolves many substances, we call these **aqueous** solutions.
- When we wash our food, our clothes or ourselves, we are making a solution to wash dirt or impurities away.
- Other solvents make **non-aqueous** solutions. Some examples are kerosene, turpentine, acetone (nail varnish remover) and ethanol. Any of these solvents can be used to separate mixtures where only one of the parts is soluble in the solvent. An example is the extraction of chlorophyll with ethanol (page 29).

Applications of distillation

- Separating pure water from a solution, e.g. making distilled water from dirty water or seawater.
- Separating the solvent (water or other solvent) from a solution.
- Separating a mixture of two miscible liquids with different boiling points, e.g. collecting ethanol (alcohol) from fermented fruit juice.
- Fractional distillation can also be used to separate mixtures of several liquids if the parts (or fractions) have different boiling points (see pages 62 and 63).

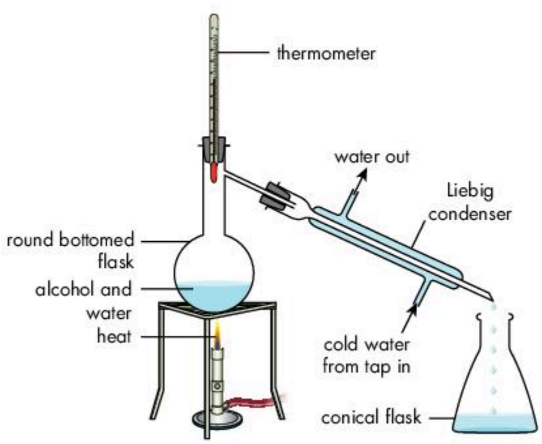
9.21 Using a condenser for distillation

Materials: mixture of alcohol (ethanol) and water, round-bottomed flask with side arm, rubber bung and thermometer, heating apparatus, Liebig condenser, support, rubber tubing and water supply, two conical flasks

Method

Your teacher will carry this out as a demonstration. Distillation will be used to separate a pure liquid from a mixture of liquids. The liquids, e.g. alcohol and water have different boiling points.

1 Examine and describe the special characteristics of each piece of apparatus. Watch carefully as your teacher assembles the parts.
2 The mixture in the flask will be heated to 80 °C (just above the boiling point of alcohol). Observe and record what happens in (a) the heating flask (b) the condenser and (c) the conical flask. Your teacher will adjust the heating to keep the temperature at around 80 °C for five minutes.
3 The conical flask will be changed and the temperature in the heating flask raised to 100 °C. Record your observations (a) to (c) as above.



Questions

1 What processes (changes in state and heating and cooling) occur in (a) the heating flask and (b) the condenser.
2 Explain why it is possible to use distillation to separate these two liquids.

▶ **See Workbook Elements, mixtures and compounds.**

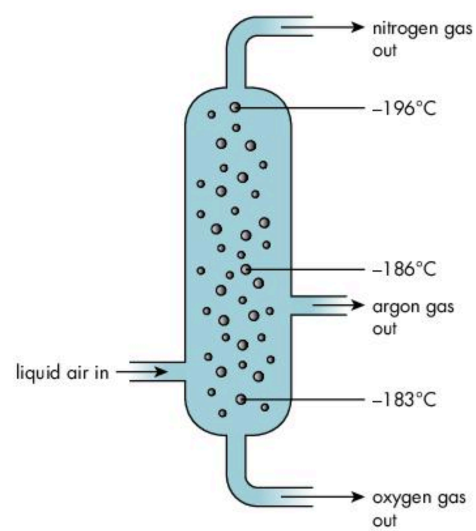
9.22 Using fractional distillation: air

ICT

Fractional distillation is used to separate mixtures with several parts (fractions). You will do this activity as a research project. Find the answers to these questions and prepare a report.

Questions

1 What must be true about the boiling points of the fractions?
2 Can only mixtures of liquids (e.g. as in crude oil, page 62) be separated by fractional distillation or can gases (e.g. those in the air) also be separated?
3 What (a) elements and (b) compounds are present in the air?
4 Prepare a table and pie chart to show the composition of air using Excel®.
5 'Fractional distillation of liquid air' is used. What does this mean?
6 How are these removed as the air is cooled? (a) dust (b) water vapour (c) carbon dioxide.
7 When cooled to –200 °C the remaining gases become liquid. How can they be made back into gases? (a) by raising or (b) by lowering the temperature more.
8 Oxygen liquid boils to a gas at –183 °C and nitrogen at –196°C, with argon in-between at –186 °C. How can they be separated?
9 Explain how the fractionating column below works to separate the gases.

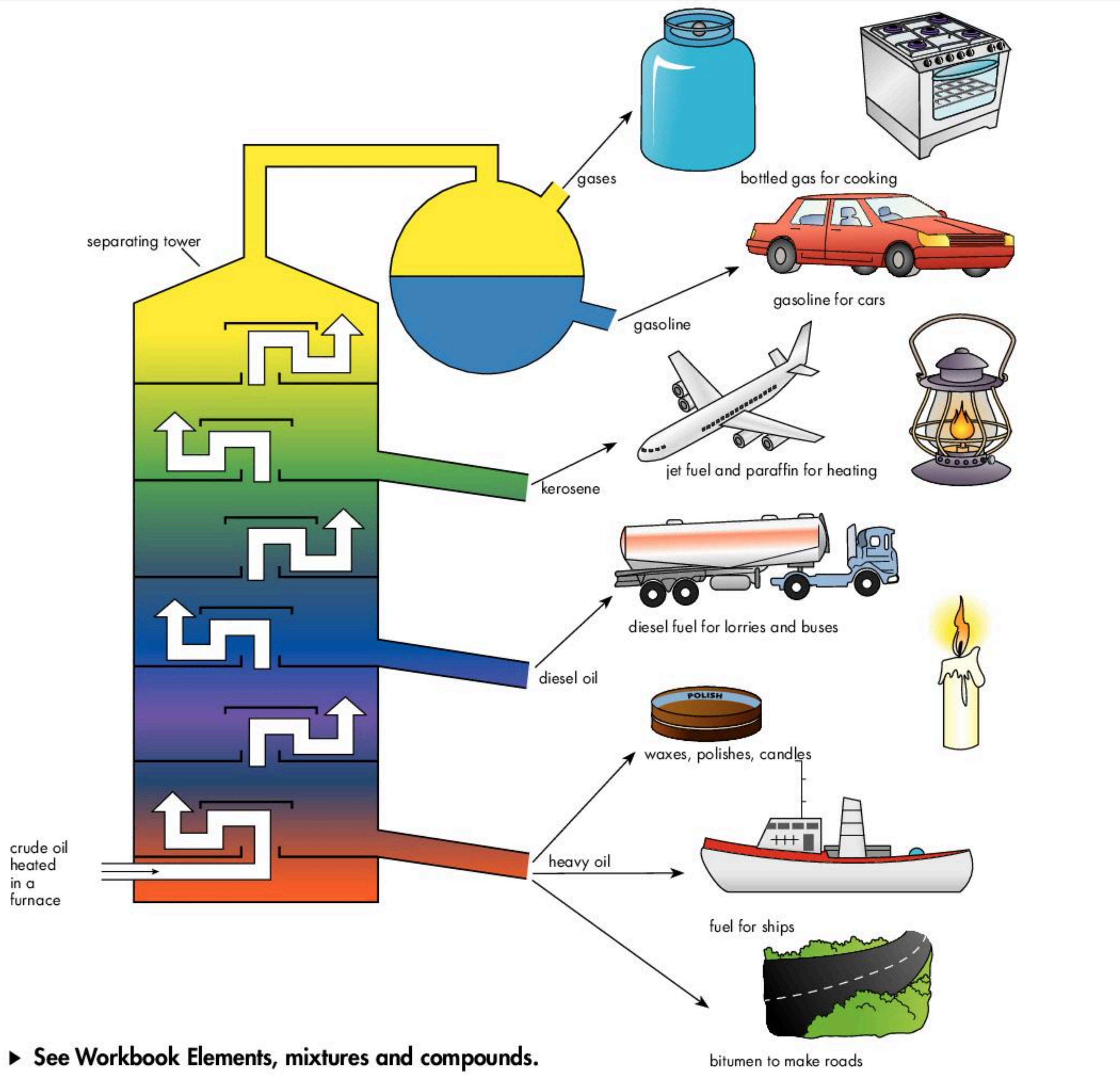


9.23 Using fractional distillation: oil

Fractional distillation is used to separate fractions of crude oil. You will do this activity as a research project. Find the answers to the questions and prepare a report.

ICT

1 Why can fractional distillation be used to separate the parts of crude oil?
2 Why does the crude oil first have to be heated in a furnace?
3 What is the proper name for the 'separating tower? Why does it have to be so tall?
4 Which fraction rises furthest up the tower? Why? How is this used?
5 Prepare a table showing all the fractions: their names and uses.
6 Which fraction is left behind at the bottom of the tower? Why? How is it used?
7 What are all the fractions made of?
8 Name the fractions that can be used as fuels. Where did they get the energy that they release when they are burned?
9 Research the full range of products made.



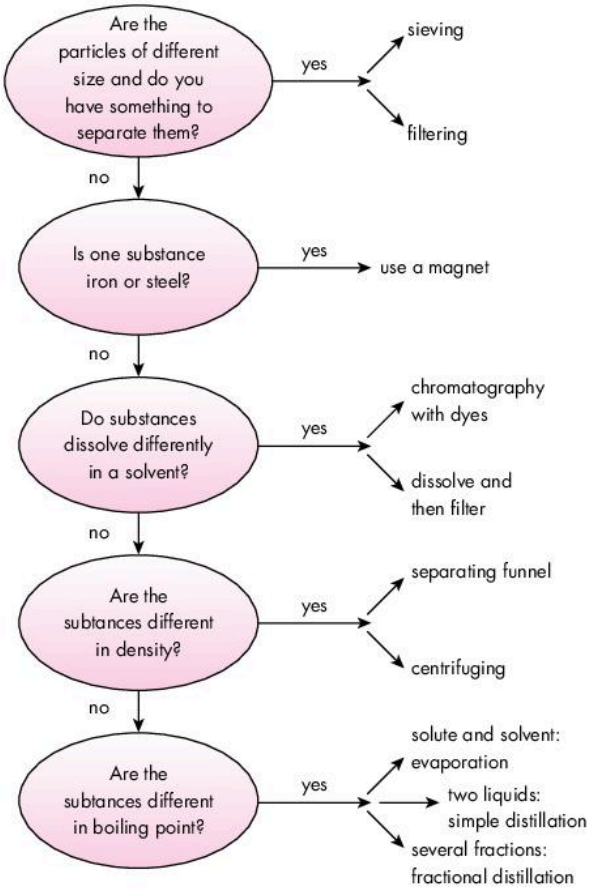
▸ See Workbook Elements, mixtures and compounds.

Summary on separation techniques

A mixture contains two or more substances that can be separated by physical means. The parts must differ in some way, and an appropriate technique be used.

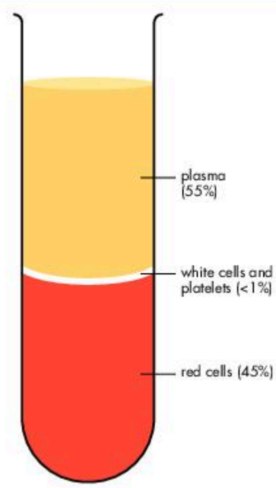
Differences	Techniques
• particle size	• sieving • filtering
• attraction to a magnet	• using a magnet
• solubility	• chromatography
• density	• separating funnel
• boiling point	• evaporation • simple distillation • fractional distillation

Flow chart for choosing a separation method



9.24 Separation techniques

1 Use the ideas on the left to prepare a large flow chart for the classroom to show how to decide which separation technique to use to separate the parts of a particular mixture.
2 Find or draw a labelled diagram to show each technique and attach them to your chart.
3 Identify and describe industrial applications of separation techniques. **ICT** Some ideas are the sugar cane, rice, bauxite and petroleum industries, and flourmills, waste separation, beverage and dying companies. Washing, drying and cleaning are also separation techniques. Each group does in-depth research on one example and prepares an illustrated account for the class.
4 Discuss the impact on society of the products and wastes that are made. Based on research, make recommendations on better treatment and disposal of wastes.
5 Use the Engineering design process to make a sorting machine to separate iron and steel items from plastic and aluminium ones. Test and improve your machine and then demonstrate it to the class.



The blood shown has been separated into its parts by one of the techniques in the flow chart. Which technique is it, which property difference does it make use of, and how does the machine work?

Quick check ☑

Substances are ________, mixtures and ________. Mixtures are of different kinds depending on the ________ and ________ of their parts. Mixtures can be separated by ________, evaporation, chromatography, a magnet and ________ depending on the properties of their components.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

elements **sizes** **filtering**
distillation **state** **compounds**

Questions

Answer these questions in your notebook

For questions **1–33** answer **A**, **B**, **C** or **D**.

1 An impure substance
A is always made of molecules
B is a mixture of substances
C cannot easily be made pure
D is made of only one kind of particle

2 Which of these is a pure substance in the scientific sense?
A a cup of tea **B** fresh orange juice
C common salt **D** sugar solution

3 What is the boiling point of pure water?
A about 100 °C **B** exactly 100 °C
C it varies **D** slightly above 100 °C

4 What does salt do to the boiling point of pure water?
A raises it
B lowers it
C makes no difference
D it depends on how much salt is added

5 In an impure substance
A all the particles are the same
B the melting point is always the same
C it is always easy to decide if it is impure
D there is more than one kind of particle

6 Which of these is an element?
A chlorine **B** salt solution
C bronze **D** salad dressing

7 Elements can exist as
A atoms only
B molecules only
C atoms or molecules
D only as parts of compounds

8 What is true about a mixture and a compound? They
A never contain the same kinds of atoms
B can be made from the same kinds of atoms
C are both pure substances
D always contain molecules

9 What is the main difference between elements and compounds. Only elements:
A are pure substances
B can contain particles made of atoms
C can contain particles made of molecules
D are made of two or more substances

10 Air is a
A single gas **B** compound
C pure substance **D** mixture

11 Which is an example of a chemical change?
A water boiling **B** butter melting
C a match burning **D** a powder being made

12 Which of these processes is an example of a physical change?
A evaporation **B** combustion
C respiration **D** photosynthesis

13 Which of these would suggest that a chemical change had occurred?
A change in colour
B new substances are made
C a gas is given off
D all of the above

14 Which is formed during a chemical change?
A a compound **B** an element
C a mixture **D** all of the above

15 Which of these indicates a physical change?
A a change in state
B a new substance is made
C properties of the elements are no longer seen
D there is a flame and rise in temperature

16 Air contains
A only elements
B only compounds
C both elements and compounds
D particles all of the same kind

17 Which of these might be a chemical change?:
A sublimation of iodine
B adding a substance to water
C heating ice to make water
D mixing flour and salt

18 What is needed for rusting to occur?
A air only **B** water only
C air and water **D** high temperatures

19 Which of these methods reduces rusting?
A painting **B** making stainless steel
C adding grease **D** all of the above

20 When iron and sulphur are mixed together, the mixture shows
A the properties of iron only
B the properties of sulphur only
C the properties of both iron and sulphur
D new properties unlike the elements

21 When iron and sulphur are heated to make iron sulphide, the compound shows
A the properties of iron only
B the properties of sulphur only
C the properties of both iron and sulphur
D new properties unlike the elements

22 Which is the most common chemical in the body?
A carbohydrates **B** proteins
C water **D** fats

23 Which elements are most important for healthy bones?
A iron **B** calcium and phosphorus
C iodine **D** sodium and potassium

24 How are alloys and salt solution similar? They are
A liquid mixtures **B** homogeneous mixtures
C suspensions **D** heterogeneous mixtures

25 The particles of which kind of mixture settle out on standing?
A a suspension **B** a solution
C a foam **D** an alloy

26 The particles of which kind of mixture are the smallest?
A a suspension **B** a solution
C a foam **D** an alloy

27 What does 'immiscible ' mean?
A not able to mix
B easily mixed
C parts of a solution
D melting easily

28 Which techniques could be used to separate two immiscible liquids?
A evaporation
B filtering
C separating funnel
D chromatography

29 Which process does NOT depend on parts of a mixture having different sizes?
A sieving **B** filtering
C osmosis **D** chromatography

30 Which process could NOT be used to separate salt from seawater?
A filtering **B** evaporating
C distillation **D** boiling

31 Fractional distillation depends on the parts that are mixed having different
A solubility **B** particle size
C boiling points **D** densities

32 In which process can we collect pure water?
A evaporation
B filtering
C chromatography
D distillation

33 Which property is used to separate the parts of the air? Different
A solubility **B** particle size
C density **D** boiling points

For questions **34–52** write the answers in your notebook.

34 What do we mean by 'pure' (a) in science and (b) in everyday life?

35 What do we mean by 'impure' (a) in science and (b) in everyday life?

36 Give named examples of (a) pure and (b) impure substances in science, and draw a simple diagram with circles to illustrate each one.

37 Is seawater a pure or impure substance? What test would you do to see if you were right?

38 Distinguish between atoms and molecules.

39 What are the possible structures for the particles of (a) elements, (b) compounds and (c) mixtures?

40 Distinguish between physical and chemical changes, giving examples to illustrate your answer.

41 Is it true that physical changes make mixtures and chemical changes make compounds? Explain your answer.

42 Is the mixing of carbon dioxide in limewater a physical or chemical change? How could you show that you were right?

43 (a) Describe fully how you can set up a controlled experiment to find the conditions necessary for rusting. (b) Do you think rusting occurs faster with salt spray? How could you find out?

44 Explain how testing, mixing and heating together iron and sulphur can show us the differences between elements, mixtures and compounds.

45 Prepare a table to distinguish between elements, mixtures and compounds.

46 Give examples of elements, mixtures and compounds in the human body.

47 What are (a) homogeneous and (b) heterogeneous mixtures and give an example of each.

48 Prepare a table to distinguish between Solutions, colloids and suspensions.

49 What needs to be true about the particles in the substances of a mixture so they can be separated by sieving or filtering?

50 (a) Describe the procedure for finding the dyes in a felt tip pen. (b) In what ways do the dyes differ from each other?

51 (a) Give an example of two liquids that can be separated using a separation funnel and why the process works? (b) How is it similar to and different from centrifuging?

52 (a) What processes are involved in simple distillation? (b) Why can fractional distillation be used for the separation of fractions from crude oil?

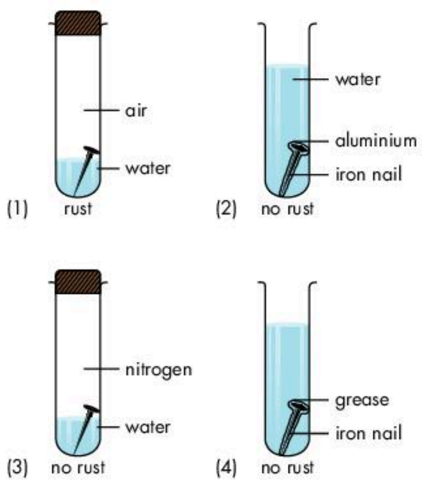
Key ideas

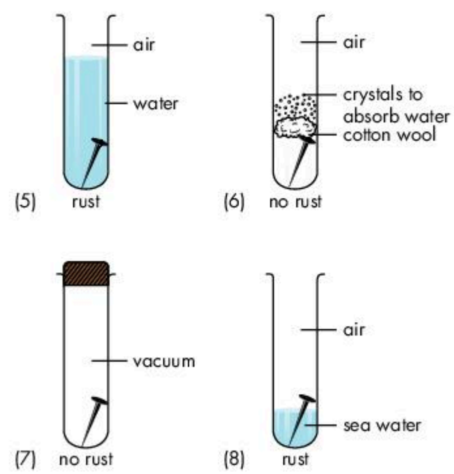
- Pure substances (elements and compounds) have particles that are all the same; impure substances (mixtures) have particles of more than one kind.
- Pure substances have fixed boiling and melting points. A solute, such as salt raises the boiling point and lowers the melting point.
- Atoms are single particles, e.g. carbon.
- Molecules are made of two or more atoms joined together, e.g. oxygen (O_2).
- Elements can be made of atoms, e.g. sulphur or molecules, e.g. hydrogen (H_2)
- Compounds only contain molecules, e.g. carbon dioxide and water (H_2O).
- A mixture can contain elements only, compounds only or both elements and compounds.
- Physical changes, e.g. change of state do not make new substances, can be reversed easily, do not change properties or mass.
- Chemical changes, e.g. rusting of iron make new substances, cannot be easily reversed, have changed properties and mass.
- Properties of the elements are shown in a mixture, but not in a compound.
- The result of physical changes is a mixture; the result of a chemical change is a compound.
- Iron needs air and water to rust.
- Elements, mixtures and compounds are found in living things.
- Unlike compounds, mixtures do not have a fixed composition. They can be homogeneous solutions, or heterogeneous colloids and suspensions.
- Mixtures are separated by different methods, depending on the properties of their constituents.
- When the particles of the constituents differ in size they can be separated by a sieve or filter paper.
- To separate a solute and solvent we need to use evaporation or simple distillation.
- Dyes with different solubility can be separated by chromatography.
- Substances that are attracted by a magnet are removed using a magnet or electromagnet.
- A separating funnel and a centrifuge can separate substances that have different densities.
- Several parts (fractions can be separated from a mixture, e.g. air, crude oil, by using fractional distillation based on different boiling points.

▶ **See Workbook Physical and chemical changes.**

Problems

1 Test tubes were set up as shown below. For each test tube, there is a note on whether or not the iron rusted.
(a) Make a table of results
(b) For each test, explain the conditions under which the nail has been left.
(c) summarise the conditions necessary for rusting.

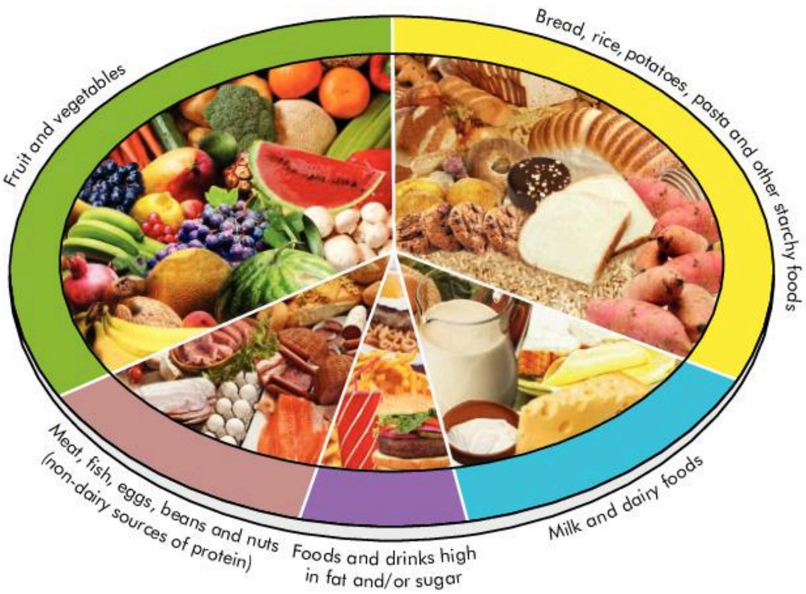




2 Work in pairs. Each pair has a candle, a dish, a matchbox of matches. You are to make the base of the candle melt and then set it in the dish. Light the candle and observe the flame.
(a) From striking the match you should record in a table all the changes that occur and identify them as physical and chemical changes.
(b) See which pair of students can record, correctly, the largest number of changes.

Unit 10

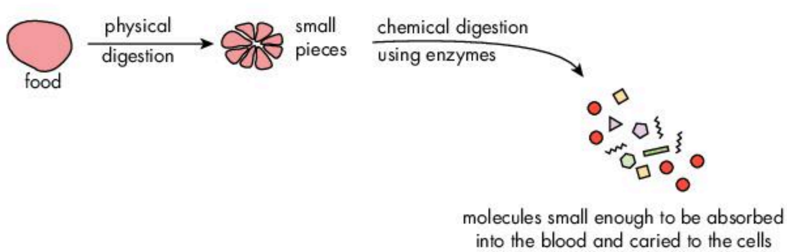
Human nutrition



1 *Make a list of the main food groups in a balanced diet. Then identify three examples of each one.*

This unit will help you to:

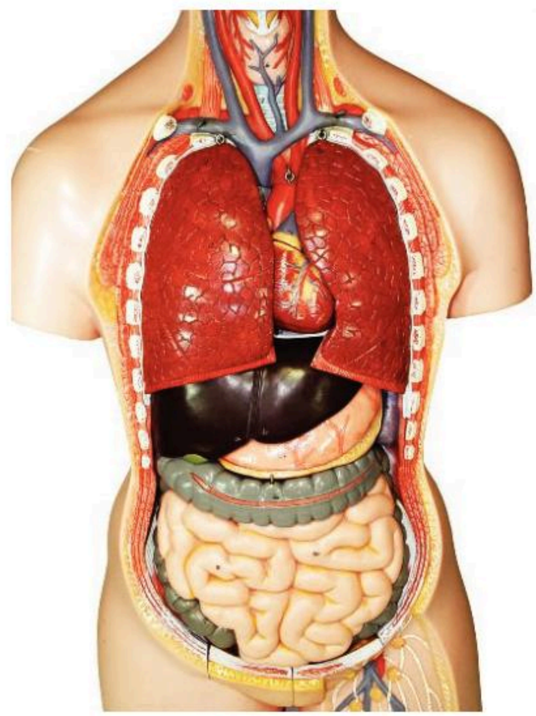
- identify food groups and nutrients and plan healthy balanced meals
- recognise that nutritional choices become lifestyle practices, affecting health and well-being
- identify food nutrients by carrying out simple tests
- investigate functions of different kinds of teeth
- investigate dental care
- distinguish between mechanical (physical) and chemical digestion using enzymes
- describe the main stages of digestion to produce soluble end-products
- describe the importance of absorption, egestion and assimilation.



2 *Why is mechanical digestion, e.g. in the mouth also called physical digestion? How is it different from chemical digestion?*

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.



3 *On the model of a human body identify parts of the alimentary canal and associated organs. Which important organs of digestion are not shown?*

Foods and food tests

What we eat and drink affects our health. We need a balance of many different kinds of foods, because their constituents have different functions in the body.

Food groups

Foods may be grouped into food groups as described by the Caribbean Food and Nutrition Institute (CFNI) (see page 67). Some examples are staples and fruits. The sectors are of different sizes. This shows the relative amounts of each group that is recommended for a healthy diet.

Food nutrients

Our food contains different nutrients. Some examples are proteins, fats and carbohydrates. These provide the cells with substances for making new cells, for releasing energy and for the chemical reactions that keep the body healthy.

The table below shows the main nutrients, and fibre, that are present in each of the six food groups. The number of ticks shows how important each food group is for providing each nutrient.

	Food nutrients					
Food groups	Pro	Carb	Fat	Vits	Mins	Fibre
Staples	✓	✓✓✓	✓	✓✓	✓	✓
Legumes and nuts	✓✓✓	✓✓✓	✓	✓	✓	✓
Food from animals	✓✓✓		✓✓	✓✓	✓✓	
Fats and oils			✓✓✓	✓✓		
Fruits		✓✓		✓✓✓	✓✓	✓✓
Vegetables		✓		✓✓✓	✓✓✓	✓✓✓

Key: Pro = Protein, Carb = Carbohydrate, Vits = Vitamins, Mins = Minerals

10.1 A balanced diet

Work in a small group:
Discuss and carry out research from a variety of sources to answer the questions.

ICT

1 What is a balanced diet? Why is it important?
2 What is obesity? How might it be caused? Why is it dangerous? What can be done about it?
3 What are deficiency diseases? Give two examples and what could be done about them.
4 What is anorexia? What can be done to help?
5 How do age, gender, physical activity, illness, and pregnancy each affect what we should be eating in a balanced diet?

Objectives

- Identify food groups and nutrients and plan healthy balanced diets.
- List and describe the uses in the body of the nutrients found in food.
- Recognise that nutritional choices become lifestyle practices, affecting health and well-being.
- Carry out simple food tests.

Fun facts

- The Caribbean also has many herbs and spices, e.g. lemon grass, pimento, scotch bonnet and nutmeg.

10.2 Interpreting data

Work in small groups:
The tables below show the daily energy requirements (in kJ) for different ages and activities.

ICT

1 Research what a kJ is and how it compares to a kCal.
2 For the top table, (a) how do the energy requirements of boys and girls change as they grow? (b) give two reasons why this might be so.
3 By hand, or by using Excel®, prepare appropriate bar charts to show the information.
4 For the bottom table, (a) describe what is being shown, (b) give two reasons why there might be differences between men and women, (c) explain the differences in energy requirements between light and heavy work.

Age (years)	Boys	Girls
2–6	6800	6800
7–11	9680	6800
12–15	12 000	9600

Activity	Men	Women
Lying in bed	7300	6300
Light work	11 500	9450
Heavy work	14 700	12 600

Food nutrients

The food nutrients have different functions in the body.

Protein: For growth. Good sources are meat, fish, cheese, peas and beans. Proteins are broken down into amino acids. The body can re-assemble these to make new proteins for growth and, for example, to make enzymes and haemoglobin.

Carbohydrates: starch and sugars. Good sources are starchy storage organs such as yam, potato, rice and cereals, and sweet fruits for sugars. Carbohydrates are digested to make simple sugars such as glucose, which is used for release of energy.

Fats and oils: Fats are mainly solid at room temperature, and come from animals, e.g. red meat and oily fish. Oils are mainly liquid and come from plants, e.g. corn oil, avocado and ackees. They release twice as much energy as carbohydrates.

Vitamins: Needed in small amounts for health. For example, vitamin A in butter, eggs and orange vegetables such as carrots. The vitamin B group is important, e.g. for respiration, and is found in brown rice and wholemeal bread. Vitamin C is found in fruits and vegetables.

Mineral salts: Needed in small amounts for health. For example, calcium and phosphorus for healthy bones are found in milk, fish and eggs, and iron for healthy blood is found in liver and leafy vegetables.

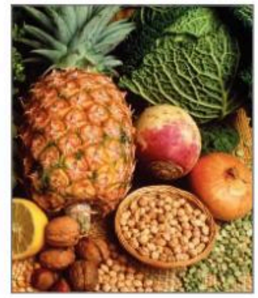
Water: For all chemical reactions in the body. Water is a good solvent, so substances dissolve in it and react together. It is also an important transport medium, e.g. in the blood and for the exchange of gases. It also takes part in digestion.

Fibre or roughage: This is not really a nutrient as it cannot be digested and does not enter the cells. But it helps to prevent constipation. It is mainly the cellulose cell walls of plants.

Proteins

Vitamins

Carbohydrates



Minerals

Fats and oils

Fibre

10.3 Food groups

Materials: pictures of foods

Method

1 Identify some foods belonging to each food group.
2 Prepare a large class chart showing pictures of foods in each of the sectors.

Which kind of fat?

- Polyunsaturated fats: these are very good fats. Found in vegetables oils, such as sunflower and corn oil, and in oily fish, e.g. sardines and mackerel. Help maintain a healthy heart and lower cholesterol (a fatty substance in the arteries). These fats are changed when they are heated, so only use them uncooked.
- Monounsaturated fats: these are good fats. Found in olive oil and avocados. May help to reduce cholesterol levels. Their good qualities are changed by heating, so best used fresh.
- Saturated fats: excess of most of these can be bad for health. Found in fatty meat, sausages, full-fat milk and cheese, and butter. A diet high in these fats, can, over time, raise cholesterol and increase the risk of heart disease. It is suggested these foods are eaten in small amounts.
- Trans fats: these are very bad fats. Have been linked with causing cancer. They were present in hard margarines and biscuits and cakes made from them. Some countries have banned their use altogether. If you see them as an ingredient in a food, try to choose a different alternative.

Summary: Reduce what you fry; if you do fry food use a non-stick pan or a little cooking spray.

Planning snacks and meals

The easiest way to have a healthy diet is to eat a variety of fresh foods. This is especially important for vegetarians who do not eat food from animals.

It is also important to consider the cost. Buying packaged snacks is much more expensive than making a jam or banana sandwich with wholemeal bread and taking that to school. Fresh fruit will also usually be cheaper, and better for you, than packaged and sweetened fruit juices.

Choosing cheaper alternatives may also be better for your health. For example, chicken is better for your health than beef, if you combine it with green vegetables to provide iron. Oily fish, such as sardines or mackerel, contains oils that are better for you than the fat contained in red meat.

10.4 Planning healthy snacks and meals

Here are some pairs of snacks. In each case the two sets of food cost about the same. Answer the questions below.

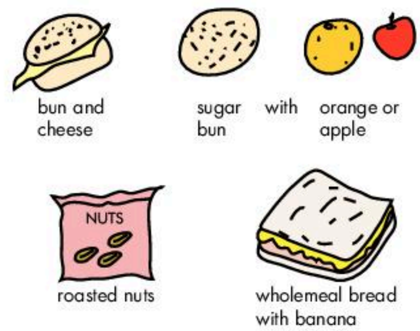
(a) Carton of milk	Bottle of fizzy soda
(b) Sky juice or icicle	Fresh fruit, e.g. orange
(c) Bun and cheese	Packets of sweet biscuits
(d) Banana chips	Ripe banana
(e) Sweets	Nuts, plain or roasted
(f) Chicken patty	Meat patty
(g) Cheese trix	Crackers and cheese
(h) Brown bread and jam	Fried dumplings
(i) A hard-boiled egg	Potato chips
(j) Fries	Roast chicken

1 For each pair, pick out the one you like best and give your reasons.
2 Then, for each pair decide which would be healthier as part of your diet, and give your reasons.
3 Check with your teacher to find out how many times, out of ten, you picked the healthier food as your favourite.
4 For a week write down the snacks that you eat and drink. Record how much each costs.
5 Make three lists of what you can buy, for J$ 150, 200 and 300.
6 Ask your parents and guardians how much lunch money you could have in a week. Divide by five, and plan healthy snacks you could buy, with something different each day.
7 Explore what snacks you could make at home that would be cheaper and healthier.
8 Plan a day's menu for yourself – snacks and meals.
9 Work with other students to make up balanced meals for (a) a 6-year old child, (b) a 30-year old vegetarian woman and (c) an elderly man.

Healthy snacks

These usually contain:

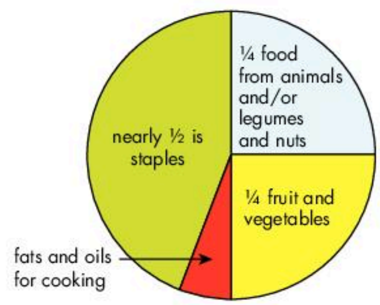
- a staple
- one other food group
- small amounts of fats, sugar and salt.



Healthy meals

These usually contain:

- a staple
- food from animals, and / or legumes and nuts
- fruits and vegetables
- fats, sugar and salt in small amounts for cooking and flavouring.



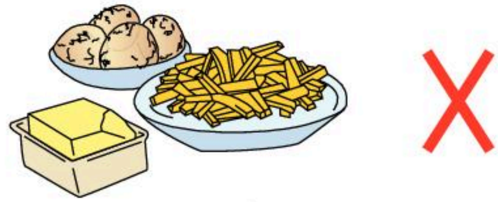
▶ See Workbook Foods and food tests.

Fun facts

- Soya beans contain almost twice the amount of protein of beef or fresh fish.
- Peanuts and cheese contain quite a lot of fat, so they are high-energy foods.
- Corn and rice contain about the same amount of carbohydrate.
- Chips provide more than double the amount of energy of boiled potatoes.

Helpful hints for healthy eating

- Eat only small amounts of meat and full-fat cheese.
- Choose lean chicken, and fish (contains unsaturated fat).
- Grill or boil instead of frying food.
- Choose semi-skimmed milk, yoghurt, and margarine made from unsaturated vegetable oils.
- Avoid trans fat used in some processed snacks and meals.



1. Eat less saturated fat

- White sugar only supplies energy. Starchy foods also supply fibre and vitamins, and release energy more slowly.
- Cut down on sweets, sweet syrup drinks, soft drinks, cakes, biscuits and chocolates.
- Eat fresh fruit or squeezed fruit juices instead of sweetened tinned fruit or processed fruit juices.

2. Eat less sugar and sweets

- Salt may make some people more likely to develop high blood pressure. Check with your doctor.
- Some salt is needed to replace that lost as we sweat, especially in hot weather.
- Use other seasoning and some salt in the cooking, but do not add too much at the table.

3. Eat less salt

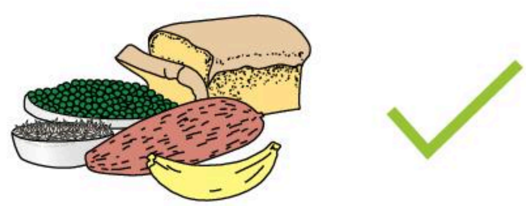
- Fresh vegetables are rich in vitamins and minerals, e.g. vegetables like callaloo, pumpkin and cabbage.
- Wash vegetables to remove any chemicals such as fertilisers and pesticides.
- Eat vegetables raw or cook them for only a very short time in a little water, or steam them.

4. Eat more vegetables

- Fresh fruit is rich in vitamins and minerals, e.g. mangoes, bananas, pineapples and oranges.
- Fruit is naturally sweet; you get sugar for energy and other nutrients, and fibre, as well.
- Fresh fruit is better for you than sweetened tinned fruit.

5. Eat more fruit

- Eat wholemeal bread instead of white bread, which has had nutrients removed.
- Eat brown rice, and more peas and beans
- Eat fruit and vegetables with their skins on, e.g. guava, otaheite apple, cucumber, tomato and potato.



6. Eat more fibre

10.5 Deficiency diseases

ICT

1 Carry out research to link the vitamins and minerals below to the deficiency diseases their lack might cause (on the right).

2 Name two foods to supply each one. Vitamins A, B1, C and D; Iron, Calcium, Iodine, Sodium

Night-blindness	Anaemia
Scurvy	Muscle cramps
Goitre	Beri-beri
Poor bones and teeth	Rickets

Food tests

Plants and animals are made up of chemical compounds built up from elements. Most of the cells of living things consist of water, and most of the dry matter is made up of 14 elements. The most important of these are carbon, hydrogen, oxygen, nitrogen, sulphur and calcium.

In the previous pages you have seen that certain foods contain certain nutrients. You can now carry out some tests on the foods to find their nutrients. During these **food tests** you will use chemicals that react with the nutrients in different ways. These are chemical reactions with changes in colour that show which nutrients are present. If the nutrient is not present, you will not see that particular colour change.You will need to set up tables for recording your reults.

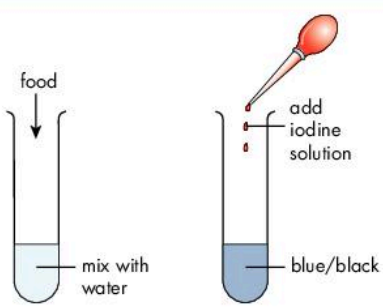
Work in small groups. Begin by mixing each food substance with some water. Also make sure to use clean spoons, test tubes and dropping pipettes for each test. Why is this important?

10.6 Starch test: Iodine solution

Materials: starch powder, plastic teaspoon, water, test tubes, Iodine solution (or tincture of iodine), dropping pipette, knife, food samples, white tile

Method

1 Put a quarter of a teaspoon of starch powder into the test tube. Add a 1 cm depth of water and shake.
2 Use the dropping pipette to add two drops of iodine solution. You should observe a blue-black colour showing starch.
3 Choose three food items that you think may contain starch. Cut a small sample of each one and break it up in a small amount of water. Test each one in turn and record your results.



Testing for starch

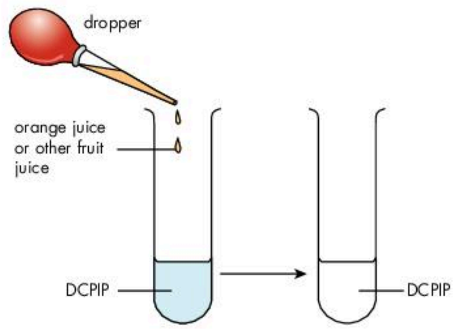
10.7 Testing for Vitamin C

Materials: 0.1% DCPIP solution, test tubes, dropper, squeezed fruit and bottled fruit juice

Method

DCPIP is a dye that goes colourless when Vitamin C is present.

1 Put 2 cm^3 of DCPIP in a test tube. Use a dropping pipette to add fruit juice., drop by drop
2 Shake the test tube after each drop.
3 Record the number of drops from each sample needed to change the colour.
4 Does squeezed juice or bottled juice contain the most Vitamin C?
5 How do you ensure it is a fair test?



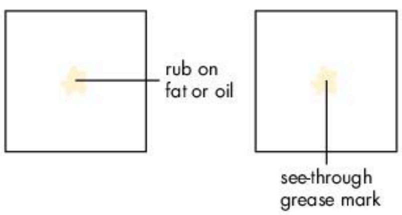
Testing for Vitamin C

10.8 Fat test: Grease spot test

Materials: cooking fat or vegetable oil, white file paper, scissors, water, knife, food samples

Method

1 Cut two 5 cm^2 pieces of white paper. On one, place a spot of fat. On the other, put a spot of water.
2 Let the papers dry and then hold them up to the light. For the fatty substance, the spot will be greasy and translucent (it will allow some light to go through). The water spot will just dry.
3 Choose three food items that you think may contain fats. Rub a small sample of each one onto separate pieces of paper. Hold them up to the light and record your results.



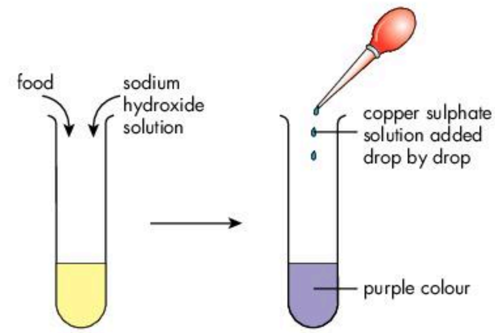
Testing for fat

10.9 Protein test: Biuret test

Materials: white of an egg, plastic teaspoon, test tubes, sodium hydroxide solution, 1% copper sulphate solution, dropping pipettes, food samples

Method

1 Put half a teaspoon of egg white into the test tube. Add a 1 cm depth of sodium hydroxide solution.
2 Add drops of copper sulphate solution, one drop at a time. (Do not add it too quickly.) Shake the test tube after each drop. You should observe a purple colour showing protein.
3 Choose three food items that you think may contain protein. Test them each in turn and record your results.



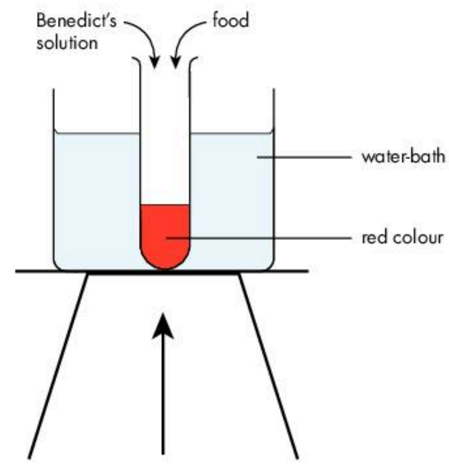
Testing for protein

10.10 Test for simple sugars: Benedict's test

Materials: glucose sugar, plastic teaspoon, water, test tubes, Benedict's solution, dropping pipettes, water-bath, knife, food samples

Method

1 Put a quarter teaspoon of glucose sugar into the test tube. Add a 1 cm depth of water and shake.
2 Add a 2 cm depth of Benedict's solution.
3 Place the test tube in a water-bath (beaker of boiling water) for five minutes. You should observe a colour change from green to yellow or orange to red showing a simple sugar.
4 Choose three food items that you think may contain simple sugars. Use a small sample of each one and mix it in a small amount of water. Test them in turn and record your results.



Testing for simple sugars

10.11 Testing food for nutrients

Materials: samples of food from a meal, apparatus and chemicals that you need for the food tests

Method

1 Test each food in turn for the four nutrients and Vitamin C.
2 Record the colour changes and your conclusions in a table.

▸ **See Workbook Foods and food tests.**

Questions

1 Why did you first carry out each test with a substance that was known to contain the particular nutrient?
2 Describe a control test that you could perform for (a) starch and (b) protein.
3 List all the practical and safety techniques you have used.
4 Explain why cleanliness of all the apparatus is very important.

Quick check ☑

The main food nutrients are ________, carbohydrates and ________. Vitamins and ________ are important, and also water and ________. ________ give a translucent stain on paper. Starch turns blue-black with ________ solution. Proteins turn purple with the ________ test. Simple sugars, such as glucose, turn red with the ________ test.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

proteins **minerals** **Benedict's** **Iodine** **fats** **fibre** **Biuret**

Teeth and ingestion

10.12 Looking at teeth

Materials: mirrors, two each of human incisor, canine and premolar/molar teeth, modelling clay, soap, water, cloth

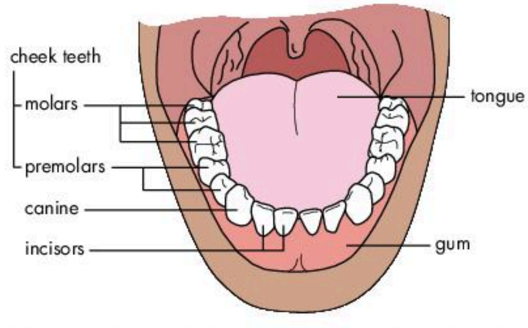
Method

Work with a partner:

1 Wash your hands.
2 Use the mirror and also feel your teeth to count how many you have. (It should be 14 in the top jaw and 14 in the bottom jaw, making 28).
3 Record any missing or filled teeth.
4 Compare the arrangement of your teeth to the artwork on the right. Use it to help you and your partner to make similar drawings of your own teeth and label them.
5 Examine the model teeth and describe them. In turn, use them singly and in pairs to make impressions on the modelling clay to see how they would work on the food in your mouth. Describe each one.
7 Make a table of teeth type, structure and function.

Objectives

- Investigate the structure and function of different kinds of teeth.
- Collect and use information on dental care and oral hygiene.
- Describe the ingestion of food.
- Distinguish between mechanical (physical) and chemical digestion.

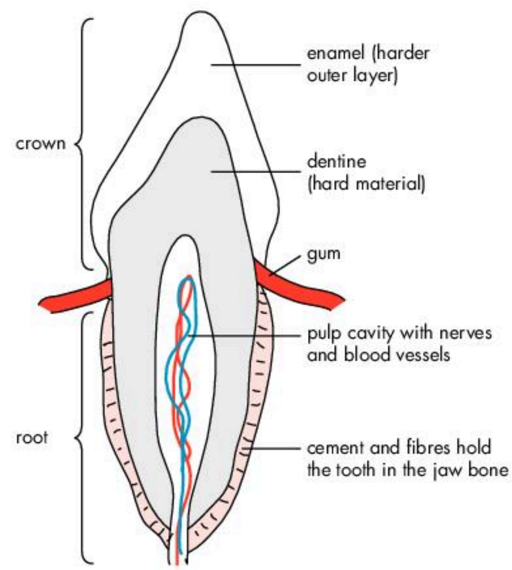


Adult teeth (total of 32, which includes 4 molars that form from 20 years old)

Structure and care of the teeth

Most of the tooth is made of a hard material called **dentine**. It is covered by an even harder layer of **enamel**: the hardest material in the body. Inside the tooth is a cavity filled with **pulp**. This consists of nerves and blood vessels. The tooth above the gum is called the **crown**. The part held in the jaw bone by cement and fibres is called the root (see diagram).

- *Healthy teeth:* These need calcium and vitamin D to grow strongly. Small amounts of fluoride added to drinking water help to harden the outer enamel.
- *Healthy gums:* These need vitamin C, and crispy food such as carrots and apples. The gums should be kept clean.
- *Cleaning:* Brush teeth after meals to remove food remains, otherwise these build up with dead bacteria to make **plaque**. A chewstick or toothbrush can be used. Toothpaste is usually alkaline and helps neutralise bacterial acids.
- *Bacterial acids:* Bacteria decay food remains to make acids, which can attack the enamel. They are removed by brushing.
- *Tooth decay:* If acids wear away the enamel they can also attack the dentine. This can expose nerves in the pulp cavity and we feel pain (**toothache**). The decayed part of the tooth may need to be removed by a dentist, and a **filling** put in to replace the missing material.
- *Oral hygiene:* This is the entire process of keeping the mouth clean and fresh and taking action to have strong teeth.
- *Whitening teeth:* Research the various ways in which teeth enamel can be whitened. Does this make the teeth stronger? Does it make them look more attractive? ICT



L.S. of a canine tooth

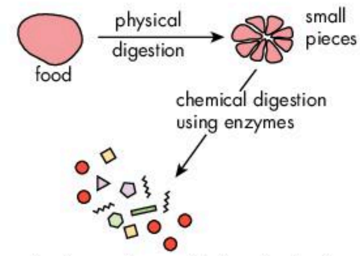
A teenager should have:

- four incisors with a sharp cutting edge, for biting pieces off food,
- two canines with pointed tops, for tearing and gripping food,
- eight cheek teeth (four premolars and four molars) with bumps on them for chewing and grinding food. (You will get two more molars in each jaw when you are older.)

Why is digestion necessary?

We eat food in large pieces. This has to be broken down into small pieces so it can be absorbed. This is done:

- by physical means, into smaller pieces of the same kind. This is done, for example by the mechanical action of the teeth and the grinding action of the stomach. This is a physical change.
- by chemical means, into small, soluble molecules. This is done with the help of **enzymes**. Each of the main nutrients is broken down into its building blocks. This is a chemical change.



molecules small enough to be absorbed into the blood and caried to the cells

Ingestion and digestion in the mouth

Food is taken into the alimentary canal through the mouth. We cut off pieces of food and chew them using our teeth **(mastication)**. We use our teeth for mechanical/ physical digestion and enzymes in the saliva for chemical digestion.

PS 10.13 What happens in the mouth?

Materials: crackers, iodine solution, dropping pipette, dishes

Method

1 Try to break off a piece of cracker without using your teeth. You will find this is difficult, as we use our front teeth for biting. Now try to break up the cracker, but without using your back teeth for chewing. How successful were you?
2 Try using your teeth in the wrong way. Try to bite off a piece of cracker using your back teeth. Try to chew the crackerjust using your front teeth.
3 Now you can use your teeth in the usual way, but try to eat the cracker without using your tongue. You will find that the tongue is useful in mixing the food with the saliva, and moving it close to the teeth.
4 What did the cracker taste like when you began eating? Did it taste sweet? Test a small piece of uneaten cracker with iodine solution in a dish. If starch is present, the cracker will go blue-black.
5 Continue to chew your cracker; do not swallow it. You will find that it starts to taste sweet. Put a little of your chewed cracker into a dish. Test it with iodine solution. Does it still contain starch?

The salivary glands produce saliva that begins the chemical digestion of cooked starch. The enzyme is called an amylase (starch-digesting enzyme). It changes the starch to a sugar called maltose. You could test your digested cracker and it would show the presence of a sugar.

6 Continue to chew your cracker. You will feel that it is being made into small balls of food. These are slippery with the mucus, which is also made by the salivary glands. The mucus helps you to swallow the balls of food. Try to chew the cracker to make the smallest pieces you can before you swallow them.

Fun facts

- Although you eat food, it is not strictly inside your body until it is absorbed into the blood.
- Humans are omnivores (we eat both plant and animal food). We use knives and cooking to prepare our food. Our teeth are not very specialised.
- Herbivores, e.g. cows and sheep, have large, flat cheek teeth for grinding hard plant material.
- Carnivores, e.g. dogs and lions, have very large canines to kill and tear prey and strong premolars for grinding meat and cracking bones.

What does it mean?

Nutrition: The whole feeding process including ingestion, digestion, egestion, absorption and assimilation.

Alimentary canal: The tube from mouth to anus.

Digestive system: The alimentary canal plus associated glands (liver and pancreas).

Questions

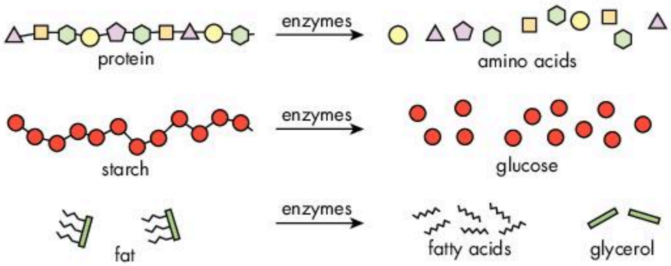
1 Summarise the activities that take place in the mouth. Include the importance of different kinds of teeth, the tongue and the enzyme and mucus present in the saliva.
2 Distinguish the changes in the mouth as mechanical (physical) and chemical changes. List the changes in a table and write down your explanations for each entry.

Digestion, absorption and egestion

10.14 Overview

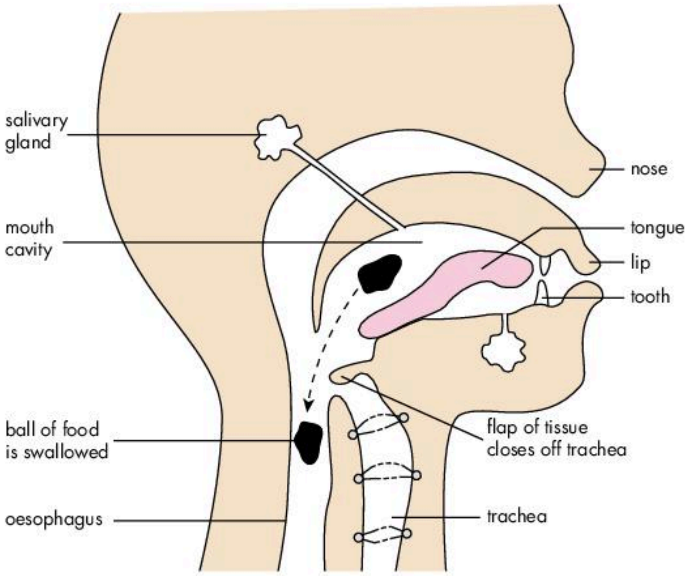
1 Role play different ways of caring for the teeth.
2 Observe a chart of the digestive system with the names shown by numbers. Each group takes turns to select numbers from a bag to identify an organ. Sequence the numbers to show the route of the food and say what happens to it.
3 Watch a video about the stage in the process of nutrition. Identify and write summaries about them.
4 Begin a KWL chart on digestive juices (enzymes). Write what you know and want to find out.

Our food contains proteins, carbohydrates and fats. These are broken down by physical changes in the mouth and then by chemical changes using enzymes to make the end products.



Swallowing and the oesophagus

The balls of food from the mouth are swallowed. A flap of tissue folds over the entrance to the windpipe so the food goes into the oesophagus and not the trachea. The food balls are pushed along by muscular contractions called **peristalsis**.



Objectives

- Identify the parts and functions of organs of the digestive system.
- Identify the role of enzymes in the breakdown of food during digestion.
- Distinguish between the stages of nutrition.

What does it mean?

Ingestion: The taking in of food into the mouth.

Digestion: The physical and chemical breakdown of large molecules of food into small, soluble ones.

Egestion: The removal of dry food remains (faeces) from the anus.

Absorption: The uptake into the blood of soluble food substances.

Assimilation: The use that is made of absorbed food: its integration into the body. This includes the release of energy in respiration.

Enzymes

These are catalysts inside the body. They speed up chemical reactions without being used up. They are produced by the organs and work on one kind of food, in certain conditions. For example, **pepsin** works best in the acid conditions in the stomach and digests proteins

Fun facts

- Food takes 24 to 48 hours to go along the alimentary canal.
- Peristalsis occurs all the way down the alimentary canal, as the food is pushed along. Fibre (roughage) in the diet aids peristalsis and helps to prevent constipation.
- Getting rid of faeces is not excretion, because the food remains have never been part of the cells. Production of urine is excretion.

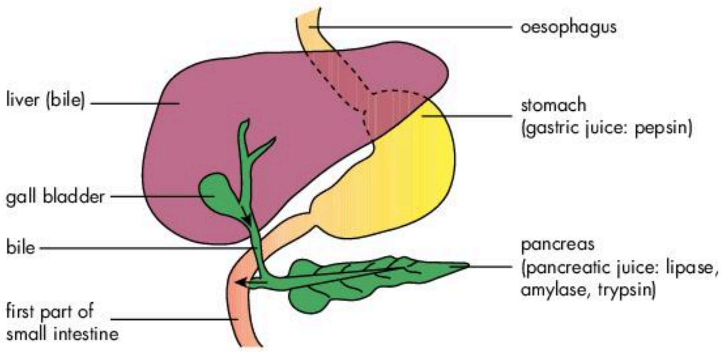
Digestion in the stomach

The stomach is part of the alimentary canal that is enlarged like a bag. It has several layers of muscles which means that it can churn and break up the food into smaller pieces. The wall also produces an acidic stomach (gastric) juice, which contains an enzyme (**pepsin**) that begins protein digestion.

The hydrochloric acid in the juice kills most bacteria, and makes conditions suitable for pepsin to work. Semi-fluid food passes bit by bit into the first part of the small intestine.

Digestion in the first part of the small intestine

The digestion that occurs here is mainly because of the bile and pancreatic juice that are secreted into it.



Bile comes from the liver

The liver produces bile, which is stored in the gall bladder and passes into the first part of the small intestine. Bile is alkaline and it neutralises the stomach acid so that enzymes in the small intestine can work properly.

Bile breaks up (**emulsifies**) fat and oil into small droplets. Bile is not an enzyme: the fat is *not* changed chemically.

Pancreatic juice comes from the pancreas

The pancreas produces pancreatic juice, which is alkaline and contains enzymes and passes into the small intestine.

- Fat droplets are digested by **lipase** into the building blocks of fatty acids and glycerol.
- Starch is digested by **amylase** to make a sugar called maltose.
- Proteins are partly digested by **trypsin** to make shorter length proteins.

The pancreas also makes insulin

Insulin is produced by special cells in the pancreas. It is not a digestive juice; it is a hormone. It goes straight into the blood. and helps keep the balance steady between the glucose level in the blood and stored glycogen in the liver.

If insufficient insulin is produced, the glucose level rises and the person has diabetes. Some people can control diabetes by their diet, otherwise they may need to have daily injections of insulin.

PS 10.15 Action of pepsin

Materials: pepsin, boiled egg white, distilled water, test tubes, dilute hydrochloric acid, dilute sodium hydroxide, pH paper, heating apparatus

Method

You are given instructions for a fair test to find the effect of pepsin on protein. And the most favourable conditions for the reaction. In your group discuss why each step is important.

1. Cut a 1 cm^3 cube of egg white. Divide it into four equal parts.
2. Put one part in test tube A with 5 cm^3 water and three drops of acid. Record the pH. Add 5 cm^3 of pepsin.
3. Put another part in test tube B with 5 cm^3 water and three drops of alkali. Record the pH. Add 5 cm^3 of pepsin.
4. Put another part in test tube C with 5 cm^3 water. Record the pH. Add 5 cm^3 of pepsin.
5. Put the last part in test tube D with 5 cm^3 water.
6. Place all the test tubes in warm water (kept at about 40 °C) for an hour.

If the egg (which contains protein) is digested the water will become cloudy.

7. Draw a labelled diagram of all your test tubes.
8. In which test tube(s) does digestion occur? Under what conditions does pepsin work best?

PS 10.16 Action of bile

Bile emulsifies fats (makes them into small droplets). You can show a similar action by using oil with washing-up liquid.

1. Put a few drops of oil into half a test tube of water. Describe the size of the drops.
2. Add a few drops of washing-up liquid and shake the test tube. What happens to the size of the oil drops?

Is this a physical or chemical change? Explain your answer.

Digestion in the rest of the small intestine

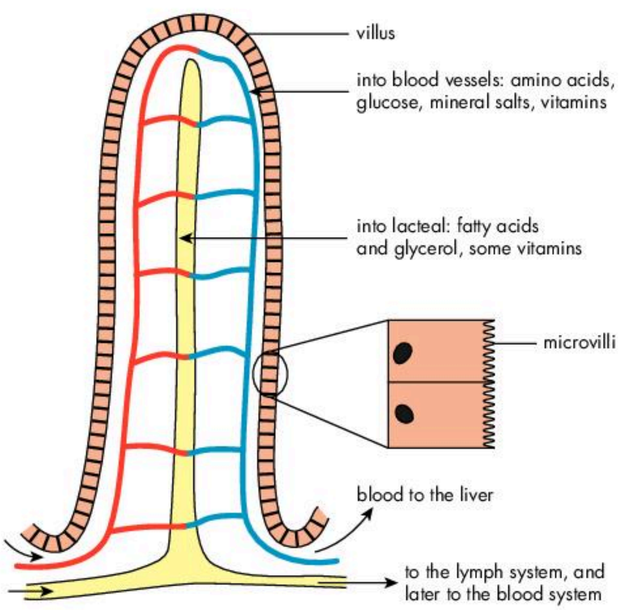
Intestinal juice is produced, which is alkaline and contains enzymes that complete digestion.

- Fat droplets are digested by lipase into fatty acids and glycerol.
- Maltose and sucrose are digested into simple sugars, such as glucose.
- Smaller proteins are digested into amino acids.

Absorption of food in the small intestine

All the food nutrients have been digested to their smallest, soluble building blocks. These then have to be **absorbed** through the wall of the small intestine into the blood. The small intestine is well adapted for its role in digesting and absorbing food.

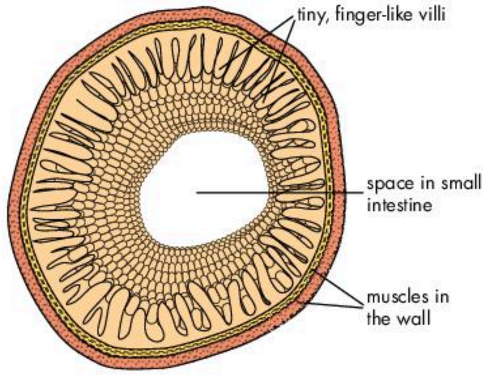
- It has two layers of muscles, so that contractions, peristalsis, can keep the food moving.
- It is very long, up to 7 m. It takes about 8 hours for food to pass through, so it can to be digested and absorbed.
- It is not very wide, only about 2 cm, so the food is in close contact with the inner surface of the wall.
- The lining is covered by tiny, finger-like projections called villi. Each square centimetre of wall contains about 4000 villi. This make a total of about 17 million villi!
- The wall of the villus is only one-cell thick. The cells also have even smaller folds, called microvilli, so diffusion can occur very easily through it.
- The blood vessels, into which most of the food passes, are also very close to the surface of the villi.
- The lacteal, into which the fatty acids and glycerol pass, are in the centre of each villus.



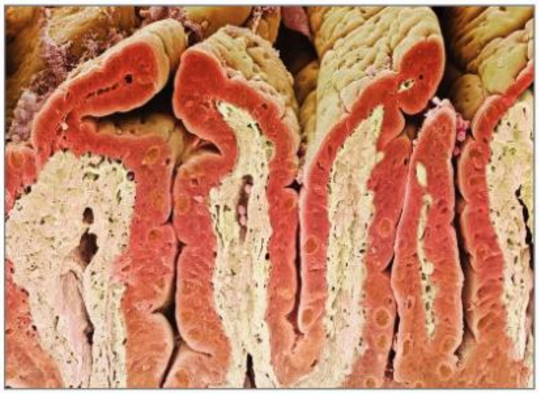
LS of a villus

Questions

1. How are pepsin and trypsin (a) similar and (b) different?
2. Bile is not an enzyme, but it assists in the digestion of fats. Explain how.
3. Choose two characteristics of the small intestine and explain how they are important for its twin roles of digestion and absorption.



Cross section of the small intestine



Photograph inside the small intestine showing the lining of villi

10.17 Digestive organs

Refer back to Activity 10.14, on page 76. For the organ that your group chose:

1. Prepare a summary of the changes that occur there. ICT
2. Add any other information you have found out.
3. Research and draw a labelled diagram of its internal structure.
4. Attach your summary by a thread to the organ.

Summary on the digestive process

Part of digestive system	Processes occurring and Digestive juices made	Enzymes present in the juice	Substances acted on	Substances produced after digestion
Mouth	Ingestion Cutting and chewing food Saliva in salivary glands	Salivary amylase	Cooked starch	Maltose
Oesophagus	Swallowing / peristalsis			
Stomach	Churning of food Gastric juice and acid	Pepsin	Protein	Smaller proteins
Liver	Produces bile (not an enzyme). Emulsifies fats		Fat	Fat droplets
Pancreas	Pancreatic juice (acts in the first part of small intestine)	Lipase Amylase Trypsin	Fat droplets All starch Protein	Fatty acids & glycerol Maltose Smaller proteins
Small intestine	Intestinal juice Absorption of food into villi	Lipase Maltase Sucrase Peptidases	Fat droplets Maltose Sucrose Smaller proteins	Fatty acids & glycerol Glucose Glucose & fructose Amino acids
Large intestine	Water absorbed into the blood from food remains			
Rectum	Dried food remains stored			
Anus	Egestion of faeces			

Caecum and appendix

Where the large intestine joins the small intestine, there are structures called the **caecum** and **appendix**. These do not have a function in humans. But they are very well developed in herbivores, such as rabbits. Within the rabbit's caecum are millions of bacteria that help with the digestion of cellulose from the plant walls in the food.

The appendix in humans can cause a problem if it becomes infected. This can lead to pain and **appendicitis** and the appendix may have to be removed in an operation.

Colon and rectum

The main part of the large intestine is the **colon**. It is shorter, but wider than the small intestine, about 7 cm wide. All the undigested food remains, such as cellulose, fibre, salts, dead cells and bacteria, and water pass into the colon. They take about 36 hours to pass along the colon. During this time, water and salts are absorbed from the food remains and pass into the blood. If this process is upset, then runny stools is the result.

The removal of water produces material in the form of partly solid **faeces**. These are stored in the last part of the large intestine, called the **rectum**.

Egestion

Faeces are passed out of the body in the process of **egestion** through the **anus**.

Problems in the digestive system

Vomiting: if something in the food upsets the alimentary canal, then the food is sent back out of the mouth.

Diarrhoea: bacteria in the food may irritate the large intestine. The intestine does not absorb water, but sends the faeces out as runny diarrhoea.

Constipation: if there is insufficient fibre (roughage) in the food, then peristalsis will be slow. The faeces will become hard and dry and difficult for the person to pass them out of the anus.

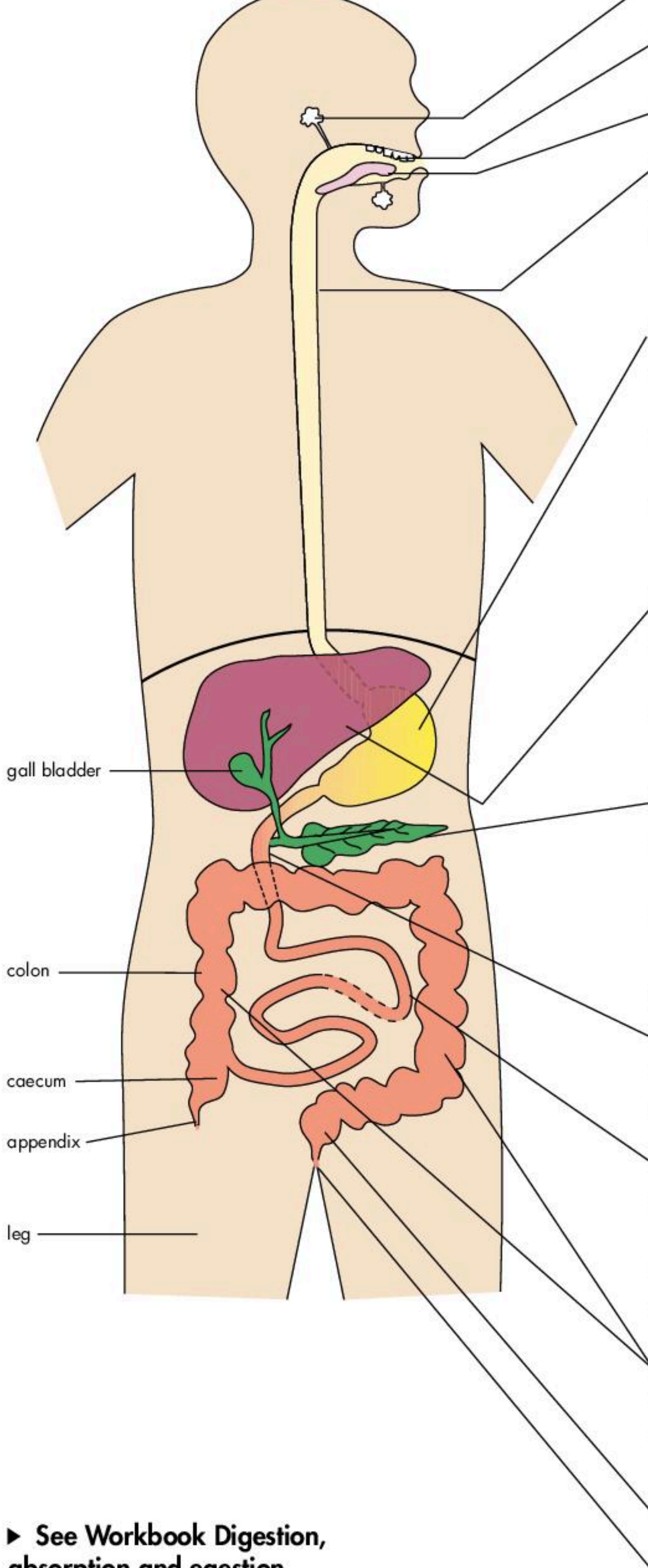
Hepatitis: this is inflammation of the liver caused by drugs, alcohol use or viruses that upset its functioning.

10.18 Digestive enzymes

ICT

Use information from this text book and from the Net, as well as teacher material and other sources to complete your KWL chart on digestive enzymes.

What happens in the digestive system



Mouth
- Salivary glands produce saliva that begins the digestion of cooked starch
- Teeth bite, tear and grind the food into smaller pieces.
- Tongue mixes the food with saliva.

Oesophagus
- Food is formed into a ball and swallowed.
- The ball is pushed down to the stomach by muscular contractions of the wall.

Stomach
- Muscular wall churns and breaks up the food into smaller pieces.
- Wall produces an acidic stomach juice, which contains an enzyme that begins protein digestion.
- Semi-fluid food passes bit by bit into the first part of the small intestine.

Liver
- Produces bile, which is stored in the gall bladder and passes into the first part of the small intestine.
- Bile breaks up (emulsifies) fat into small droplets. Bile is *not* an enzyme: the fat is not changed chemically.

Pancreas
- Produces pancreatic juice, which is alkaline and contains enzymes.
- The juice passes into the first part of the small intestine.

Small intestine

First part
- Fats are emulsified by bile and then digested.
- Starch and protein are partly digested.

Longest part
- Intestinal juice is produced, which is alkaline and contains enzymes.
- Sugars and smaller proteins are digested.
- Digested food is absorbed by villi into the blood.

Large intestine
- Caecum and appendix: no function in humans.
- Colon: important for re-absorbing water from food remains.
- Rectum: undigested food remains (faeces) are formed.

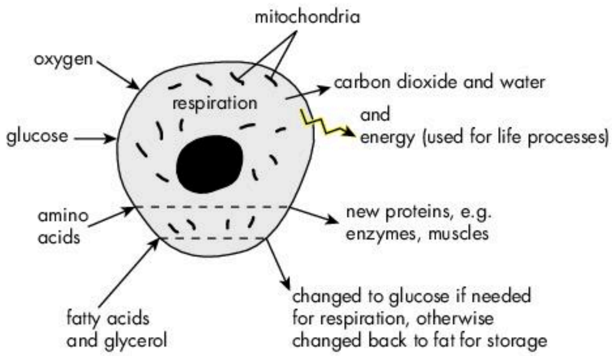
Anus Faeces passed out of the body.

▶ **See Workbook Digestion, absorption and egestion.**

Assimilation

Assimilation is the use that the body makes of absorbed food. The food absorbed in the intestines is taken first to the liver (see box). The blood vessel from the liver returns blood to the heart. From the heart the blood goes to the lungs to pick up oxygen and returns to the heart. It is then pumped to all the body cells.

When the food reaches the body cells, it is used in various ways.



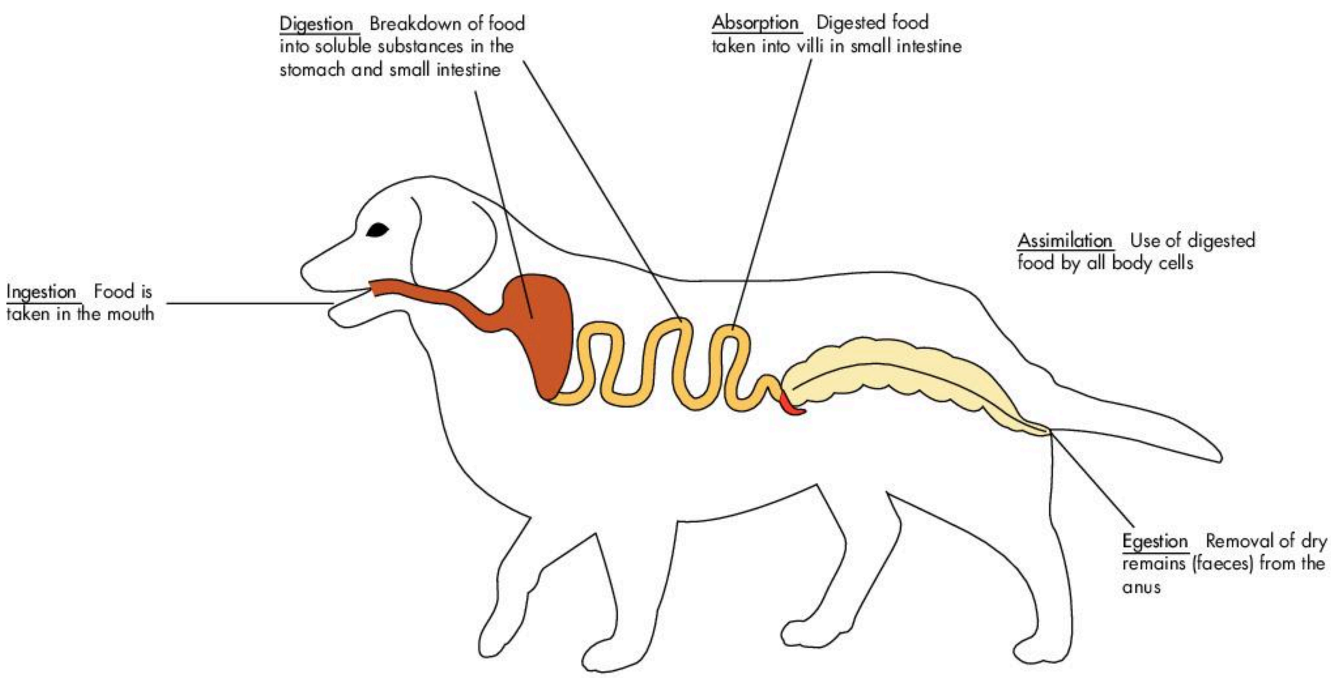
How a cell uses food and oxygen

What does the liver do?

Most of food absorbed into the blood in the small intestine, is taken to the liver. The liver controls what happens to absorbed food.

- Glucose is needed for respiration. A constant supply of glucose circulates in the blood. The liver converts excess glucose into insoluble glycogen for storage. This can be changed back to glucose when it is needed.
- Excess carbohydrates are converted to fats, and some of these can be stored under the skin.
- Amino acids are used for growth and repair of the body. Excess amino acids are changed to urea, which is passed in the blood to the kidneys where it is excreted in the urine.

(Note that digested fats go into the lacteals inside the villi. They then go into the blood.)



A diagram of an animal to show where ingestion, digestion, absorption, assimilation and egestion take place

Quick check ☑

Physical digestion occurs because of the __________, __________ muscles and __________. Chemical digestion occurs because of __________ and occurs mainly in the small __________. Soluble food molecules then pass through the walls of the __________ and into the __________ to the __________. Waste food material is egested as __________.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

faeces **liver** **blood**
teeth **villi** **enzymes**
intestine **bile** **stomach**

Questions

Answer these questions in your notebook

For questions **1–37** answer **A, B, C** or **D**.

1 Which food group forms the largest part of our diet?
A legumes and nuts **B** food from animals
C staples **D** fats and oils

2 Which food groups provide most of our vitamins and minerals?
A fruit and vegetables
B food from animals
C legumes and nuts
D staples and fats

3 Which food group provides protein for growth?
A legumes and nuts
B food from animals
C milk and milk products
D all of the above

4 Which of these should form a large part of a healthy diet?
A fruit and vegetables
B fats and oils
C fats and salt
D sugar and sweets

5 In the human body the main ingredient is
A protein **B** water
C fat **D** carbohydrate

6 A vegetarian could get most of her protein from
A animal foods **B** legumes and nuts
C fruit and oils **D** staples

7 Sufficient fibre or roughage helps to prevent
A diarrhoea **B** indigestion
C vomiting D constipation

8 Which nutrients are needed in small amounts to maintain health?
A fats and oils
B carbohydrates
C vitamins and minerals
D proteins

9 Which of these people use up the greatest amount of energy in 30 minutes?
A a woman typist
B a man cutting cane
C a girl playing a piano
D a boy playing football

10 Which kinds of fat are the healthiest?
A monounsaturated
B polyunsaturated
C saturated
D trans

11 Which of these contains the most protein?
A soya beans **B** beef
C fresh fish **D** bread

12 Which of these would provide the most nutrients?
A fruit juice **B** tinned fruit
C fresh fruit **D** cooked fruit

13 A lack of which of these causes scurvy?
A Vitamin A **B** Vitamin B1
C Vitamin C **D** Vitamin D

14 A lack of which of these causes poor bones and teeth?
A Calcium **B** Iodine
C Iron **D** Sodium

15 Which of these nutrients will be needed in larger amounts during pregnancy?
A proteins
B carbohydrates
C vitamins and minerals
D all of the above

16 Sodium hydroxide and copper sulphate solutions are used to test for
A starch **B** simple sugars
C proteins **D** fats and oils

17 In the test in Question **16**, what colour shows a positive result?
A red **B** blue-black
C blue **D** purple

18 When fat is rubbed on paper it leaves a mark that is
A translucent **B** transparent
C pale blue **D** invisible

19 The action of the teeth is an example of
A physical digestion
B chemical digestion
C physical and chemical digestion
D egestion

20 Which kind of teeth cut the food?
A molars **B** premolars
C incisors **D** canines

21 Which part of a tooth is buried in the jaw?
A crown **B** root
C enamel **D** gum

22 Which part of the tooth is most protected?
A pulp cavity **B** enamel
C dentine **D** crown

23 Which kind of adult teeth develop the last?
A molars **B** premolars
C incisors **D** canines

24 Food taken into the mouth is called
A digestion **B** absorption
C ingestion **D** indigestion

25 To have healthy teeth we should
A eat foods with calcium and Vitamin D
B have crispy foods containing Vitamin C
C brush the teeth after meals
D all of the above

26 What does an enzyme do?
A Carry out physical digestion
B Speed up chemical breakdown of nutrients
C Absorb water from the food remains
D Change into a soluble substance for absorption

27 What happens in the mouth is
A chemical digestion only
B physical digestion only
C digestion of protein
D physical and chemical digestion

28 Which nutrients begin to be digested in the stomach?
A all kinds of starch **B** cooked starch
C proteins **D** all of the above

29 Which pair do NOT have something in common?
A saliva and lipase
B trypsin and pepsin
C lipase and teeth
D lacteal and villus

30 What are the end products of digestion of fats?
A glucose
B amino acids
C oils
D glycogen and fatty acids

31 What is the function of the gall bladder?
A to store bile
B to store urine
C to make bile
D to make pancreatic juice

32 Which is NOT part of the alimentary canal?
A stomach **B** mouth
C colon **D** liver

33 Where does absorption of foods occur?
A mouth **B** small intestine
C liver **D** colon

34 Which is a characteristic of the small intestine?
A thin with muscular walls
B contains finger-like villi and microvilli
C has a good supply of blood
D all of the above

35 The passing of waste food remains is called?
A excretion **B** egestion
C absorption **D** assimilation

36 The use of food by the body is called?
A excretion **B** egestion
C absorption **D** assimilation

37 Where is absorbed food first taken?
A heart **B** body cells
C liver **D** lungs

For questions **38–59** write full answers.

38 Name six food groups used in the Caribbean and give two example of each.

39 List the food nutrients. For each one, (a) name two good food sources, and (b) how the nutrient is used in the body.

40 Fibre is not digested or absorbed. So how is it useful to the body?

41 (a) What is a balanced diet? (b) Give two examples of problems that can occur from an unbalanced diet.

42 (a) Describe a meal that contains five foods that are good for your health. (b) Describe a meal that contains five foods that are bad for your health.

43 (a) List the lunch snacks you had this week. (b) For each one, try to suggest a healthier alternative that would cost about the same amount.

44 Prepare your own list of six suggestions for healthy eating.

45 List the four kinds of fat, foods in which they are found, and the effect in the body.

46 Describe the food tests for starch, fat, protein and simple sugars. List the chemicals needed and the expected results for each one.

47 Explain four pieces of advice given for the care of the teeth.

48 Draw and label an LS of a canine tooth.

49 What are the main causes of tooth decay and what can be done about it?

50 State the main differences between (a) ingestion and digestion, (b) digestion and absorption, (c) absorption and assimilation, (d) egestion and excretion.

51 Explain why digestion is necessary.

52 Explain how both physical and chemical digestion occur in (a) the mouth and (b) the stomach.

53 (a) Name in order the parts of the alimentary canal. (b) Name the associated organs.

54 How are (a) the liver and (b) the pancreas important in digestion and assimilation?

55 (a) Draw and label an LS of a villus. (b) Describe how it is well suited for its role.

56 Name the building blocks of (a) starch, (b) fats, (c) proteins.

57 What are the functions of the following in humans? (a) caecum, (b) colon, (c) anus?

58 How is the liver important in assimilation?

59 What happens to the food in the living cells?

Key ideas

- A healthy diet contains a balance of the six food groups: staples, legumes and nuts, food from animals, fats and oils, fruits, vegetables.
- The food groups provide nutrients: proteins for growth, carbohydrates and fats for energy, vitamins and minerals for health, fibre to avoid constipation, and water used for chemical reactions.
- A balanced diet contains all the nutrients in the correct proportions and amounts for health.
- The energy needed (in kJ) and the nutrients needed vary with age, gender, size, physical activity, state of health and pregnancy.
- A poor diet leads to malnutrition and deficiency.
- In particular, small amounts of fats, oils and sugar should be eaten,
- Nutrients are identified by food tests: starch turns Iodine solution blue-black, fats makes a translucent stain, proteins turn purple with the Biuret test, and simple sugars turn red with the Benedict's test.
- The teeth (incisors, canines, premolars and molars) have different functions in breaking down food.
- Regular cleaning of teeth and a good diet are important to reduce tooth decay.
- Physical digestion is the breakdown into smaller particles of the same kind. Chemical digestion (assisted by enzymes) produces new, smaller, compounds.
- Proteins are digested to amino acids, carbohydrates to simple sugars, e.g. glucose, and fats to glycerol and fatty acids.
- The liver provides bile (for emulsification of fats) and the pancreas produces pancreatic juice.
- Pancreatic juice and intestinal juice carry out most of the chemical digestion in the small intestine.
- Soluble substances are absorbed, mainly in the small intestine, through the villi into the blood.
- Undigested waste has water removed from it, and it is then egested through the anus.
- Absorbed food is taken to the liver and assimilated into the body.

▶ **See Workbook Human nutrition.**

Problems

1 Your friend's father is a dentist and he has agreed to come to the class to talk about dental prosthetics, which is his speciality. However, he wants the class to do some research ahead of time.

(a) Use a variety of sources to find out the meaning of the following words. **ICT**

(1) dental prosthetics (2) amalgam
(3) dentures (4) partials
(5) crowns (6) dental hygiene

(b) Discuss in your class, which group should do further research on each topic For the topic in your group, prepare a page that describes the term, when the procedure is needed, some idea of cost, an illustration you make or download (with a reference) and any disadvantages or problems associated with the procedure.

(c) Use a word-processing program to make a neat copy of your page so it is ready to go into a class booklet. Help with the preparation of the book covers and Contents list (which can list the students involved in each part of the research.

(d) Brainstorm questions you will ask the visitor. After the visit, add the information you have heard into your booklet.

2 Make a list of the organs in the alimentary canal and the associated organs. Each group chooses one organ and does research on possible diseases that can occur. **ICT**

(a) Name the organ and a disease it can have.
(b) Research what might cause the disease.
(c) Research the symptoms and treatment.
(d) Prepare a word-processed sheet that can go into a Class-book on 'Diseases associated with the digestive system'

3 Your friend says she has seen a programme about plants eating insects. You say, 'Do you mean, insects eating plants?', but she insists it is the plants that are getting the benefit of the food. She says they are called insectivorous (insect-eating) plants.

(a) Hold a class discussion about how you will find out about insectivorous plants. **ICT**
(b) Carry out your research and also make labelled diagrams to show the important parts of the plants.
(c) How is the digestion similar to and different from digestion in humans? What use to the plant is this method of getting food?
(d) Prepare a colour chart of the class findings.

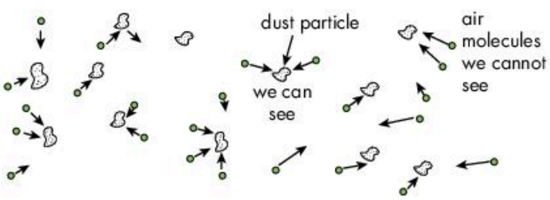
Unit 11

More about matter

1 Students finding out the chemicals present in different substances

This unit will help you to:

- understand the kinetic theory to explain the movement of particles and properties and changes of state
- investigate diffusion and osmosis
- identify the characteristics and arrangement of subatomic particles
- name and build models of the atomic structure of elements 1–20
- distinguish between atoms, molecules and ions
- arrange elements in the periodic table and identify important groups based on their atomic structures
- distinguish physical and chemical properties of metals and non-metals.



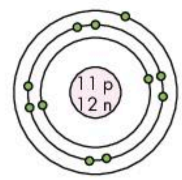
2 We cannot see particles moving, but we can see the movement of dust particles that have been hit by moving air molecules. The arrows show how air molecules move and hit the dust particles.

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.

Metals: e.g. sodium

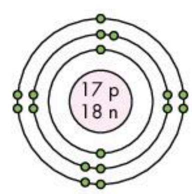
Hard, usually solids
High density
Easily shaped
High melting point
High boiling point
Conduct electricity
Metals lose electrons to make +vely charged ions



Sodium atom

Non-metals: e.g. chlorine

Soft, solids or gases
Low density
Cannot be shaped
Low melting point
Low boiling point
Do not conduct electricity
Non-metals, gain electrons to make –vely charged ions



Chlorine atom

3 How are metals and non-metals similar and different?

Particles and atomic structure

Matter is everything that has mass and takes up space. You will find out how it is made up of moving particles, and that these have even smaller particles inside them. Particles make up solids, liquids and gases and all the different kinds of matter.

Objectives

- Appreciate that all substances are made up of minute moving particles.
- Explain diffusion, osmosis, properties and changes of state based on the kinetic theory of matter.
- Identify characteristics of subatomic particles and distinguish between atoms, molecules and ions.

11.1 Particles in matter

Materials: chalk, stone, paper, water, salt, spoon, beaker
Method
Work in small groups:

1 Break up solid substances.
Use a small piece of chalk. Use the stone to grind it into smaller and smaller pieces. Can you make a very fine power?
Pick some up on the end of your finger and see if it can make a mark on the chalkboard. Are the pieces still chalk? Do you think you could grind the chalk until you got all the single particles of which it is made?

2 Water and salt.
Fill a beaker completely with water. Now, can you sprinkle a teaspoonful of salt into the water, without any spilling over? Where do you think the salt goes? Do you think there might be spaces between the water particles that the salt fits into?

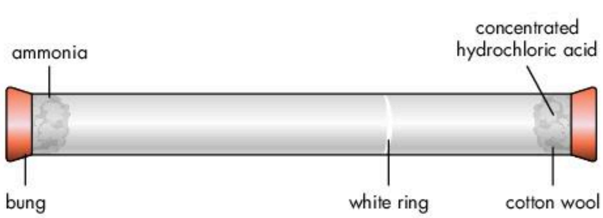
Do these experiments support the idea that matter is made of particles and that there are spaces between them?


The left picture shows bromine gas placed in the lower gas jar. Explain what happens and what it tells you about particle movement.

11.2 Diffusion in gases

Materials: concentrated ammonia solution, concentrated hydrochloric acid, a long 40 cm tube of glass, retort stand, tweezers, cotton wool, droppers, two bungs
Method

1 The tube is held level in the retort stand.
2 Using tweezers, small balls of cotton wool are placed in both ends.
3 With care, droppers are used to saturate the cotton wool with the solutions at the same time, and rubber bungs put into the ends of the tube.
4 Observe, record and explain the results.



Do you think the particles of the gases have moved?

11.3 Brownian movement

Materials: fine chalk powder, alcohol, evaporating dish, hand lens, microscope
Method
You cannot see particles moving, but you can see the effect, e.g. early in the morning, in a dim room, you may see dust particles being hit by moving air particles; this is Brownian movement.

1 Pour a little alcohol into an evaporating dish. Use some of your very fine chalk dust to sprinkle a little on the surface.
2 Place the dish on a dark surface and observe with the hand lens. Can you see the chalk particles moved around by the movement of the alcohol particles?
3 You can also look at the set-up using the low power of a microscope.

Can you observe Brownian movement?

11.4 Diffusion in liquids

Materials: potassium permanganate crystals, beaker half full of water, straw, tweezers

Method

Work in small groups:

1 Put the straw in the water. Pick up a small crystal of potassium permanganate with the tweezers and drop it down the straw into the water. Remove the straw.
2 Observe immediately and after 30 minutes and 1 hour.
3 Describe and explain what happens.

What happens to the particles of the crystal and the particles of water?

11.5 Movement of water: osmosis

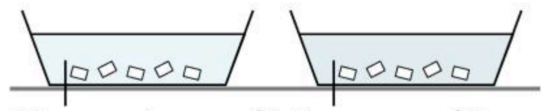
Materials: Irish potato, cork borer, knife, dishes with distilled water and with strong sugar solution, ruler, balance, measuring cylinder

Method

Work in small groups:

Set up a fair test to compare what happens when potato tissue is put in water and in sugar solution. Consider which variables should be kept constant. What will be the dependent variable? How will you measure it? And what do you expect to happen?

1 Your teacher will show you how to use the cork borer to make lengths of potato.
2 Set up your fair test. Make sure you have the same amounts of potato lengths (how will you decide this?) and the same amounts of liquids (how will you decide this?).
3 Leave for 30 minutes. What are your observations? What do your measurements tell you?
4 For the strips in water, **(a)** in which direction did water particles move? How do you know? What is the reason? For the strips in strong sugar solution, **(b)** in which direction did water particles move? How do you know? What is the reason?



(a) pure water (b) strong sugar solution

How does your investigation show osmosis?

▶ **See Workbook Particles and atomic structure.**

What does it mean?

Brownian movement: random movement of small particles as they collide with moving air or water particles.

Diffusion: movement of particles from where they are in high concentration to a place of lower concentration.

Osmosis: movement of water particles from where they are in high concentration to where they are in lower concentration through a partially (selectively) permeable membrane.

The kinetic theory of matter

This says that matter is made up of large numbers of particles. We can show this by breaking up substances into small pieces. The particles are in constant motion.

- Solids: the particles are tightly packed together and can only wobble around and not move from place to place.
- Liquids and gases the particles have more energy (kinetic energy: the energy of movement) and are continually moving from an area where they are in high concentration to an area of lower concentration. We see this in diffusion and osmosis.

Questions

1 In the interaction between ammonia and hydrogen chloride gas where does the ring form? Why do you think this is?
2 Would Brownian movement occur in solids, liquids and gases? Explain your answer.
3 What must be true for diffusion to occur?
4 Do you think osmosis is a special case of diffusion? What are your reasons?
5 What is a partially (selectively) permeable membrane? Give an example. What does it do?

The arrangement of particles

Particles in a substance can be arranged in different ways. We can take water as an example

- Solid water is ice. It is water below 0 °C (freezing point).
- Liquid water is water between 0 °C and 100 °C.
- Gas is water vapour. It is water above 100°C (boiling point).

As we heat solids we provide the particles with more kinetic energy. At first the particles spread apart a little more: this explains expansion, e.g. of a metal. If the particles gain enough kinetic energy they can separate and begin to move – the solid melts to a liquid. In a similar way liquids can become gases.

When we cool gases, we slow down the movement of the particles, until eventually they condense to form a liquid. In a similar way a liquid can be cooled and changed to a solid.

What are the particles in matter?

The particles inside ice, liquid water and water vapour are all the same; the only difference between the states of water is in how close or far apart the particles are; their kinetic energy. It is the different arrangement of particles that make the differences between solid, liquid and gas.

In Unit 9, you identified pure and impure substances.

- Pure substances have particles of only one kind. These particles can be of single **elements**, e.g. hydrogen, oxygen or of elements joined together to make **compounds**, e.g. water. The particles of elements are found as single atoms, e.g. carbon or as molecules (atoms joined together), e.g. oxygen, hydrogen. The particles of compounds are always molecules, e.g. carbon dioxide, water.
- Impure substances are mixtures of two or more substances, e.g. air, or water with salt dissolved in it.

PS 11.6 Atoms and molecules

Materials: modelling clay of different colours, paper
Method

1. Make 12 purple balls (to represent carbon) and 12, similar sized, of orange (for oxygen). Then make 12 very small balls of blue (for hydrogen).
2. Use the balls to show models of: carbon atoms, hydrogen molecules, water molecules, oxygen molecules, and carbon dioxide molecules.
3. Match your models to the pictures **(a)–(e)** below. Describe each model as an element or compound, atom or molecule.

(a) (b) (c) (d) (e)

Fun facts

- A substance is described as the state it is at room temperature (20 °C), for example iron is solid, water is liquid and carbon dioxide is a gas.
- Pure substances have set (fixed) temperatures at which they change from solid to liquid, and liquid to gas.

Kinetic envergy

This is the energy of movement of particles and objects. Particles of:

- solids have the least kinetic energy, are tightly packed and can only wobble from side to side,
- liquids are less tightly packed and the particles have more kinetic energy so they can flow from one place to another,
- gases have the most kinetic energy and their particles can move far apart from each other.

UK 11.7 States of matter

1. Recap the work you did on solids, liquids and gases in Grade 7. Make drawings to show the arrangement of the particles inside each state of matter.
2. Prepare a table to list a property of solids, liquids and gases and describe how it can be explained on the basis of the arrangement of the particles.
3. When a solid is heated it expands. What is happening to the particles? How do you explain this?
4. If a solid is heated to its melting point, it becomes a liquid. What is happening to its particles?
5. Prepare a diagram of the states of matter and the processes as they are heated from solid to liquid and to gas.
6. When a gas is cooled, what happens to its particles? If it is cooled enough what will it become?
7. Prepare a diagram of the states of matter and the processes as they are cooled from gas to liquid and to solid

What is inside the particles?

We can look at the particles inside atoms: the **subatomic** particles. We can make a model of an atom that is a bit like the solar system. There is a central denser area, the nucleus, and electrons in orbit around it. Most of an atom is empty space: the nucleus is 10 000 times smaller than the atom.

The three basic subatomic particles are **protons**, **neutrons and electrons**:

- **Protons**: These are in the nucleus. They each have one positive charge, written as +1. The number of protons in the nucleus is characteristic of each kind of element. For example a carbon atom has six protons and oxygen has eight.
- **Neutrons**: These are also in the nucleus. They are neutral; they do not have any charge. Each one has a similar mass to a proton. The number of neutrons varies.
- **Electrons**: These are found in orbits around the nucleus. Each one has a negative charge, written as -1. They are minute: it would take 1860 electrons to have the same mass as a proton. In an atom the number of protons equals the number of electrons; their charges cancel out. So an atom is neutral.

How the electrons are arranged

The electrons orbit the nucleus at very high speeds. They stay at certain fixed distances from the nucleus. Each set of electrons weaves a **shell** around the nucleus; these are called **energy levels**. The electrons in the shell closest to the nucleus have least energy, and those in the outermost shell have the most energy. The first shell can contain two electrons, and the second shell can contain eight.

You can now make your own models of some atoms.

11.8 The structure of atoms

Materials: paper punch machine, red, green and white paper, paste, pair of compasses.

Method

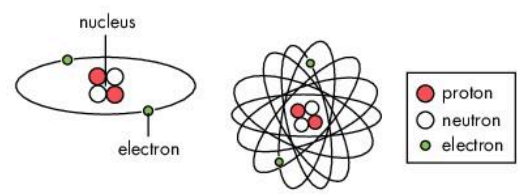
1. Use the paper punch to punch out red circles (as protons), green circles (as electrons) and white circles (as neutrons).
2. Using the information in the account above, fill in the numbers in the table and make models.

	Protons	Neutrons	Electrons
Hydrogen	1	none	1
Carbon	6	6	
Oxygen		8	8
Sodium	11	12	

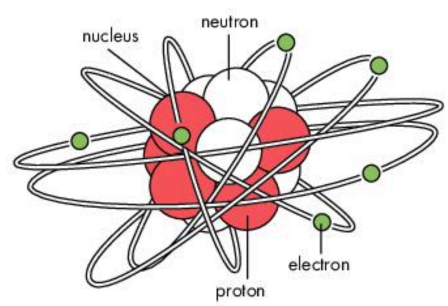
Parts of an atom			
	Position	**Charge**	**Relative mass**
Proton	nucleus	positive	1
Neutron	nucleus	neutral	1
Electron	orbit	negative	1/1860

Fun facts

- If the nucleus were the size of a tennis ball, the nearest electron would be 1 km away.
- By smashing atoms together at great speeds, scientists have found over 200 particles inside atoms. But few last for more than a fraction of a second.



A helium atom



An atom: The central nucleus with neutrons (neutral) and protons (+), surrounded by the orbiting electrons (–)

Questions

1. How are the solar system and an atom (a) similar and (b) different? What different instruments would be needed to find out their structure?
2. If we know the number of protons can we predict the number of electrons in an atom? Explain your answer.
3. If we know the number of protons can we predict the number of neutrons in an atom? Explain your answer.

▶ **See Workbook Particles and atomic structure.**

Atomic number and mass number

We can use two numbers to describe each kind of atom. These numbers depend on the numbers of protons and neutrons that are present in the atom.

- **Atomic number:** This is the number of protons in the nucleus. It is the same for every atom of a particular element. Every element has a different atomic number; it is unique to that element. For example oxygen has eight protons in its nucleus, so its atomic number is 8. Because the number of protons in an atom equals the number of electrons, if we know the atomic number we also know the number of electrons in the atom. Also, if we know the number of electrons, this will be equal to the number of protons and to the atomic number.
- **Mass number:** This gives the relative mass of the atom. It is found by adding together the numbers of protons and neutrons. The mass of the electrons is ignored as it is so very small.

We can use this information. For example, the mass number of oxygen is 16. Because we know its atomic number is 8, we know it has 8 protons. It must therefore have 8 neutrons: 16 (mass number) – 8 (atomic number) = 8 (number of neutrons). Note: In some elements, such as chlorine, there are atoms with different numbers of neutrons.

11.9 Using atomic number and mass number

Materials: paper punch machine, red, green and white paper, paste, pair of compasses.

Method

Work in small groups:

1 Use the paper punch to punch out red circles (as protons), green circles (as electrons) and white circles (as neutrons).

2 Use the following information to work out the numbers of protons, neutrons and electrons in these elements.

	Mass number	Atomic number	Number of electrons
Lithium	7	3	
Carbon	12	6	
Nitrogen	14		7
Fluorine	19		9
Neon	20	10	
Magnesium	24		12
Aluminium	27	13	
Silicon	28		14

3 Record the numbers of protons, neutrons and electrons in a table. Then use your coloured circles to make models of the atoms. Remember only 2 electrons fit in the first shell, and 8 in the second shell. (The third shell can contain 18 electrons.)

▶ **See Workbook Particles and atomic structure.**

Fun facts

- The protons, neutrons and electrons of all matter are the same. Elements are different because of the numbers and arrangement of these particles.
- In an atom, the number of electrons is equal to the number of protons.

Questions

1 Look at the information given in Activity 11.8. What are (a) the atomic numbers and (b) the mass numbers of hydrogen, carbon and sodium?

2 Look at the model of a helium atom on page 89. What are the atomic number and mass number of helium?

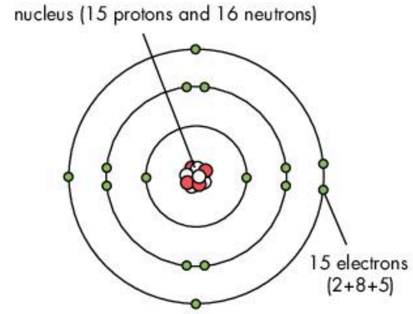
Information:
Phosphorus: Mass number = 31
Number of electrons = 15

Calculation:
In an atom, number of electrons = number of protons, so the phosphorus atom has 15 protons.

If the mass number is 31, and there are 15 protons there must be 16 neutrons (31 – 15 = 16).

Data:
The atom has 15 protons and 16 neutrons in the nucleus. It has 15 electrons arranged in shells: 2 + 8 + 5.

Drawing:
Put the nucleus in the centre. Use your compasses to draw three circles on the paper, and put the electrons in their correct shells.

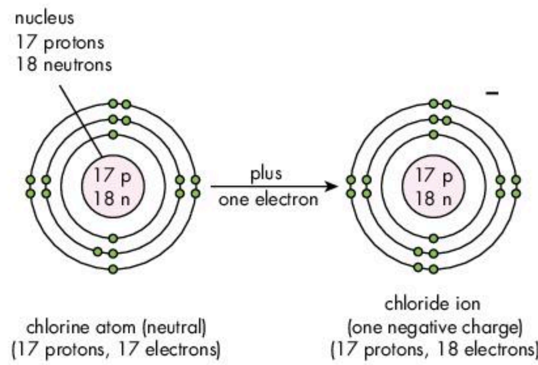


Atoms and ions

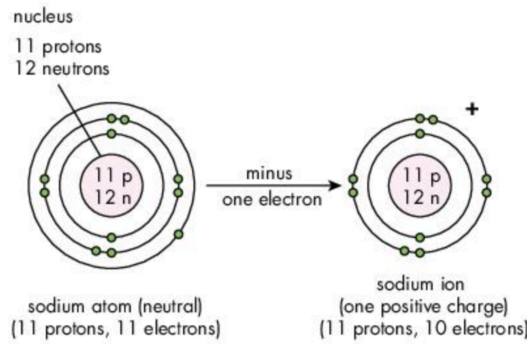
You have seen how atoms are neutral: they have the same numbers of protons and electrons.

But atoms can gain or lose electrons to become **ions**. Ions have negative (–ve) or positive (+ve) charges depending on whether they gain or lose electrons.

- If an atom gains an electron, it will become an ion with a negative charge, written as –1 or as –. There will be more electrons than protons. We can see this is the formation of a chloride ion. (See on the top right.) If the atom gains two electrons, the charge on the ion will be –2.
- If an atom loses an electron, it will become an ion with a positive charge. There will now be more protons than electrons. If one electron is lost, the charge will be written as +1 or as +. We can see this in the formation of a sodium ion. (See bottom right.) If two electrons are lost, the charge will be +2.



A chlorine atom becomes a negative chloride ion by gaining one electron



A sodium atom becomes a positive sodium ion by losing one electron

11.10 Atoms or ions?

Materials: paper punch machine, red, green and white paper, paste, pair of compasses.

Method

1. Use the paper punch to punch out red circles (as protons), green circles (as electrons) and white circles (as neutrons).
2. Look at the table below. For each line, fill in the missing information.
3. For the ions, add the size of the charge (+1 or +2 etc.).
4. Choose one of the atoms or ions and make a labelled model.

Atom or ion?	Atomic number	Number. of electrons	Number of protons
(a)	3	3	
(b)	11	10	
(c)		18	17
(d)	12	10	
(e)		6	6
(f)		10	13
(g)	9	10	
(h)	10	10	

Information:
A beryllium atom has an atomic number of 4. It loses 2 electrons when it becomes an ion. What is the charge on the ion?

Calculation:
The atomic number is 4, so the atom has 4 protons and 4 electrons. If the atom loses 2 electrons, then 2 of the protons will not be balanced. The ion will have an overall positive charge of +2. Work out other examples given to you by your teacher.

Quick check

_________ are close together in _________ ; particles in gases and _________ can _________ . _________ in elements can be _________ or molecules. The proton is _________ and the electron is _________ . The number of protons equals the _________ number. _________ are neutral. An ion is _________ or _________ .

Use these words to fill in the spaces as you write the sentences in your Exercise book.

atomic **–ve** **particles** **+ve** **atoms** **solids** **liquids** **diffuse**

Elements and the periodic table

In this topic you will see how elements can be arranged in the periodic table and recognise groups with similarities. This is done on the basis of their structures and properties.

We begin by looking at the structure of the atoms in the elements with atomic numbers 1-20. We will see how the structure of each succeeding one becomes more complex.

Atomic structure

In an atom:

- The number of protons is called the **atomic number**.
- The number of protons equals the number of electrons. This makes the atom neutral.
- The number of protons plus the number of neutrons gives the relative mass of the atom. This is called the **mass number**.
- The electrons are arranged in shells (energy levels) around the nucleus. The first shell can contain 2 electrons and the second shell can contain 8 electrons. The third shell (up to element number 20) can contain 8 electrons.

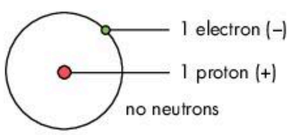
As the atomic number increases by one:

- The number of protons and electrons each increase by one.
- The number of neutrons do not show a set pattern. The number of neutrons in a particular element has to be worked out by knowing the atomic number and mass number.
- If the electrons cannot fit in a particular shell (because it is 'full up') then they go to a higher level.

Notice in the descriptions and diagrams below, that each atom has one more proton and one more electron than the atom that came before.

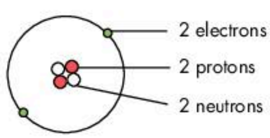
Hydrogen: Atomic number 1, mass number 1

We use this information to work out that there is one proton, one electron and no neutrons. We can draw the atomic structure as shown on the right.



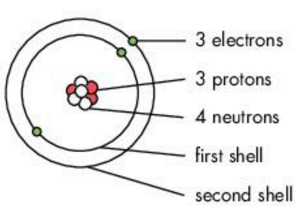
Helium: Atomic number 2, mass number 4

So we work out there are two protons, two electrons and two neutrons.
We can draw the atomic structure as shown on the right.



Lithium: Atomic number 3, mass number 7

So we know there are three protons, three electrons and four neutrons. Note that in the atomic structure, the first shell is full, so the third electron starts a new one.



Objectives

- Know the chemical symbols of elements with atomic numbers 1-20.
- Use atomic number and mass number to interpret atomic structure.
- Describe how the elements with atomic numbers 1-20 are arranged in the periodic table.
- Recognise characteristics of important groups in the periodic table.

The naming of elements

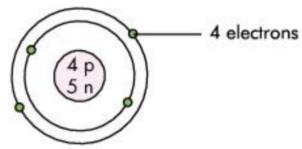
Scientists have a shorthand way of writing about the elements. They use chemical **symbols** instead of the names.

- The symbol is often the first letter, e.g. hydrogen (H), carbon (C), nitrogen (N), oxygen (O), sulphur (S).
- The second letter is also often used, especially if the first letter has already been used, e.g. helium (He), neon (Ne), silicon (Si), calcium (Ca), aluminium (Al), argon (Ar).
- Sometimes a different second letter is used, e.g. magnesium (Mg), chlorine (Cl), zinc (Zn).
- Sometimes the abbreviations come from Latin words, e.g. sodium (Na), potassium (K), copper (Cu), iron (Fe), silver (Ag), gold (Au).
- The first letter is a capital, and a common letter for the second one.

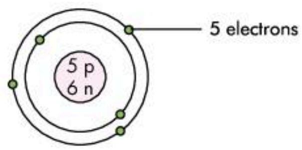
Fun facts

- There are 92 naturally-occurring elements. But scientists have created over 20 other ones, though some of them only exist for a very short time.
- Every element is unique. Its properties depend on its numbers of protons, neutrons and electrons.
- Elements that have similar arrangements of electrons, especially in their outer shells, belong to the same 'family'.

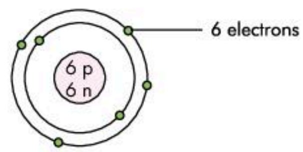
Beryllium: Atomic number 4, mass number 9
So we know there are four protons, four electrons and five neutrons. The electrons will be arranged with two in the first shell and two in the second shell.



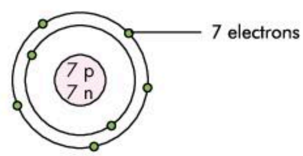
Boron: Atomic number 5, mass number 11
So we know there are five protons, five electrons and six neutrons. The electrons will be arranged with two in the first shell and three in the second shell.



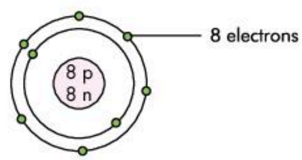
Carbon: Atomic number 6, mass number 12
So we know there are six protons, six electrons and six neutrons. The electrons will be arranged with two in the first shell and four in the second shell.



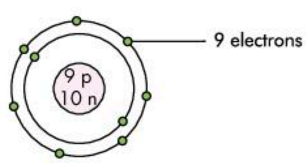
Nitrogen: Atomic number 7, mass number 14
So we know there are seven protons, seven electrons and seven neutrons. The electrons will be arranged with two in the first shell and five in the second shell.



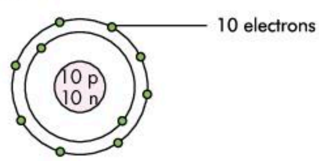
Oxygen: Atomic number 8, mass number 16
So we know there are eight protons, eight electrons and eight neutrons. The electrons will be arranged with two in the first shell and six in the second shell.



Fluorine: Atomic number 9, mass number 19
So we know there are nine protons, nine electrons and ten neutrons. The electrons will be arranged with two in the first shell and seven in the second shell.



Neon: Atomic number 10, mass number 20
So we know there are ten protons, ten electrons and ten neutrons. The electrons will be arranged with two in the first shell and eight in the second shell.



You can now work out the atomic structure of the atoms with atomic numbers 11–18 (see Activities 11.11 and 11.12).

▶ **See Workbook Elements and the periodic table.**

UK 11.11 Atomic structures

Use the following information:

	Atomic number	Mass number
Sodium	11	23
Magnesium	12	24
Aluminium	13	27
Silicon	14	28
Phosphorus	15	31
Sulphur	16	32
Argon	18	22

1 Work out, for each element, how many protons, electrons and neutrons there will be in the atom.
2 As we have seen, 2 electrons fit in the first shell, and 8 electrons in the second shell. Because all these elements have 11 or more electrons, some of them will have to go into the third shell. Make labelled diagrams.

Isotopes

Every atom of a particular element has the same number of protons (and electrons). But in the atoms of some elements there are different numbers of neutrons. These different forms of the same element are called **isotopes**.

An example is chlorine. The atomic number is 17. So there are 17 protons and 17 electrons in every atom. But some atoms of chlorine have 18 neutrons and some have 20 neutrons. The result of this is that the overall mass number of chlorine is 35.5.

UK 11.12 Isotopes

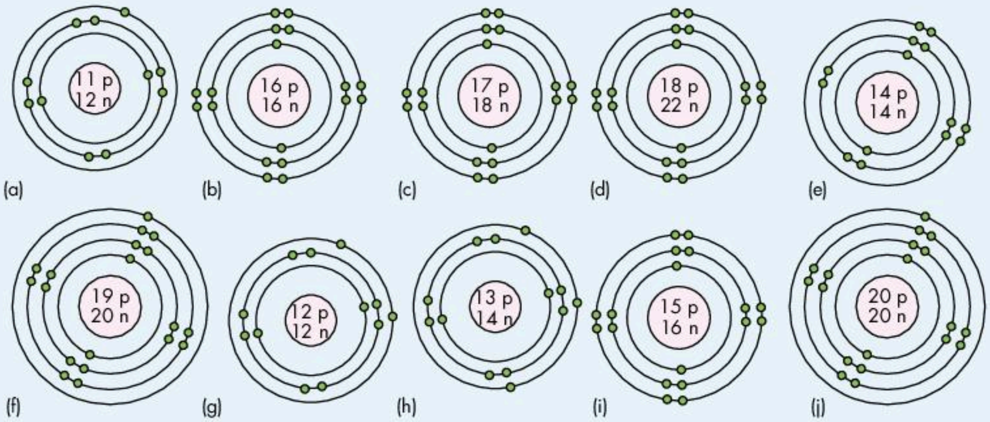
Use the following information:

	Protons	Electrons	Neutrons
Chlorine–35	17	17	18
Chlorine–37	17	17	20

Make diagrams of the atoms of the two isotopes of chlorine. Label the protons, neutrons and electrons.

11.13 Match atoms and elements

1 The diagrams show the electron arrangements for atoms of elements 11–20.
2 Match each one to its symbol (and element) and arrangement of electrons.



Elements	
Na	2,8,1
Mg	2,8,2
Al	2,8,3
Si	2,8,4
P	2,8,5
S	2,8,6
Cl	2,8,7
Ar	2,8,8
K	2,8,8,1
Ca	2,8,8,2

The periodic table

In 1817, a German chemist Johann Döbereiner, noticed several sets of three elements with similar properties, e.g. lithium, sodium and potassium, and chlorine, bromine and iodine.

In 1864, an English chemist John Newlands, put forward his law of octaves. He arranged elements by their relative atomic masses and saw similar properties every eighth element. But this produced some mistakes, so was not generally accepted.

In 1869, a Russian chemist Dmitri Mendeléev, also arranged the elements by their relative atomic masses, but put similar elements into the same groups (vertical columns) and left some spaces. He worked out the atomic masses and properties for the 'missing' elements and they were later discovered.

In 1913, a British chemist, Henry Moseley, arranged the elements by their atomic numbers and this solved the previous problems and led to the present-day periodic table.

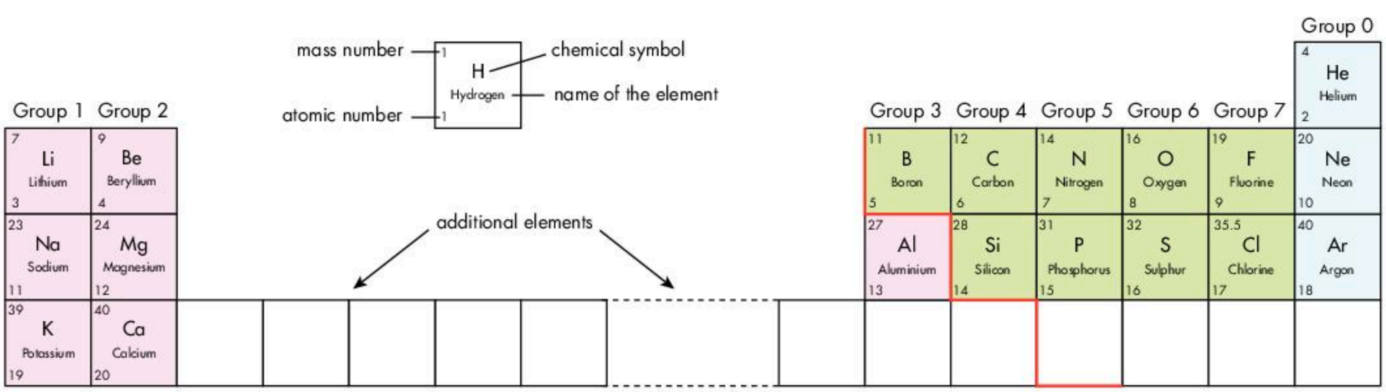
11.14 The periodic table

Work in groups:

1 Research on the Internet and other resources to trace the contribution of the following scientists to the arrangement of elements in the periodic table: Döbereiner, Newlands, Mendeléev and Moseley. **ICT**

2 Discuss how important it was to (a) 'look for patterns', (b) build on what was done before, (c) leave spaces for unknown elements.

3 Create a montage/ digital story to represent your information. Present a 5-minute play, song, etc. to the class.

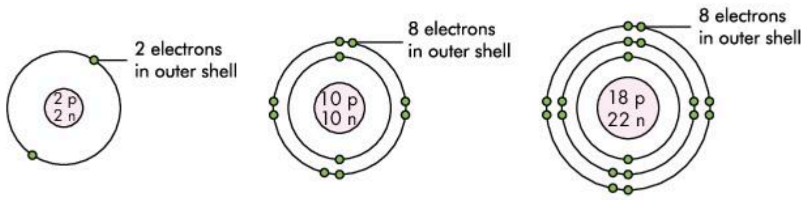


Groups of elements

- During chemical changes, atoms interact so that their outer shell becomes full (usually eight electrons).

The noble gases: Group 0

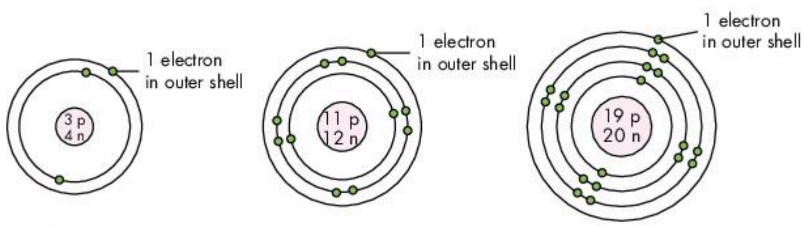
These gases already have a full outside shell (2 or 8). They do not need to lose or gain electrons. They are very unreactive.



helium *neon* *argon*

The alkali metals: Group 1

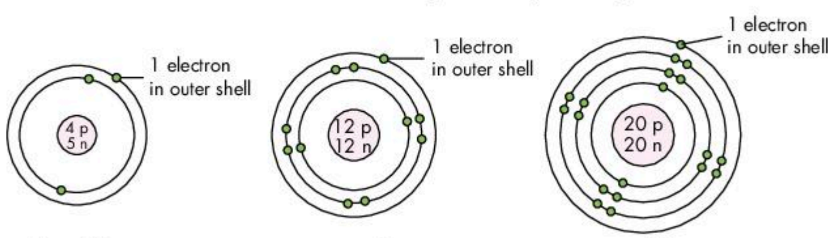
The alkali metals have one electron in their outside shell. They are very reactive metals. They easily lose their outer electron in chemical reactions, to become positively charged ions.



lithium *sodium* *potassium*

The alkaline earth metals: Group 2

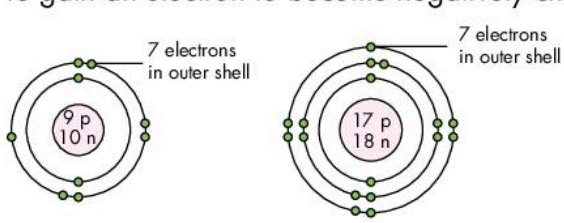
The alkaline earth metals have two electrons in their outside shell. They are reactive metals. They lose their outer electrons in chemical reactions, to become positively charged ions.



beryllium *magnesium* *calcium*

The halogens: Group 7

The halogens have seven electrons in the outside shell. So they are very reactive non-metals. In chemical reactions they tend to gain an electron to become negatively charged ions.



fluorine *chlorine*

11.15 Looking for groups

Elements are arranged into groups based on the number of electrons in their outer shell.

1 Use the table below, and the periodic table on page 94 to identify elements that could belong to the same group.
2 Then check your answers with the text.

		Electrons in shells			
Symbol	**Atomic number**	**1st**	**2nd**	**3rd**	**4th**
H	1	1			
He	2	2			
Li	3	2	1		
Be	4	2	2		
B	5	2	3		
C	6	2	4		
N	7	2	5		
O	8	2	6		
F	9	2	7		
Ne	10	2	8		
Na	11	2	8	1	
Mg	12	2	8	2	
Al	13	2	8	3	
Si	14	2	8	4	
P	15	2	8	5	
S	16	2	8	6	
Cl	17	2	8	7	
Ar	18	2	8	8	
K	19	2	8	8	1
Ca	20	2	8	8	2

Members of the same family have some characteristics in common. They also have differences. The same is true of the elements belonging to each group.

11.16 Working with elements

1 Design games to help you remember the names and symbols of the elements 1–20. Also research common metals and add them to your collection, such as silver, gold, copper and zinc. Here are some ideas:
  (a) Make separate cards of names and symbols. Mix them up and then sort them into pairs.
  (b) Give several mixed cards to each student and they have to find other students to make 'matches' of elements and symbols.
  (c) Make cards for the elements in Groups 0, 1, 2 and 7 (an extra member is bromine (Br)). Then use the cards with a friend to play 'Happy families' to match up the members.
  (d) Design a game of Bingo, using the numbers 1–20 of the elements mixed up on the individual cards. Plan and improve your prototypes and play a game.

2 Collect and display common everyday elements that are shown on the periodic table. Identify which are solids, liquids or gases at room temperature, and which are metals or non-metals. Discuss where the elements belong.

3 Select an element of choice for your group and research where it is found, its properties and uses. Create and an illustrated poster of your findings. ICT

4 Select an element that is important in the body, e.g. iron and research where it is found and its uses. Create an illustrated poster of your findings. ICT

Arrangement in the periodic table

Look at the periodic table on page 94. Note that:

- in each square there is the mass number, atomic number, chemical symbol and name of the element.
- each vertical column has a group number. You can find the inert gases in Group 0, the alkali metals in Group 1, the alkaline earth metals in Group 2 and the halogens in Group 7.
- across each horizontal row (the periods), the atomic numbers go up one-by-one. The elements in the first row (hydrogen and helium) have only one shell; in row two, the elements have their electrons in two shells and so on. At the start of a period are the metals (shaded pink), then later raises non-metals (green) and ending with a noble gas (pale blue).

11.17 Groups and periods

Look at the periodic table on page 94. As a class project make a large copy of the periodic table:

1 In each square enter the information about an element: its mass number, atomic number, symbol and name. Also add a picture where possible.
2 Write the numbers for the groups and add the names noble gases, alkali metals, alkaline earth metals and halogens to their columns.
3 Colour the metals pale pink, the non-metals light green and the noble gases light blue.
4 Number the periods on the left hand-side, 1, 2, 3.

▶ **See Workbook Elements and the periodic table.**

Metals and non-metals

- Sodium is an example of a metal. Metal elements usually have only a few electrons in their outer shells. In chemical reactions they usually lose electrons to make positive ions. Sodium is so reactive it has to be stored under oil so it does not react with the air.
- Chlorine is an example of a non-metal. Non-metal elements usually have a lot of electrons in their outer shell. In chemical reactions many of them gain electrons to make negative ions. Other non-metal atoms share electrons.

There is more about metals and non-metals in the next topic.

Quick check ☑

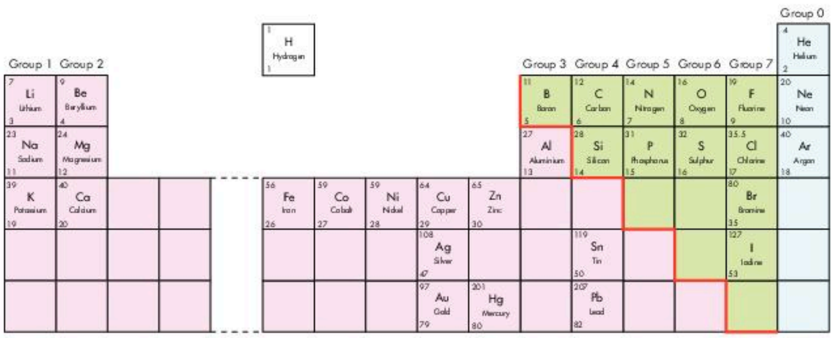
The atomic number is the number of ________ in the atom. The mass number equals the number of ________ plus the number of ________ . The ________ are arranged in ________ around the nucleus. Elements are arranged in ________ in the ________ table.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

periodic **shells** **protons**
electrons **groups** **neutrons**

Metals and non-metals

The diagram shows an extension of the periodic table. Some other important metals and non-metals have been included. The pink boxes show metals and the green boxes show non-metals. You can test samples to find their different properties.



Objectives

- Realise that elements behave differently because they are metals or non-metals.
- Investigate and classify elements as metals and non-metals based on physical and chemical properties.
- Give examples and uses of metals and non-metals.

11.18 Classifying metals and non-metals

Materials: iron nail, carbon (graphite from a pencil), sulphur, copper wire, aluminium foil, zinc, candle, matches, incomplete electrical circuit, hammer

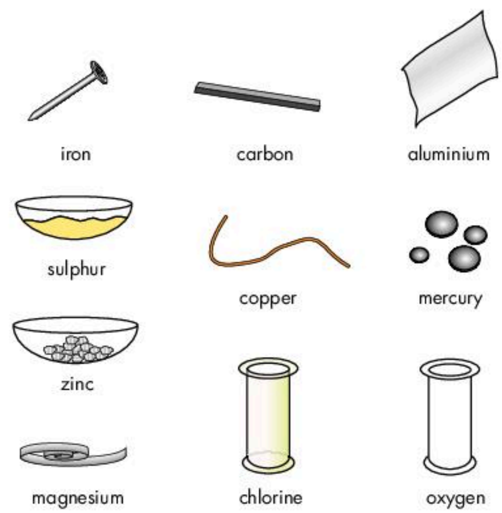
Method

Compare the properties of the metals and non-metals and record your results in a suitable table.

1 Appearance: are they shiny or dull?.
2 Hardness: are they hard (strong) or soft (easily broken). You can carefully use the hammer on a small sample to find out.
3 Density: using equal-sized pieces, which one is heavier (more dense)?
4 Malleable? This means it can be easily shaped, e.g. beaten into thin sheets.
5 Ductile? This means it can be pulled out to make wires.
6 State of matter? What state are all metals (apart from mercury)? Can you name some non-metals that are gases? What can you find out about boiling and melting points? **ICT**
7 Conduction of heat? Hold a sample in a candle flame. Record if the part in your hand becomes warm.
8 Conduction of electricity? Make up an incomplete electrical circuit with a dry cell, bulb in a bulb holder and connecting wires. Try each of your samples in the circuit to see which ones can allow electricity to flow to complete the circuit.

You will probably find that metals are shiny, hard, dense, malleable, ductile, solid, and able to conduct heat and electricity. The non-metals have properties that are the opposite of these. Record if any of the samples seem to be exceptions.

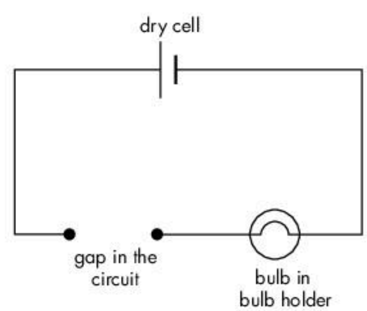
▸ **See Workbook Metals and non-metals.**



Which ones are metals and which ones are non-metals? List them in a table, together with their chemical symbols.

Fun facts

- Metals allow electrons to flow through them easily. This is why they are good conductors of electricity.
- Carbon is a non-metal, but as graphite it can conduct electricity.



A circuit diagram of an incomplete electrical circuit. Use it to test the samples to see if they conduct electricity. How will you know?

Physical properties of metals and non-metals

Physical properties describe the appearance and nature of a single substance. They describe its state, melting and boiling points and whether or not it conducts heat and electricity. (Chemical properties are how substances interact with each other.)

Property	Metals	Non-metals
Appearance	Shiny when polished or freshly cut. Some (e.g. silver and gold used for jewellery).	Dull. Also include coloured gases (e.g. chlorine) and colourless gases (e.g. oxygen and nitrogen
Hardness and strength	Hard and strong. Strong bonds between the metal particles. Make them good for building materials.	Soft and weak. Some are powders (e.g. sulphur). Some have a strong structure (e.g. carbon in the form of diamonds).
Density	High densities. Particles are tightly packed. Exceptions are the alkali metals, e.g. sodium, which are light. Most are solids.	Low densities. Particles are not tightly packed even in the solids. Many are gases.
Malleable	Easily shaped. Can be beaten into sheets. The bonds within the metal are strong, so they can withstand movement.	Not malleable. Bonds between particles easily broken. Cannot be made into sheets.
Ductile	Can be stretched into wires. The bonds in the metal are strong, so they don't break. Can make wires, e.g. copper.	Cannot be drawn into wires. The bonds are not strong. Non-metals break easily.
State of matter	Solids. Only one, mercury, is a liquid at room temperature.	Solids and gases. Only one, bromine, is a liquid at room temperature; it changes to a gas at 59 °C.
Melting and boiling points	High melting and boiling points. Because of the strong bonds in the metals, it takes a lot of heat to melt the solids, and a lot more to change the liquids into gases.	Low melting and boiling points. Because of the weak bonds holding the particles together, non-metals melt and boil easily. Many are gases at room temperature.
Conduction of heat	Good conductors of heat. Most metals are dense, with particles close together. So the particles pass on heat easily by conduction.	Poor conductors of heat. Non-metals are less dense, or they are gases. So their particles are further apart. Compounds of non-metals, e.g. plastics, are insulators.
Conduction of electricity	Good conductors of electricity. Metals have a structure with free electrons. These can move to conduct electricity. Metals also make good electrical wires.	Poor conductors of electricity. Non-metals do not have free electrons. Compounds of non-metals, e.g. plastics, are used for plugs and insulation on electrical wires.
Magnetism	Some metals are magnetic, i.e. they can be attracted by a magnet. Iron, nickel and cobalt are magnetic, and any alloy (e.g. steel) made from them.	No non-metals are magnetic.

Properties and uses of metals

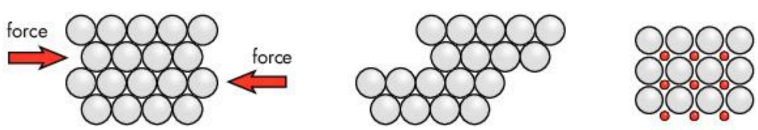
The different physical and chemical properties of particular metals suit them for different uses.

Metal	Properties	Uses
Sodium (Na)	very reactive, forming many compounds	fertilisers, glass and soaps
Magnesium (Mg)	light, burns brightly	aeroplanes, fireworks, cars and antacids
Aluminium (Al)	light and strong	aeroplanes, window frames, cans, foil
Copper (Cu)	very good conductor, resists corrosion	electrical wires, water pipes, cooking pans
Iron (Fe)	grey, very malleable, easily magnetised	most widely used metal, especially as its alloy: steel, e.g. bridges, cars, pots, cutlery
Tin (Sn)	does not rust or corrode	tin-plating for steel cans, also in alloys
Zinc (Zn)	does not rust or corrode	thin coating on steel prevents rusting, in alloys
Mercury (Hg)	only metal that is liquid	in thermometers, long-life batteries
Silver (Ag)	shiny grey metal, easily shaped	jewellery, cutlery, on photographic film
Gold (Au)	shiny yellow, does not tarnish	jewellery, electronics
Uranium (U)	radioactive	used as a fuel in nuclear reactors

Alloys

Although metals have many uses, they are even more useful as **alloys**. An alloy is a mixture of two or more metals. Alloys are usually made by melting the metals together, and then letting them cool and harden.

- Alloys are stronger than the pure metals.
- Alloys are resistant to corrosion or rusting.
- Alloys can be designed to have special properties to fit them for particular uses.



pure metal — layers slide over each other easily in a pure metal — an alloy of two metals is stronger

For example, pure iron is weak and soft. When small amounts of carbon are added to it, it becomes steel. But it can still rust. With the addition of small amounts of nickel and chromium, it can be made into stainless steel, which does not rust. This is more expensive than ordinary steel but has many building uses.
Here are some other common alloys.

Alloy	Metals present	Uses
Duralumin	aluminium, copper, magnesium, silicon	light-weight, corrosion resistant for aeroplanes
Brass	copper and zinc	screws, electrical fittings
Bronze	copper and tin	'copper' coins
Gold alloys	with copper or silver	rings (the alloy is harder)
Solder	tin and lead	for joining hot metals

Fun facts

- Pure gold, called 24-carat, is too soft to use on its own. Most jewellery is made of 14-carat gold, which is about 60 % gold with copper or silver to harden it.
- An alloy of iron with manganese is so strong it can break rocks.
- A 'tin' can is made of steel. It has a thin layer of tin added to the inside to make it resistant to the food.

Questions

For each of the following properties of metals, give an example, and describe a use that is based on the property.

1 Metals are shiny when clean.
2 Metals are good conductors of heat.
3 Metals are good conductors of electricity and can make wires.
4 Metals can be given sharp cutting edges.
5 Metals 'ring' when they are struck.
6 Metals have high melting and boiling points.
7 One metal is a liquid at room temperature.
8 Metals expand and contract different amounts when heated and cooled.

Aluminium as an example of a metal

In Jamaica, deposits of bauxite (impure aluminium oxide) occur in limestone rocks at an average depth of 6 metres, but are only mined down to about one and three-quarter metres.

Mining

The overlying soil and rocks are removed and the bauxite extracted from opencast mines. If it is to be exported as bauxite, it is first dried to reduce the water content.

Preparing pure alumina

Bauxite is aluminium oxide mixed with sand and iron oxide. To separate the mixture, the bauxite is mixed with sodium hydroxide (caustic soda). This dissolves the aluminium oxide and leaves the impurities as red mud. The pure aluminium oxide (alumina) forms as crystals and can be separated and dried.

Preparing aluminium

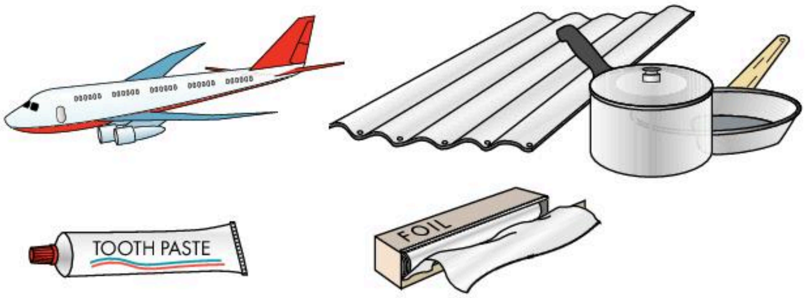
In Jamaica, the alumina is exported for the extraction of aluminium. This is because the final stage requires a lot of energy (18 000 kWh for one tonne of aluminium) and is usually done in countries with a cheaper energy source and a large market for aluminium products.

The extraction of the aluminium from aluminium oxide is done by using electricity. Melted aluminium oxide (mixed with other chemicals) has an electric current passed through it between charged electrodes.

The negatively-charged oxide ions are attracted to the positive electrode, and form oxygen. The positively-charged aluminium ions are attracted to the negative electrode and are removed as pure aluminium.

End products

Aluminium is a silver-white metal with a low density (2.7 g/cm^3). It is used to make wire and cooking pans, as it is a good conductor of electricity and heat. It is also used in lightweight alloys, such as duralumin, in aircraft manufacture.



Some uses of aluminium

Pollution problems

The purification of bauxite to make alumina leads to the production of red mud. Large lakes of this have been built, which affect the water and living things. There is also a release of fumes of sodium hydroxide, which is harmful to the lungs. The removed earth also needs to be replaced and replanted.

The top layers of soil and rock are removed. The bauxite is then taken out and loaded onto trucks

Lake of red mud, from the preparation of alumina. It can damage water supplies and living things.

The pits in mined-out bauxite lands are filled in with soil. The land is then planted with grass and trees, or used to build roads and houses

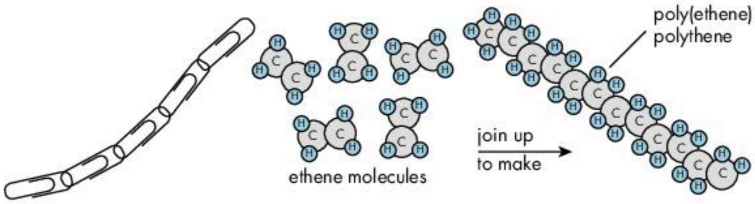
Properties and uses of non-metals

The different physical and chemical properties of particular non-metals suit them for different uses.

Non-metal	Properties	Uses
Carbon (C)	occurs in different forms; graphite can conduct electricity, diamond is very hard	graphite (electrical uses), diamond (cutting tools and jewellery), soot (colouring)
Nitrogen (N)	invisible gas, does not support burning	fertilisers, food processing, explosives, part of all proteins (essential for life)
Oxygen (O)	invisible gas, supports burning	welding, in many foods, needed for burning of fuels, including respiration (essential for life)
Phosphorus (P)	solid that burns with a coloured flame	matches, fertilisers, necessary for bones
Sulphur (S)	yellow solid and powder	sulphuric acid, gunpowder, matches, rubber
Fluorine (F)	invisible gas, very reactive	prevents tooth decay, makes gas used in refrigerators
Chlorine (Cl)	greenish, poisonous gas, very reactive	disinfect swimming pools and drinking water, bleach, part of common salt
Iodine (I)	grey solid giving a violet gas	dye, medicinal (needed for thyroid functioning)

Plastics and artificial fibres

Many of these are made up of the non-metals carbon and hydrogen. They have large molecules that have been made from a repeated pattern of smaller molecules. They are called **polymers**. The small molecules, such as ethene, often come from breaking up crude oil. They are joined together to make the polymer, rather like stringing paper clips together.



Other plastics contain additional elements, such as chlorine in polyvinyl chloride (PVC). Artificial fibres include nylon, vinyl, terylene, lycra and acrylic.

Advantages of plastics:

- they are cheaper and lighter than similar metal items.
- they do not rust and they are long lasting.
- they do not conduct electricity; so can be used as insulators.
- they do not break, so they are better than glass or china.
- they can be coloured with dyes.
- they are resistant to many chemicals (though not all).
- they can be made as transparent sheets (cling film), polythene bottles and bags, and moulded into many shapes.
- used to make, e.g. non-stick covering for pans, safety helmets, adhesives, shoes, telephones, containers, aeroplane windows, paint, luggage, car doors, hoses, pipes.
- as with alloys, they can be designed for particular uses.

PS 11.19 Plastics

Materials: Variety of plastic objects

Method

1. Chose plastic objects that are useful in the ways that are listed in column 1. Make a display with objects or drawings.
2. Discuss in your group some limitations and disadvantages of using plastics as compared (a) to metal and (b) to wooden objects.
3. Research the different types of plastic, and how they are recycled. Investigate how new enzymes are being used to digest waste plastic materials to help reduce the pollution problem. Make a chart of your findings. ICT

A range of items made from different plastics

Summary on the periodic table

The table below summarises the electronic structure of the atoms of elements 1–20.

Groups

	1	2		3	4	5	6	7	0	Number of shells
Period 1			1 H 1						2 He 2	1
Period 2	2.1 Li 3	2.2 Be 4		2.3 B 5	2.4 C 6	2.5 N 7	2.6 O 8	2.7 F 9	2.8 Ne 10	2
Period 3	2.8.1 Na 11	2.8.2 Mg 12		2.8.3 Al 13	2.8.4 Si 14	2.8.5 P 15	2.8.6 S 16	2.8.7 Cl 17	2.8.8 Ar 18	3
Period 4	2.8.8.1 K 19	2.8.8.2 Ca 20	transition metals							4
Number of electrons in outer shell	1	2		3	4	5	6	7	8 or full	

- The atomic numbers are given below each symbol of the element (= number of protons = number of electrons).
- The electronic structures are shown in red: shell one full with 2 electrons, shell two with 8 and shell three with 8.
- Extra electrons go into the outer shell, and it is these that give the elements their main properties and group number.
- The vertical columns are Groups: Groups 1 and 2 are metals.
- There is a space between Groups 2 and 3 for other elements (such as the transition metals, e.g. iron, copper, zinc) where shell three fills up to 18 electrons.
- Groups 3–7 contain non-metals: except for aluminium that is a metal, and boron and silicon like metals and non-metals.
- Group 0 is the noble gases (with full outer shells).
- The horizontal rows are the Periods, where the atoms have that same number of shells.
- As we go down a group, the atoms have higher atomic numbers and these give them their individual differences. For metals, usually the lower down in the group, the more reactive, as they lose electrons more easily. For non-metals, usually the lower down the group, the less reactive, as they cannot gain electrons so easily.

What does it mean?

Electronic structure: The arrangement of electrons in shells in atoms.

Non-metals: Elements that do not usually conduct heat and electricity. They usually have 4–7 electrons in their outer shell and gain or share electrons in chemical reactions.

Metals: Elements that conduct heat and electricity. Their atoms usually have 1–2 electrons in the outer shell, which they lose in chemical reactions.

Alkali and alkaline earth metals: Most reactive metals in Group 1, e.g. sodium, and Group 2, e.g. Magnesium.

Transition metals: Less reactive but more common metals that are placed between Groups 2 and 3, e.g. iron, copper, silver, gold, zinc, mercury, nickel.

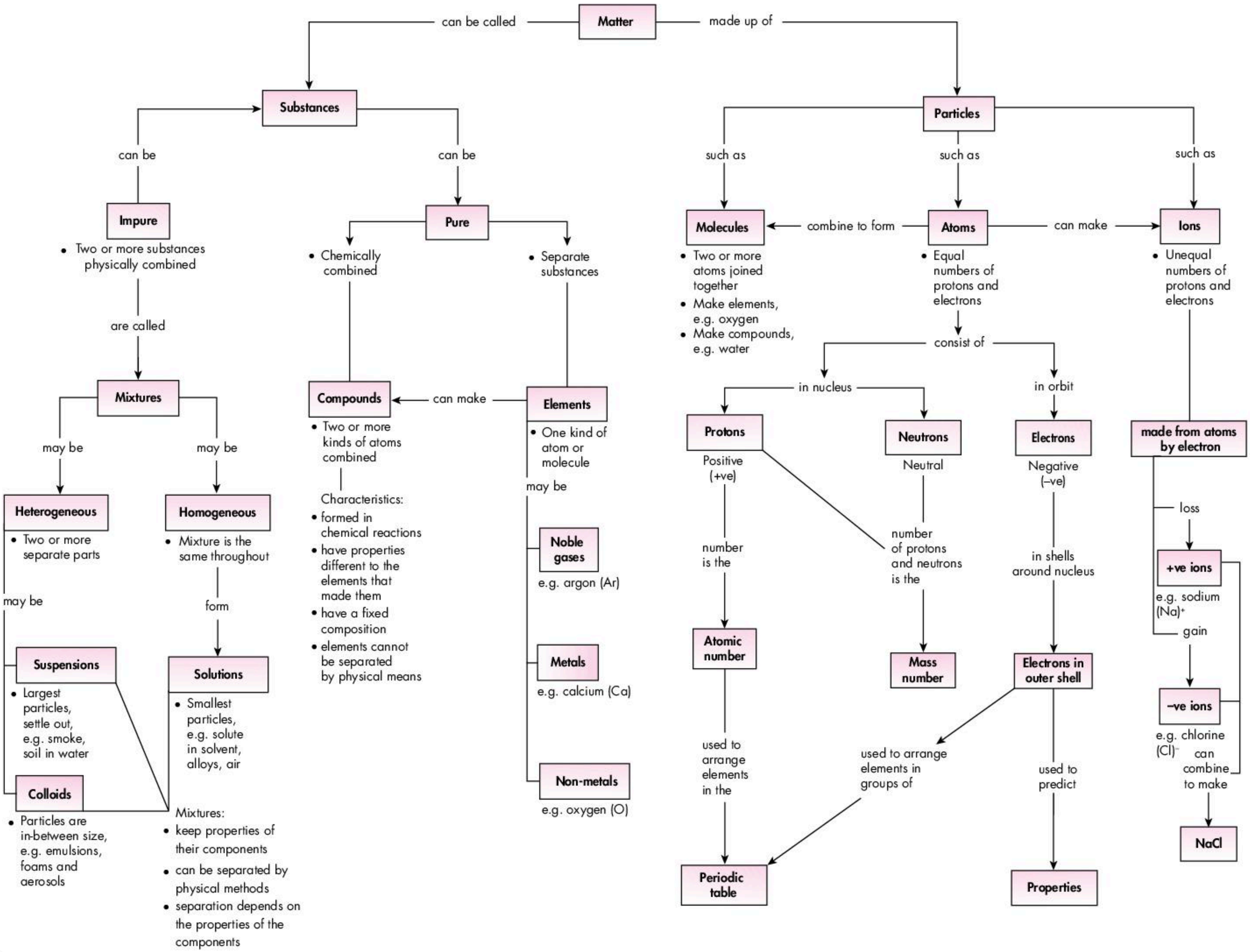
Quick check ☑

__________ are good conductors of heat and electricity; non-metals are __________ conductors, except for __________. __________ are a mixture of metals. Metals __________ electrons to become __________ ions; non-metals __________ electrons to become __________ ions.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

graphite **alloys** **–ve** **lose** **+ve** **poor** **gain** **metals**

Summary on Matter (Units 9 and 11)



Questions

Answer these questions in your notebook

For questions **1–30** answer **A**, **B**, **C** or **D**.

1 Which of these are properties of matter?
A has mass
B has volume
C varied properties
D all of the above

2 Which of these is NOT true about the diffusion of gases?
A they diffuse at the same rate
B the rate varies for different gases
C smaller molecules diffuse faster
D gases diffuse more quickly than liquids

3 What happens when a coloured crystal is placed in water?
A nothing
B the colour slowly spreads in the water
C nothing, unless the water is heated
D nothing, unless the water is stirred

4 When potato sticks are placed in strong sugar solution what happens?
A they only become smaller
B they only lose mass
C they only go soft
D they become smaller, lose mass and go soft

5 When potato sticks are placed in water what happens?
A water only travels into the sticks
B water only travels out of the sticks
C more water travels into the sticks than leaves them
D more water travels out of the sticks than enters them

6 The process occurring in Question **5** is
A evaporation **B** Brownian movement
C diffusion **D** osmosis

7 When atoms join in pairs what is made?
A bigger atoms **B** molecules
C mixtures **D** solids

8 Which statement is true?
A protons have a positive charge
B protons have a negative charge
C neutrons and electrons are found in the nucleus
D protons and electrons are found in the nucleus

9 The number of which kind of particle in an atom or iron determines the atomic number?
A neutron **B** electron
C proton **D** nucleus

10 Which part in an atom does NOT contribute to the mass number?
A neutron **B** proton
C electron **D** shells

11 The numbers of which particles are always the same in an atom?
A protons and electrons
B protons and neutrons
C electrons and neutrons
D nucleus and electrons

12 If an atom has thirteen protons, how many neutrons will it have?
A always 13
B usually 13
C always 12 or 13
D it is not possible to say

13 If an ion has ten protons, how many electrons will it have?
A always 10
B more or less than 10
C usually 10
D it is not possible to say

14 The mass number is 40, and atomic number 18. How many electrons will there be in the atom?
A 12 **B** 18
C 22 **D** 40

15 Which statement is true?
A sodium atoms lose an electron to become a positive ion
B sodium atoms lose an electron to become a negative ion
C chlorine atoms lose an electron to become a positive ion
D chlorine atoms lose an electron to become a negative ion

16 What is the electronic configuration of an atom with an atomic number of 17?
A 2,8,6 **B** 2,8,7
C 2,8,8 **D** 2,8,8,1

17 To which group will the element in Question **16** belong?
A alkali metals **B** alkaline earth metals
C halogens **D** inert gases

18 Which of these is a group 2 element?
A potassium **B** argon
C fluorine **D** calcium

19 Which of these is a noble gas?
A chlorine **B** argon
C nitrogen **D** oxygen

20 When are the shells full of electrons for the elements with atomic numbers 1-20?
A 2, 8, 8 **B** 2, 2, 8
C 8, 2, 8 **D** 8, 8, 8

21 The symbol 'P' stands for?
A potassium **B** phosphorus
C platinum **D** potash

22 The symbol 'S' stands for?
A sulphur **B** sodium
C silver **D** silicon

25 How do the isotopes of chlorine differ from each other? In the number of
A neutrons **B** protons
C electrons **D** all of the above

23 How many electrons are in the outside shell of a group 2 element?
A 0 **B** 1
C 2 **D** 7

24 How many electrons do non-metals have in their outside shells?
A 1-3 **B** 4
C 4 or 5 **D** 4-7

26 In the periodic table the horizontal rows are
A groups **B** energy levels
C periods **D** families

27 Which of these are characteristic of metals?
A malleable **B** ductile
C good conductors **D** all of the above

28 How is graphite unusual? It is
A a non-metal that conducts electricity
B a metal that conducts electricity
C a non-metal that does not conduct electricity
D able to conduct heat but not electricity

29 Which metal is most widely used in aeroplanes?
A magnesium **B** iron
C aluminium **D** stainless steel

30 Why are alloys an unusual mixture? Because they have properties
A similar to their elements
B different from their elements
C that make them very useful
D more likely to corrode

For questions **31–46** write the answers in your notebook.

31 How do (a) diffusion and (b) osmosis show that matter is made of particles?

32 (a) What is the kinetic theory of matter? (b) How does it help to explain the differences between solids, liquids and gases?

33 What is the difference between (a) an atom and a molecule? (b) an element and a compound? Give common examples in explaining your answer.

34 Prepare a table to compare the position, charge and relative sizes of the particles inside an atom.

35 (a) What is the atomic number? (b) How many electrons are needed to fill the first, second and third shells of electrons for elements 1–20? (c) The atomic numbers of some elements are given below. Use this information to draw the arrangements of their electrons in their shells.

Element	Atomic number	Element	Atomic number
Helium	2	Magnesium	12
Boron	5	Silicon	14
Fluorine	9	Potassium	19

36 (a) What is the mass number? (b) Copy the table and fill in the spaces.

Element	Atomic number	Number of neutrons	Mass number
Carbon	6	6	
Oxygen		8	16
Sulphur	16		32
Argon	19		40

36 (a) What is the major difference between atoms? (b) How is this used in arranging the elements in the periodic table?

37 In the development of the periodic table, why were Mendeleev's ideas the most useful? Give two reasons.

38 Hydrogen and helium are both gases. Hydrogen burns in oxygen to make water, but helium is very unreactive. (a) In what ways are the atoms of hydrogen and helium different? (b) How does this help to explain their difference?

39 Choose one named family of elements. In what ways are they (a) similar in structure to each other? (b) different in structure to each other?

40 (a) What do all the members of a group have in common? (b) Does this mean they all have the same properties? Explain your answer.

41 (a) What do all the members of a period have in common? (b) Choose three named elements in period 2 and draw their electronic structures.

42 List three properties of metals. For each property describe an item used in the home that makes use of that property.

43 (a) What are alloys and how are they made? (b) Give an example and why it is useful.

44 Outline the main steps in the production of pure aluminium from bauxite.

45 List three properties of plastics. For each property describe an item used in the home that makes use of that property.

46 Give two differences between alkali metals and transition metals.

Key ideas

- Matter is everything that has mass and volume.
- We show matter is made of moving particles by observing Brownian movement, diffusion and osmosis.
- Diffusion is the movement of particles from an area of high concentration to a lower one.
- Water moves by osmosis (a special case of diffusion) from a place where it is in high concentration to a lower one.
- The kinetic theory of matter states that matter is made of particles that are in constant motion.
- How tightly the particles are packed, and how much kinetic (movement) energy they contain determines the states of matter: solids, liquids and gases.
- When substances are heated, the particles gain kinetic energy and move more quickly: they change from solid to liquid to gas.
- When substances are cooled, the particles lose kinetic energy and move more slowly: they change from gas to liquid to solid.
- Atoms are single particles; molecules are made of two or more atoms joined together.
- Elements can contain atoms or molecules; compounds only contain molecules.
- An atom has protons (+ve) and neutrons (neutral) in its nucleus. The electrons (-ve) orbit in shells.
- Elements have different numbers of protons.
- The number of protons is the atomic number; the number of protons plus neutrons is the mass number.
- For elements 1–20, the shells (energy levels) are full with 2, 8 and 8 electrons.
- The number of electrons in the outer shell (0–7) influence the properties of the elements.
- The periodic table arranges the elements in vertical groups and horizontal periods.
- Groups each have a certain number of outer shell electrons, e.g. alkali metals (1), halogens (7).
- Periods have atoms with the same number of shells.
- Metals are in groups 1 and 2, plus the transition metals, e.g. iron, copper and zinc.
- Non-metals are mainly in groups 4–7.
- Metals and non-metals have different properties and uses.
- Alloys are mixtures of metals, and plastics are made from non-metals.

▶ **See Workbook More about matter.**

Problems

1 You are going to prepare a large chart to show the nuclei and electronic structures of elements 1–20.

(a) You can first do your research. Make a list of the elements' names and symbols and the numbers of neutrons and protons in each nucleus. You will also need to know how the electrons are arranged in the shells. Decide how you will draw your models and what you will need in order to make attractive and neat drawings. Different students can draw different atoms. **ICT**

(b) Use the Engineering design process to make rough plans and designs, improve them, and then make your final drawings and add colours to make the drawings attractive.

(c) Decide how you will make your chart, so that the drawings each fit into their own correct place. Think about how the Groups 1-7 and Group 0 will be placed, and the Periods 1–4. Make sure that the students making the drawings know the spaces into which they should fit what they draw.

(d) Complete and display your chart.

2 Two of the groups decided they would prefer to make solid models. They chose to make the models for Groups 1 and 2.

(a) They did similar research to find the information they needed on protons and neutrons and the arrangements of electrons. **ICT**

(b) They used the Engineering design process to brainstorm materials and designs and chose balls of two colours of modelling clay for the neutrons and protons, and small balls of another colour for the electrons attached to circles of metal wire.

(c) Make your own models and display them.

3 Another group wanted to find out why certain symbols were used for different elements. **ICT**

(a) Carry out research to find the origin of as many as possible, such as Na for sodium, and K for potassium. Also research transition metals such as copper, lead, tin, silver, gold and mercury.

(b) Use word processing to present your results in an attractive way.

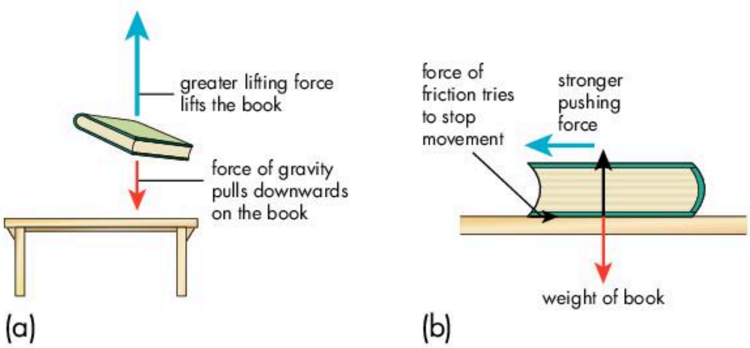
Unit 12

Forces and motion

1 *Usain Bolt: the fastest man alive*

This unit will help you to:

- describe the forces acting on objects as balanced or unbalanced and predict the results
- identify physical quantities as scalar (with size only, e.g. distance, speed) and vector (with size and direction, e.g. displacement, force and velocity)
- identify friction and investigate ways to reduce it
- use balanced and unbalanced forces for movement and in levers
- describe motion and do simple calculations involving distance, displacement, speed, velocity and acceleration.

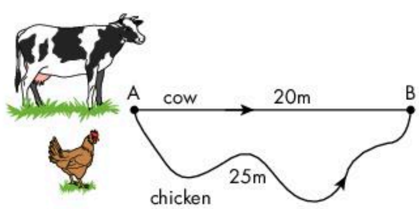


2 *Which way do the books move in (a) and (b)? Why?*

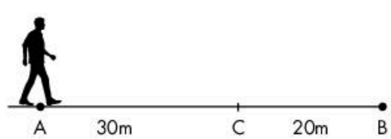
ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.

3 *Distance and displacement*



(a) A cow and chicken walk from A to B.
What is the cow's distance and displacement?
What is the chicken's distance and displacement?



(b) What is the distance and displacement if a man walks from A to B, and then to C?
What is the distance and displacement if instead he goes directly from A to C?

Balanced and unbalanced forces

What starts things moving? What makes them go faster? What makes them change direction? What makes them slow down and stop? The answer to all these questions is a **force** of some kind. We can't see forces, but we can see their effects. Whenever we push, pull or twist we are using a force.

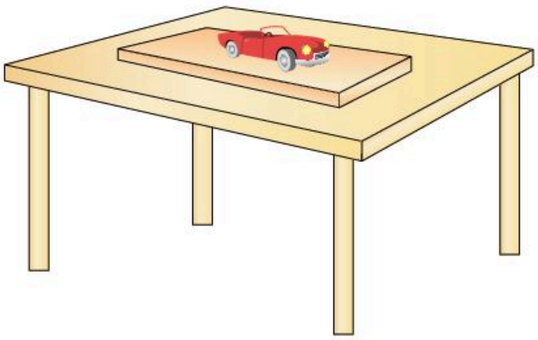
Objectives

- Identify forces (push, pull or twist) being used, and their effects.
- Distinguish between balanced and unbalanced forces and their effects.
- Distinguish between mass and weight.
- Distinguish scalar, e.g. distance, and vector quantities, e.g. force.
- Investigate friction and how to reduce it.

12.1 Starting things moving

Materials: toy car, piece of wood, ruler, paper clip, cotton thread, table or bench, cushion
Method
1 Arrange the toy car as shown in the diagram. Think of as many ways as you can to get the car moving.
2 Carry out each one in turn. How can you describe the forces that you used?

Questions
1 Did you use push forces? What did you do?
2 Did you use pull forces? What did you do?
3 Did you use pull forces? What did you do?
4 Did you make use of the Earth's force of gravity? How?



How can you get the car moving?

An object at rest (stationary) will stay that way unless a force acts on it. The force can be a push, pull or twist.

12.2 What can forces do?

Materials: toy car, ruler, table or bench, cushion, heavy mass, modelling clay, cushion
Method
1 Start the car moving. How many ways can you (a) make it change direction? (b) make it stop? Are forces needed?
2 Use a piece of modelling clay. How many ways can you make it change shape? Are forces needed in each case?

Questions
1 Did you use push, pull and twist forces? What happened?
2 Did you make use of the Earth's force of gravity? How?

12.3 Scalar and vector quantities

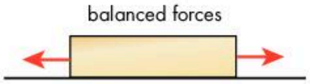
Work in groups:
1 Look at this list of physical quantities: time, temperature, force, mass, distance, speed.
2 Which have size only? These are scalar quantities.
3 Which have size and direction? These are vector quantities.

We have pushes and pulls that can work in opposite directions, so forces are vector quantities. We show forces as arrows.

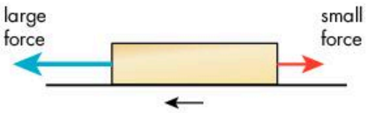
Forces

Forces can
- start things moving
- speed things up
- slow things down
- change the direction of movement
- change the shape of something.

Forces act in pairs:
- balanced forces have the same value. An object stays at rest.



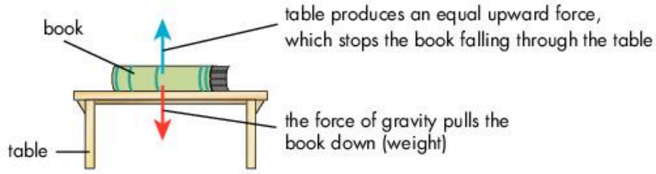
- unbalanced forces have different values. They cause a change in speed or direction of an object.



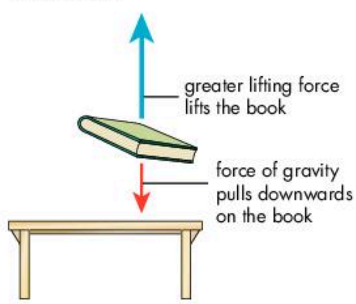
Balanced and unbalanced forces

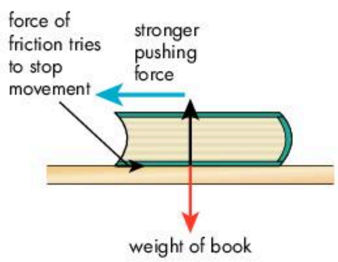
All objects usually have two or more forces acting on them.

- If these forces are acting in opposite directions and have the same value, they cancel each other out. The result is that the object stays at rest. The photographs show a swan and some acrobats that have balanced forces acting on them. They will stay in these positions until one of the forces changes.
- If an object is placed on a table or on the floor, there are equal and opposite forces acting on it. The downward force is due to the weight of the object. The table or the floor exerts an equal and opposite upward force on it. We show the direction and amount of the forces using arrows.



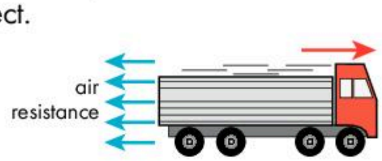
- When we push, pull or twist an object with an unbalanced force we can make it move. For example, if we lift a book from the table we are adding an extra pull force. We could also add an extra push force by pushing the book along the table. In this case we would have to push hard enough to overcome the opposite force of **friction** with the surface of the table.



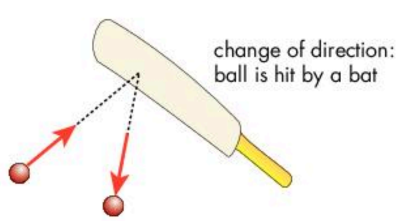


- When an object is moving, it will keep on moving in the same direction and at the same speed until it is acted on by another force. This other force may speed it up, slow it down or make it stop. Or it could change the direction in which the object was travelling. What happens will depend on the value of the new force, and the direction from which it is acting on the object.

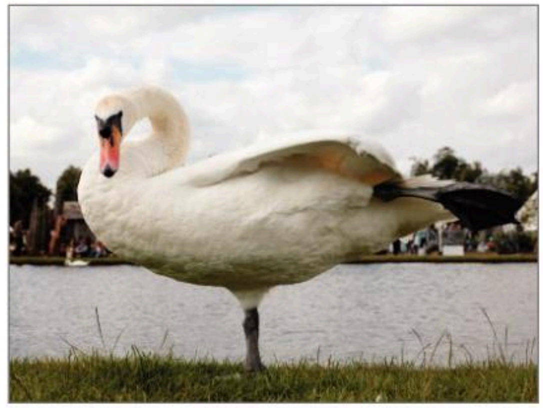
speed up: new force acts in the same direction



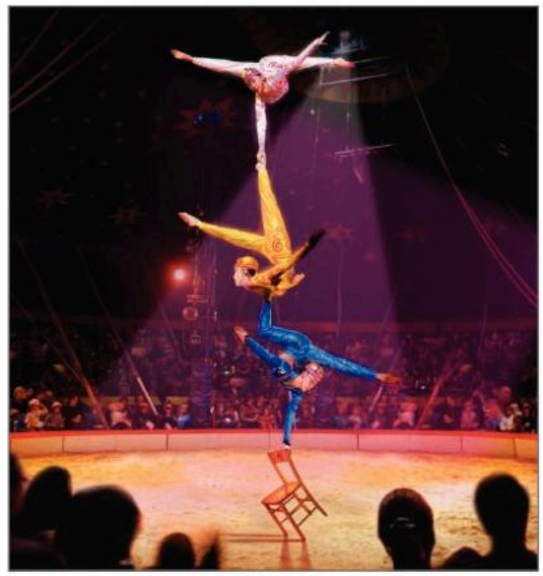
slow down: new force acts in the opposite direction



change of direction: ball is hit by a bat



How does the swan stay balanced?



How do the acrobats stay balanced?

Questions

1. Why are forces called vector quantities? Give an example.
2. List five things that forces can do. For each one, give an example from your everyday life.
3. If the forces on an object are equal and opposite, what will happen to the object?
4. If the forces on an object are not equal and opposite, what will happen to the object? How can we predict in which direction it will move?
5. An object is at rest. What is true about the forces acting on it?
6. An object is moving. Will it keep moving forever? Explain your answer.

Different kinds of forces

12.4 Investigating forces

Materials: closed door, heavy book, table, string, two bar magnets, iron nail, plastic pen, duster, scissors, very small pieces of paper, ball

Method

Work in small groups. Do the activities in turn.

1 (a) Turn the handle of the door. What force did you use? (b) Open the door. What force did you use? (c) Close the door. What force did you use?

2 (a) Put the book on the table. Make it move away from you. What force did you use? (b) Tie some string around the book. Put it on the table. Make it move towards you. What force did you use?

3 (a) Bring two North poles of the bar magnets towards each other. What do you feel? What kind of force is it? (b) Bring a North pole and a South pole of the magnets towards each other. What do you feel? What kind of force is it? (c) Bring the pole of a magnet near to the iron nail. What happens? Why does this happen? What kind of force is it?

4 Rub the plastic pen strongly with the duster. This makes static electricity on the pen. Quickly bring it close to the very small pieces of paper. What happens? What kind of force is it?

5 (a) Hold the ball in your hand. What forces are acting on it? What happens to the ball? Why? (b) Drop the ball. What forces are acting on it? What happens to the ball? Why?

Questions

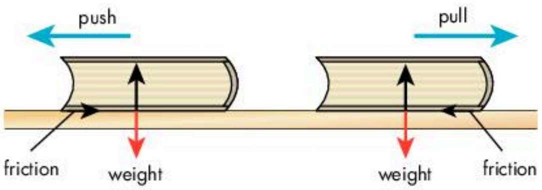
1 Prepare a table for your results. List the name of the force(s) involved in each part of the activity. Record the effect of the force(s) in each case.

2 (a) List different ways in which push forces can be made. (b) List different ways in which pull forces can be made.

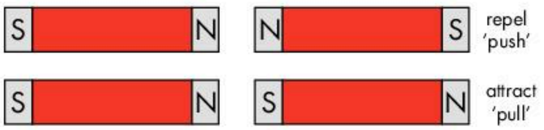
Did you identify these forces?

(a) Forces between objects that are in contact.
- Contact forces (pushes, pulls and twists) that cause motion or change of shape.
- Frictional forces that oppose movement or slow it down.

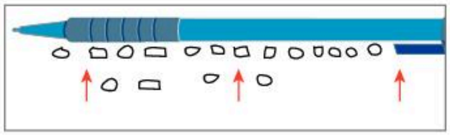
(b) Forces between objects that are not in contact. These can also make pushes and pulls.
- Magnetic forces. These are the forces that magnets can exert on iron and steel objects, and make them move.
- Electrostatic forces. Formed by static electricity, these are the forces that can make small objects move.
- Gravitational force. This is the pulling force of the Earth, which attracts all objects to it.



In which direction does friction act?



What happens when the poles of magnets are brought close together?


Why do the pieces of paper move?


What happens when you let go of a ball?

Questions

1 Why don't we fall off the Earth?

2 What keeps the Earth orbiting the Sun?

3 The force of gravity on the Moon is only one sixth that on Earth. Would astronauts be able to jump more easily on the Moon? Why?

▶ **See Workbook Balanced and unbalanced forces.**

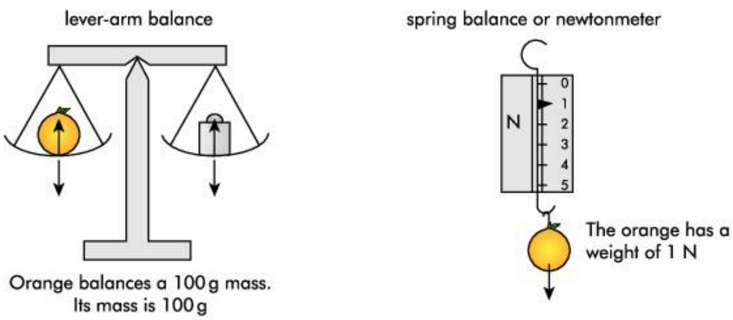
Mass and weight

All objects attract each other. Usually the force is too small for us to measure. But because the Earth is very large, we can measure the force with which it attracts objects. We call this force the force of **gravity**.

Let us recall the difference between mass and weight.

Mass is the amount of substance in an object. It is measured in kilograms (kg) and grams (g), using a lever-arm balance. The mass of an object stays the same wherever it is: for example on the Earth or on the Moon.

The **weight** of an object is the force with which it is attracted by the force of gravity. Weight is measured in newton (N) using a spring balance or newtonmeter. The weight of 1 kg mass is about 10 N. Weight will vary from place to place, depending upon the force of gravity. So an object will weigh six times as much on the Earth as it does on the Moon.



Comparing the mass and weight of an object

12.5 Using a spring balance

Materials: spring balance, ten masses each of 100 g, lever-arm balance, orange, mango

Method

Work in small groups.:

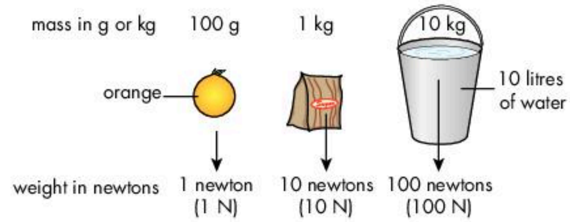
1 One at a time, add a 100 g mass to the spring balance.
2 Prepare a table and record your results.

Mass added	Reading in newton
100 g	
200 g	

3 Use graph paper to draw a line graph of your results.
4 Find the mass and the weight of the orange and mango.

You will find that the weight of a 100 g mass is approximately 1 N, a 200 g mass is 2 N, a 300 g mass is 3 N, etc. The line graph that you draw should be a straight line showing that mass and weight vary in proportion to each other

Gravity pulls objects towards the Earth and stops them from falling off



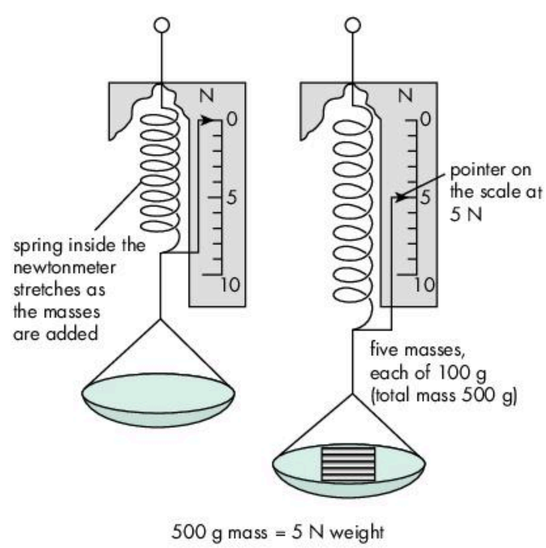
The mass and weight of some objects

12.6 Make a spring balance

Materials: thick rubber band or a spring, support, scale, lid as a measuring pan, cotton thread, scissors, marker, ten masses each of 100 g, object

Method

1 Use the Engineering design process to design a spring balance. The artwork shows one idea.
2 Record the extension of the band or spring for each 100 g mass., using a scale. What do you notice? How could your model be improved?
3 Find the weight of an unknown mass.



How a spring balance works

Water: floating and sinking

Why do some things float in water, while others sink? What is important: mass, volume or something else?

12.7 Which things float or sink?

Materials: bowl of water, tissue paper, paper clips, soap, screw-top bottle, twigs, cork, stone, wood, coins, piece of glass

Method

1 (a) Drop a paper clip into the water. What happens?
  (b) Tear a small piece of tissue paper and put a paper clip on top of it. Carefully lay the paper and clip on the water surface.
  (c) What happens to the tissue paper? What happens to the paper clip? Is it supported by the surface tension of the water? Look carefully to see the water surface.
  (d) Touch the water surface with the soap. What happens to the surface tension and to the paper clip?
2 The 'empty' screw-top bottle is full of air. Try to push it down into the water. You will feel an opposing push or force. This is the buoyancy of the water. You can feel this buoyancy when you float or swim.
3 Predict which of your objects will float, and which will sink. Make a table and enter your predictions. Give your reasons.
4 Try each object in turn. Were all your predictions correct? Do you need to change the reasons that you gave?

12.8 Does shape make a difference?

Materials: bowl of water, two pieces of aluminium foil 8 cm × 5 cm, stone

Method

1 Use one piece of foil to make a boat.

2 Take the other piece of foil and squash it tightly into a ball.
3 Put the boat and ball onto the water and see what happens. (If the ball floats, then hit it with the stone to squash more air out of it to make it smaller, so it becomes more dense.)
4 What is the difference between the boat and the ball? How could this make the difference between floating and sinking? Explain your answer.

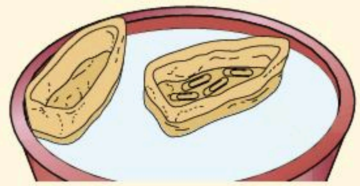
Small metal coins will sink. But large metal boats can float. What is the reason? The difference is the amount of trapped air that they contain. The trapped air in the boat makes it less **dense**, overall, than the water in which it floats.

12.9 Boats and loading

Materials: bowl of water, ball of modelling clay, paper clips

Method

1 See if the ball of clay sinks or floats.
2 Make the modelling clay into different shapes until you find one that floats.
3 Make a mark on the side of the boat to show the level of the water.



4 Now add paper clips, one at a time. The boat goes lower in the water. How many paper clips can you add before the boat is overloaded, and sinks?

The 'boat shape' floats because it has trapped air that reduces its overall weight. As paper clips are added, they replace the air, and so the boat sinks.

Fun facts

- Pumice is rock made from hardened lava froth. It is so full of air that it floats.
- It is easier to float in the sea than in fresh water. The reason is that sea water is more dense than fresh water.
- The Dead Sea is so dense that you can float in it sitting up.

Large metal boats contain trapped air, so they are light enough to float in the water

12.10 Floating in fresh and sea water

Materials: boat from Activity 12.9, bowl of seawater, paper clips

Method

1 Float the boat made from modelling clay in the seawater. Make a mark on the boat to show the level of the water.
2 Add paper clips, one at a time, until the boat sinks.
3 Compare the levels of the marks on the boat in the fresh water and seawater. Compare the number of paper clips needed to sink the boat in fresh water and seawater.

Explanation: Did you find that the boat floated higher in seawater, and could carry a heavier load before it sank? Salty water has more buoyancy than fresh water. You can also find out about loading ships and the Plimsoll line.

What determines floating and sinking?

1 The nature of the material is important. A block of wood can float but an equal-sized block of iron will sink.
2 The shape is important. Aluminium foil in the shape of a boat instead of a ball contains trapped air and pushes more water out of the way. The water pushes back and the boat floats.
3 The kind of water is important. Seawater can support a greater load than fresh water can.

How is density important?

Density is a fair way in which to compare objects. This is because it takes into account both the size of the object (its volume) and the amount of material (its mass).

Density is the mass of a given volume. We can measure the mass in grams (g) and the volume in cubic centimetres (cm^3).

Density is mass divided by volume.

$$\text{Density (in g/cm}^3) = \frac{\text{Mass (g)}}{\text{Volume (cm}^3)}$$

- 1 g of pure water has a volume of 1 cm^3. The density of pure water is therefore 1 g/cm^3.
- If an object has a density of more than 1 g/cm^3, then it will sink in pure water.
- If an object has a density of less than 1 g/cm^3, then it will float in pure water.

When a ship is built it is hollow. The space inside it makes it less dense than the water. So it floats. When the cargo is put into the ship, some of the air is displaced and the ship becomes denser. It floats lower in the water. If it was damaged, and water entered it, it could become so dense that it sank.

The little girl is using a plastic swimming ring filled with air. With the air in the ring, her overall density has been reduced to be less than that of the water, so she can float

Densities of some common materials

State	Material	Density (g/cm^3)
Solid	Gold	19.3
	Silver	10.5
	Iron	7.9
	Glass	2.5
	Ice	0.92
	Cork	0.24
Liquid	Pure water	1.0
	Seawater	1.3
	Olive oil	0.92
	Gasoline	0.80
Gas	Air	0.001 29
	Hydrogen	0.000 09

Questions

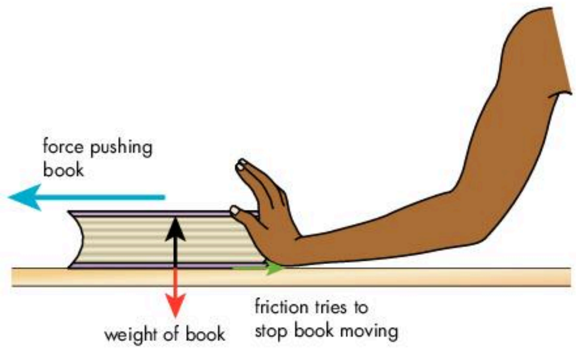
Use the data in the table above.

1 A ring has a volume of 3 cm^3 and a mass of 31.5 g. What is its density? What metal is it made from?
2 A sheet of glass has a mass of 50 g. What is its volume?
3 Name two materials that float and two that sink in pure water. Why?
4 If olive oil were poured on top of pure water, what would happen?
5 Would an ice cube float higher in seawater or in pure water? Why?
6 Do you think a boat could be made from gold? What would be important in order to try and make it float?
7 Would a balloon filled with hydrogen float in air? Explain your answer.

Friction

When you push a book on a surface you can feel a force opposing the movement: this is **friction**. It makes it difficult for one object to move over another. We say that friction **opposes** motion. Friction always acts in the direction opposite to the push, pull or twist force that we give to an object. The heavier the object the greater the push or pull force we will need to overcome friction.

When an object is moving, friction also slows it down. This may be friction from the surface on which the object is moving or it may be friction from water or air particles, which is called water or air resistance.



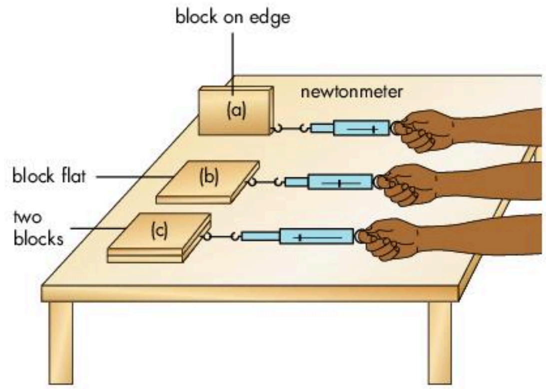
When we push, pull or twist an object, friction between the surfaces will oppose the motion

12.11 Overcoming friction

Materials: two similar blocks of wood, hooks, string, spring balance, sandpaper, paper tape, water, cloth, oil

Method

1 Screw the hook into one block of wood. Attach it by the string to the spring balance.
2 Pull the block along on its edge and read the force needed (in newton) to get it moving as shown on the spring balance (a).
3 Repeat step 2 but with the block flat (b).
4 Repeat step 2 but with both blocks together (c).



Find the forces needed to just get the blocks moving

Explanation: You should find that the forces needed in (a) and (b) are about the same. When the weight of the object is the same, it doesn't matter how much of the surfaces are in contact. But in (c), where the mass is greater, a larger force is needed to overcome friction.

5 Cover one of the blocks of wood with sandpaper (d). Repeat step 2.
6 Remove the sandpaper and make one surface of the block wet with water (e). Repeat step 2.
7 Dry the block, and cover one surface with a thick layer of oil (f). Repeat step 2.
8 Record your results for (d), (e) and (f).

Arrangement of blocks	Force needed to start the block moving
Block on edge (a)	
Block flat (b)	
Two blocks (c)	

Substance on the block	Force needed to start the block moving
Plain wood (b)	
Sandpaper (d)	
Water (e)	
Oil (f)	

Tables for comparing the forces needed to overcome friction

Questions

1 What effect does sandpaper (d), water (e) and oil (f) have on the amount of friction between the surfaces? How do you make sure it is a fair test?
2 What effect would a rough road have on the ease of pushing a heavy trolley along it?
3 What effect would wet roads have on the speed of cars and how long they would take to brake and stop?
4 Why do you think we use oil in machines?
5 Do you think friction is useful or a nuisance?
6 What suggestions do you have for reducing friction?

Questions

1 What happens if the pull on an object is less than the force of friction?
2 Why do all moving objects eventually stop moving?
3 How are balanced and unbalanced forces involved?

Friction is the force produced when two surfaces rub against each other. Friction is sometimes useful and sometimes a nuisance.

12.12 How is friction useful?

Materials: screw-top jar, soap, water, cloth, box of matches, smooth surface, shoes with smooth and rough soles, spring balance, paper clip

Method

1 Start with the lid screwed tightly onto the jar. Try unscrewing the lid with dry hands, or with the cloth. Compare this to trying to unscrew the lid with damp soapy hands. What do you notice?

2 Try lighting a match by pulling the head against a smooth surface. Feel the surface of the strip on the side of the matchbox. Use it to light the match. Explain what you find.

3 Attach the spring balance to one of the shoes using the paper clip. How much force is needed to start the shoe moving? Repeat with the other shoe. Explain what you find. In which shoe would you be more likely to slip?

4 Discuss in your group what it would be like if there was no force of friction.

We need friction:

- to grip a lid or door handle to be able to turn it.
- to strike and light a match.
- to write with a pencil.
- between the soles of our shoes and the road, otherwise we will slip and not be able to walk.
- between the wheels of the car and the road. On wet surfaces friction is reduced, and skids occur.
- between the brakes on a bicycle or car and the wheels. This allows us to stop.

12.13 How is friction a nuisance?

Materials: your hands, soap

Method

1 Rub your hands together. What do you hear and feel?

2 Make your hands soapy. Rub them together. What difference does this make?

Explanation: Friction produces heat and sound. Friction also causes the surfaces that rub against each other to be worn away. These are disadvantages when using machinery with many moving parts. We can reduce friction by using **lubricants** such as soap and oil.

Reducing friction – just enough

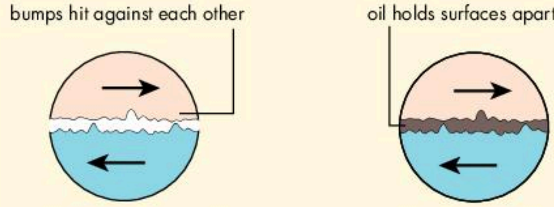
The heat and sound that friction produces is wasted energy. We usually want to reduce friction, but not so much that we cause other problems.

12.14 How can we reduce friction?

Try these methods and write your report.

Using oil

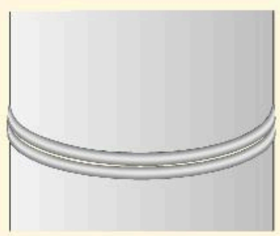
The pictures show the surfaces of two metals under a microscope. How would a layer of oil keep the slight bumps apart and reduce friction? Try using oil and grease in bicycles, cars, sewing machines etc., where parts move against each other.



Without oil: more friction *With oil: less friction*

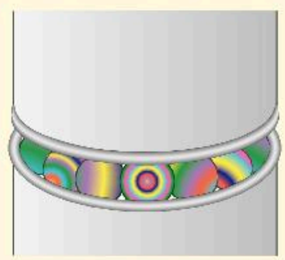
Using ball bearings

Use sets of small steel balls placed between moving parts, for example on a bicycle. Show the effect by using two tins and some small marbles.



Use two tin cans with lip edges. Try to turn one on top of another.

Without ball bearings: more friction

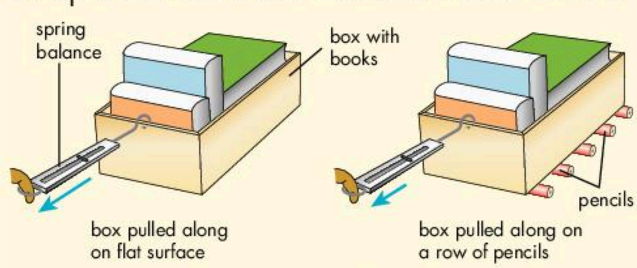


Add a ring of small marbles or ball bearings between the tins. The top tin turns more easily.

With ball bearings: less friction

Using rollers or wheels

Try pulling two boxes like those below. Compare the amount of force needed by using a spring balance. Do the rollers reduce the friction? Also set up a test with a box with and without wheels.



No rollers: more friction *With rollers: less friction*

Forces and movement

We can now look at the effect of balanced and unbalanced forces acting on objects on land and in water and the air.

Objects at rest or floating

- Objects on land stay at rest if they have balanced forces acting on them. An object on a table has a downward force acting on it. This is the force of gravity due to the weight of the object. It also has an equal and opposite upward force acting on it from the table. The forces are balanced. But an unsupported object will fall due to the pull of gravity.
- Objects float in water if they have balanced forces acting on them. If you try to push a balloon below the water you will feel the upward force of the buoyancy of the water. We call this force the **upthrust**. The other force acting on the object is the force of gravity due to its weight. This force pulls downward. If the upthrust equals the weight, the object will float. The forces are balanced. But if the weight is more than the upthrust, the object sinks, as the forces are unbalanced.
- Objects float in air if they have balanced forces acting on them. An object in the air has the force of gravity pulling down on it due to its weight. But the air resists this motion. There is **air resistance** that acts to stop the object falling to the Earth. If the forces are balanced (weight equals air resistance) then the object will float. But if the weight is greater, it will sink.

12.15 Objects at rest or floating

Materials: wooden block, table, bowl of water, assorted objects, paper, cloth, thread, scissors, modelling clay

Method

1 (a) Lay the block on the table. What are the forces acting on it? Are the forces balanced? How do you know?
  (b) Put the block near the edge of the table, so it is no longer supported. What happens? Explain why.

2 (a) Choose two objects that you think will float in water. Try them. What are the forces acting on them? Are the forces balanced? How do you know?
  (b) Choose two objects that you think will sink. Try them. What is true about the forces acting on them? How do you know?

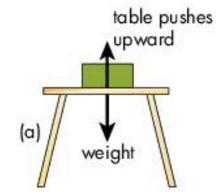
3 (a) Fold and tear the paper into two halves. Make one half into a ball. Drop both the flat sheet and the ball from a height. In which case is there more air resistance? How do you know?
  (b) Design and make a parachute with the cloth, thread and a small amount of modelling clay. Drop it from a height. Who can make their parachute float for the longest time? What is true about the forces acting on it? How doyou know?

What does it mean?

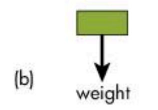
Forces: Pushes and pulls that are measured in newton (N).

Balanced forces: These act in pairs from opposite directions and have the same value. The object stays at rest or continues as it was travelling.

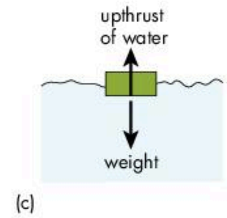
Unbalanced forces: These have different values and an object moves up or down, or right or left, or changes direction.



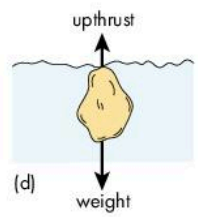
An object at rest on land



Object falling down



An object floating in water



An object sinking in water

An object floating in air

An object sinking in air

Questions

1 Identify which diagrams show balanced forces and which ones show unbalanced forces.

2 In which diagrams will the objects be moving? Why?

Objects on the move

Objects can only move if unbalanced forces act on them. There are usually two or more forces acting. The direction and speed of the object will depend on the sizes of the forces that are acting. Movement will be in the direction of the larger force.

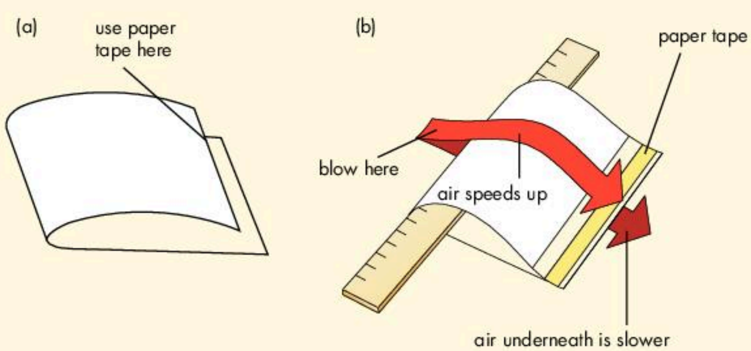
- On land the forces that cause motion are pulls, pushes and twists. The weight of the object will oppose motion. Where surfaces are in contact there will also be the force of **friction**. This will oppose motion: it will tend to stop objects starting to move and it will slow down moving objects and make them stop. Objects that move on land are also slowed down by the air. This is called **air resistance**. It is also called **drag**.
- On water, for objects that float, the upthrust will balance the weight. The force of motion may be provided in several ways. For example, by the force of the wind in the sails, by the force of a person using oars, or a ship with an engine. Animals living in the water produce their own force of motion by the contraction of their muscles. The forward motion will be opposed by the water. This is called **water resistance**. It is also called **drag**.
- In the air the force of motion may be provided by an engine (as in a plane) or by muscles (as in flying animals, which also flap their wings). This forward force is called **thrust**. Objects moving in air are also slowed down by the air. This is called **air resistance**. It is also called **drag**. Living and non-living things flying in the air usually have some kind of wing or **aerofoil**. This helps to keep them up in the air. It provides **lift**.

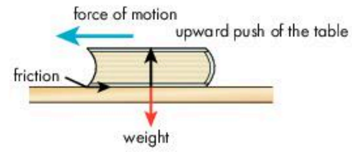
12.16 Making a model wing

Materials: paper about 25 cm × 19 cm, scissors, paper tape, ruler

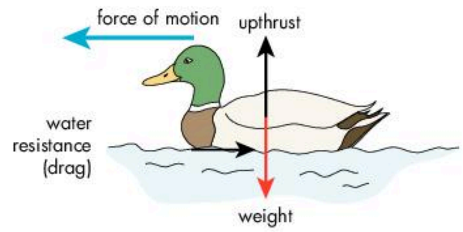
Method

1. Fold the paper in half. Tape the top half to the bottom half 2 cm from the edge. This makes the top surface curved **(a)**.
2. Put the ruler inside the 'wing' and then blow air towards it **(b)**. What happens? How can you explain it?

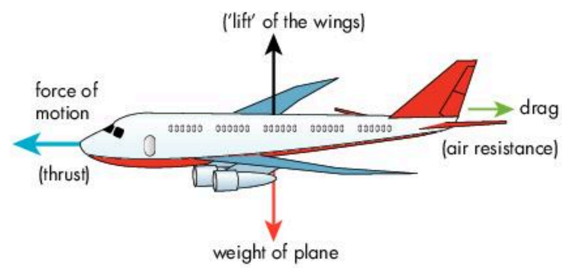




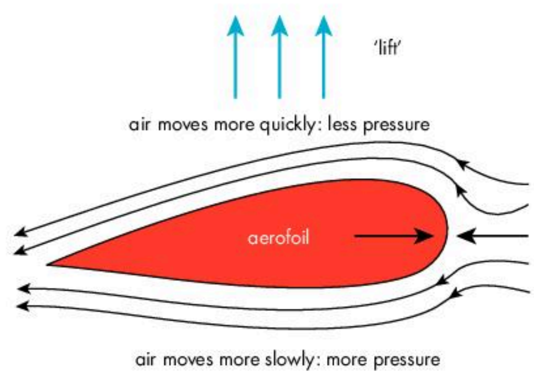
Forces acting on a moving object on land



Forces acting on a moving object in water



Forces acting on a moving object in the air



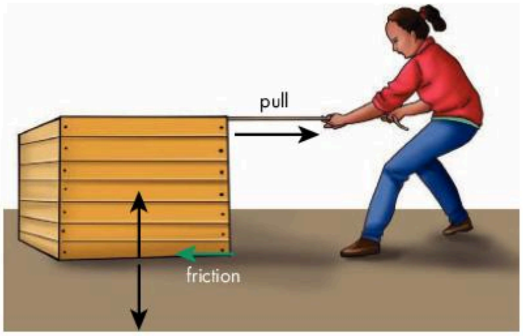
How an aerofoil provides lift

Questions

1. List the forces that act on moving objects (a) on land (b) in the water and (c) in the air.
2. If an object is moving, which force must be the greatest?
3. How does a plane stay up in the air?
4. How are birds and planes (a) similar and (b) different?

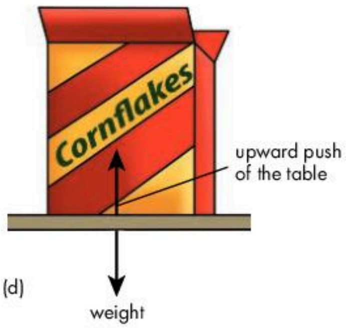
Forces at work

(a)

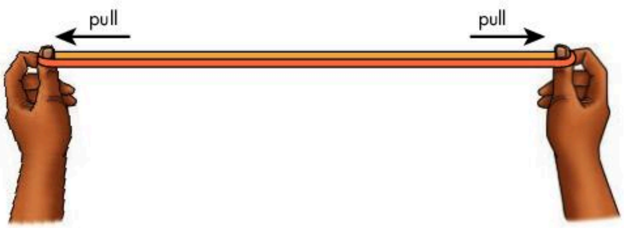


(b)

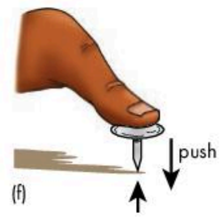
(c)



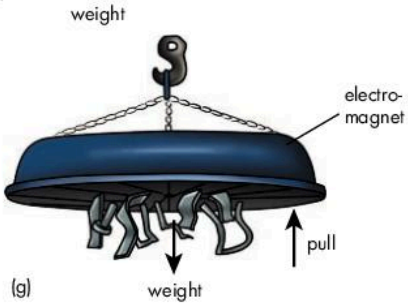
(d)



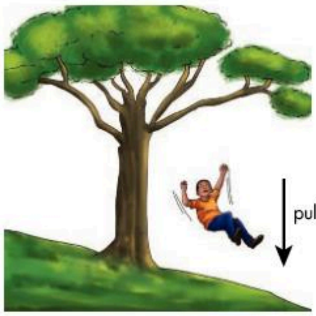
(e)



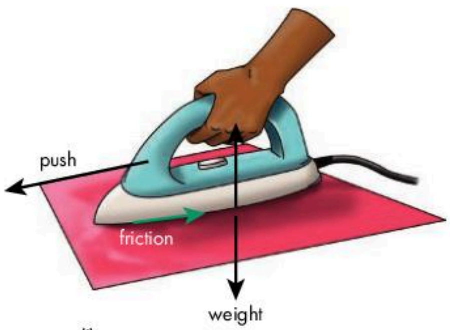
(f)



(g)



(h)



(i)

12.17 Describing forces

Work in a group:

1. Discuss the forces in each of the pictures, and what work they are doing. For example in (a): the weight of the trolley is the force of gravity pulling downward. The man is pushing the trolley with a force that is greater than the opposing force from friction (the wheels have reduced the friction). The resulting work done is that the trolley moves forward.
2. Write description cards for each of the pictures.
3. Which pictures show balanced forces? What is the result of this?
4. Which pictures show unbalanced forces? What is the result of this?
5. Which pictures show the force of friction? Why?
6. Draw your own picture from everyday life and add the arrows to show the forces. Describe what is happening.

▸ **See Workbook Balanced and unbalanced forces.**

Fun facts

- If you are standing in a bus and it suddenly stops – you keep travelling in the same direction and may fall over.
- We can use a pencil because small bits of graphite get rubbed off onto the paper because of friction.
- A man has produced enough force to lift three cars.

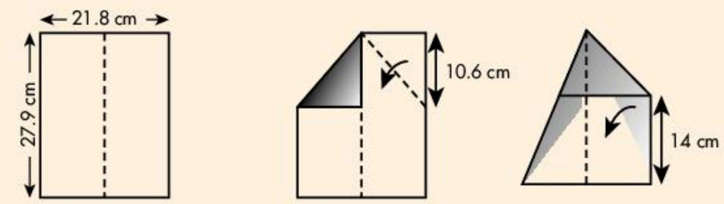
Can you explain why?

- If you throw a ball upwards it goes up to a certain height and then falls down?
- In a 'tug of war' one side can win?
- When we kick a football we might change its direction?
- A paper clip dropped into water will sink but a large cruise ship will float?
- A boat with a hole will sink?

12.18 Forces and streamlining

Materials: modelling clay, piece of cloth, thread, stopwatch, water in a tall jar, sheet of letter-size paper, ruler
Work in groups:
Use the Engineering design process to make models as described or to improve and make your own. Keep illustrated records of what you do and record all your results.

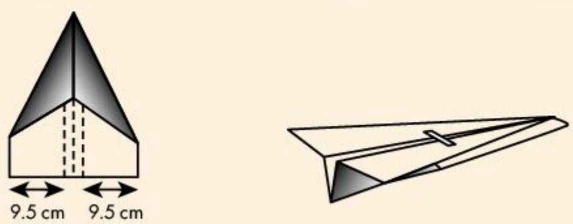
1 Drop a ball of modelling clay from a height. Record how long it takes to fall. Now design and make a parachute for the ball. Which group can make the best parachute? How will you decide? How will you make it a fair test?
2 Use two equal amounts of modelling clay. Make one into a ball, and the other into a cone with a pointed tip. Now record how long it takes (a) the ball, (b) the cone pointed-end first, and (c) the cone flat-end first to fall down in the water in the jar. How can you explain your results?
3 Design and construct a paper plane. You can use the idea below, or research and make a design of your own using a sheet of paper. **ICT**



(a) Fold paper on centre line

(b) Fold corners down

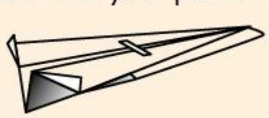
(b) Fold in again as shown



(d) Fold away from you on the centre line, and make folds toward you on the dotted lines

(e) Hold wings toethre with a small piece of sticky tape

(a) Fly your planes to see which is the best. How will you make it a fair test? How will you decide 'best'? Will you measure the best of two or three flights? Record all your results.
(b) Find the effect of increasing the drag by folding up the ends of the 'wings' on your plane. Now compare how well your planes can fly. Describe the results.



(f) ends of wings are folded up to increase the drag

What does it mean?

Weight: The downward force due to gravity.

Upthrust: An upward force, e.g. buoyancy in water or the air resistance of a parachute.

Lift: The result of the aerofoil shape of the wings of a plane or bird.

Thrust: Force causing forward motion, produced e.g. from propellers, engines or muscle strength.

Drag: Force opposing motion, e.g. friction between touching surfaces, and air and water resistance tending to slow down motion.

Motion: Movement will occur if either the vertical forces (weight and upthrust or lift), or horizontal forces (thrust and drag) are unbalanced.

Questions

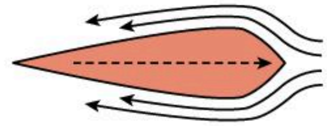
1 What is friction? Where is it found? What does it do?
2 Give examples of where we reduce friction by (a) lubrication, (b) making surfaces smoother, (c) reducing the contact between surfaces, (d) making objects streamlined.
3 Give examples of where we use friction for (a) movement on land, (b) staying suspended in the air, (c) for an aeroplane to come into land.
4 How do streamlined shapes affect the resistance to motion in water and air? Give examples.

A streamlined shape

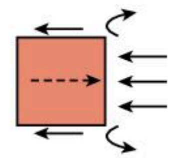
- Objects used on land, such as racing cars and bicycles and the helmets of racing cyclists.
- Objects on the water surface, such as the hull of boats and ships.
- Objects travelling in the water, such as fish and submarines.
- Objects flying in the air, such as aeroplanes.

How a streamlined shape helps movement

A streamlined shape has a gentle point. It becomes wider and then narrows towards the back. A streamlined shape cuts down on the effect of water and air resistance. It allows the object to go faster for the same use of effort, from fuel or muscles. Objects travelling on land, which are designed to go fast – such as racing cars, also have a streamlined shape.



Streamlined shape: less resistance



Flat square shape: more resistance

12.19 Investigating streamlining

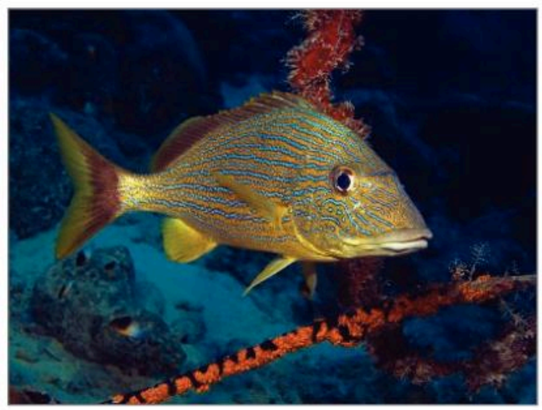
Materials: four similar-sized pieces of wood with the fronts as shaped below, string, paper tape, long trough of water, clamp, pulley, 50 g mass, stopwatch

Method

1 Attach the pulley to the end of the trough using the clamp.
2 Attach the string to a block of wood. Run the string over the pulley and attach a 50 g mass to its end.
3 Put the block at the end of the trough farthest from the pulley. Let it go. Find the time it takes for the block to travel the full length of the trough.
4 Carry out step 3, five times, using each block in turn. Find the average for each block.

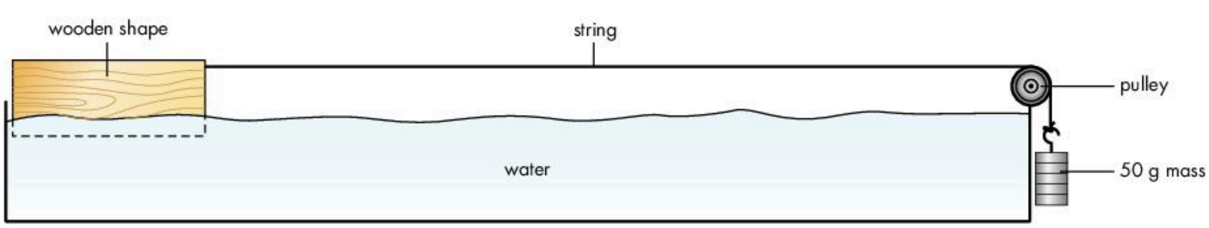
Questions

1 List all the ways in which this is designed as a fair test.
2 Which block(s) travelled fastest? Why
3 Which block(s) travelled slowest? Why?
4 Name four objects with a streamlined shape.



A fish has a streamlined shape

▸ **See Workbook Balanced and unbalanced forces.**



Quick check ☑

If the forces are balanced then the object stays at __________ or continues at a steady speed unless acted on by another __________. The downward force due to gravity is __________; on land an object is supported by an __________ and opposite __________ force. The force between touching surfaces is __________. In water and air the upward force is __________. Air and water resistance to movement are called __________.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

weight **drag** **rest**
force **equal**
upward **friction** **upthrust**

Using levers

You have seen how unbalanced forces are used in movement. Forces can also be used to do work by using a machine, such as a lever. A machine does not reduce the overall work, but it allows us to do the work more easily.

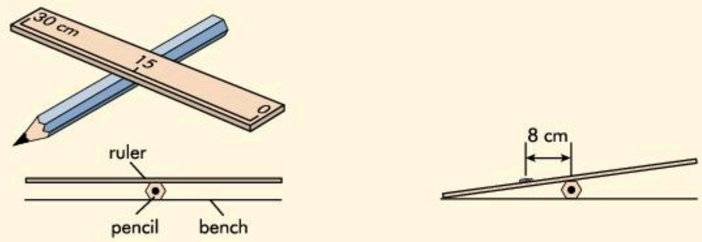
A lever is a solid bar, rather like a seesaw. It turns on a pivot called the **fulcrum**. A force (the effort) can be applied to a lever and this allows us to do work on an object (the **load**).

12.20 Balancing a ruler

Materials: 30 cm ruler, 6-sided ballpoint pen or pencil, similar coins or soft-drinks bottle tops

Method

1 Put the pen or pencil on the table. Lay the ruler on top of it and adjust it until it balances **(a)**. Where is the balance point?



(a) Ruler balanced on a pencil

(b) Coin on left 8 cm from centre

2 Put a coin on the left-hand side of the ruler. What happens to the ruler? **(b)** Add another coin to restore the balance. What did you do? Why did this work?

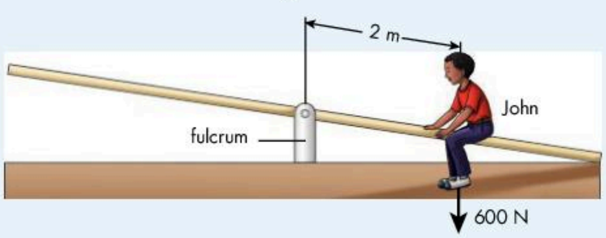
3 Add different numbers of coins or bottle tops at different distances on the left. In each case add coins or bottle tops on the right to balance them. Record your results in a table.

4 Do you need the same number of coins or bottle tops on each side? Explain your answer.

Explanation: The ruler balances if the force × distance from the balance point on the left equals the force × distance from the balance point on the right. Different numbers of coins can balance each other if they are placed at the correct distances.

Questions

John is on the seesaw. Where should Mary sit to balance the seesaw? She has a weight of 400 N.

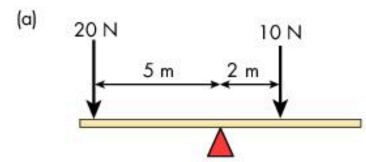


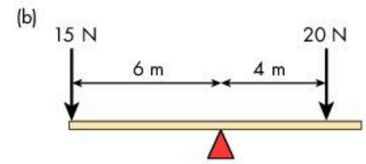
Objectives

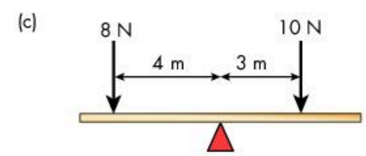
- Identify the forces involved in using a lever.
- Describe and give examples of the three classes of lever.
- Identify and describe levers in the human body.

Does it balance?

For each diagram, record if the seesaw is balanced or not. If it isn't balanced, record whether it will turn clockwise or anti-clockwise.

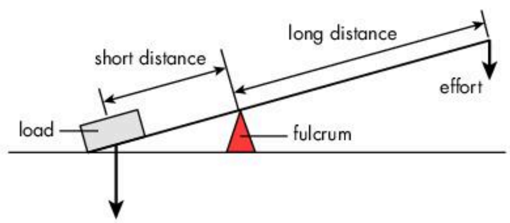






Levers

Many levers are arranged so that the effort is farther from the fulcrum than the load is. This gives the effort the greatest effect on turning the lever. In this way a small force can raise a much heavier load.



The force of the effort is less than that of the load, because it is applied at a greater distance from the fulcrum. The greater the distance of the effort from the fulcrum, the greater is its effect.

Using levers

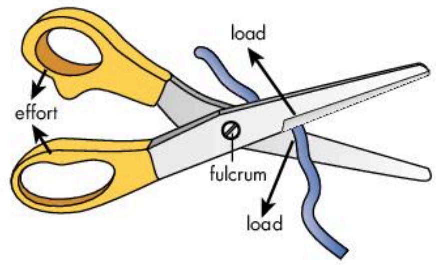
A lever can help us move a heavy load.

(a) *Man lifting a rock*

(b) *Using a lever*

In (a), the load can be moved by using a large force through a short distance.
But in (b), using a lever, we can apply a smaller force but through a larger distance.
The same total amount of work is done in both cases. This is similar to the ruler: the force × distance on one side of the fulcrum is equal to the force × distance on the other side.

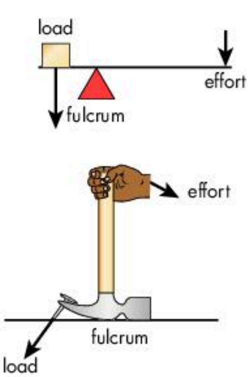
Taking off a tin lid using a lever



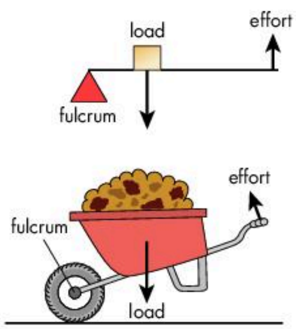
A pair of scissors is made from two levers joined together at the fulcrum

Force multipliers

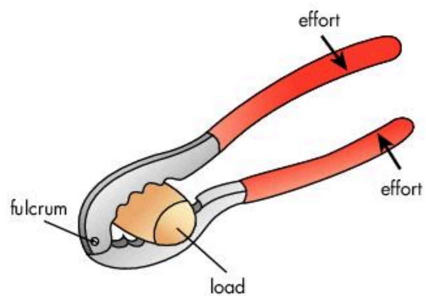
The lever is arranged so that we exert less effort, but at a point further from the fulcrum and over a longer distance. We use levers like this when we want to increase the effect of our effort. There are two different arrangements.



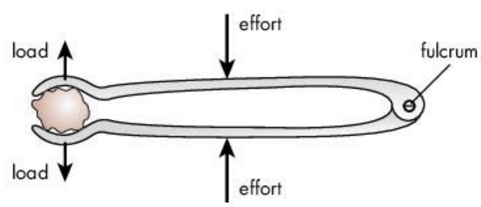
Fulcrum is between load and effort
Class I levers



The load is between the fulcrum and effort
Class II levers



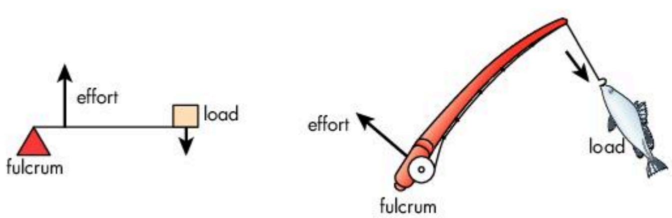
Which class of lever are these nut crackers?



Which class of lever are these tweezers?

Distance multipliers

This kind of lever is used when we want to move the load through a longer distance. To do this we have to exert a larger effort. Many levers in the body are of this kind.



The effort is between the fulcrum and the load: Class III lever

Questions

1. Look at the top photograph. Draw and label a lever diagram to show the effort, fulcrum and load.
2. Collect examples and drawings of a range of scissor-like machines. How are they each suited for their job?

▸ **See Workbook Using levers.**

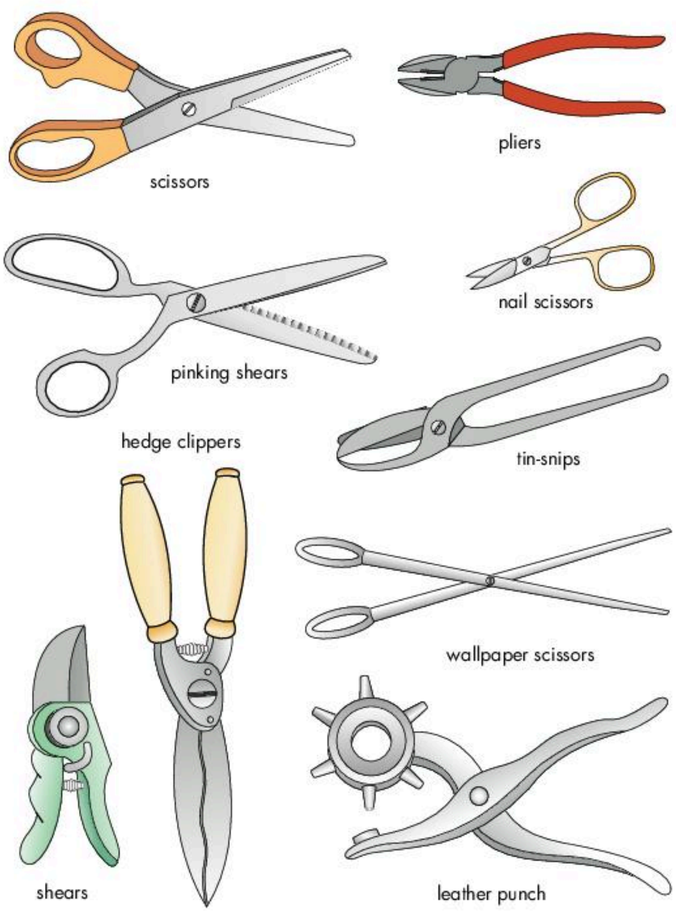
12.21 The right tool

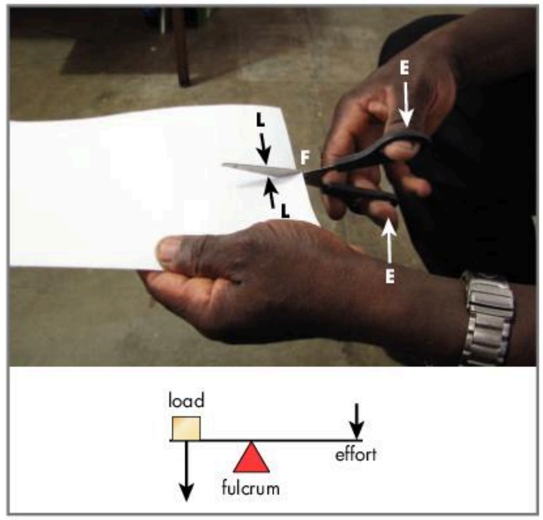
Materials: scissors, tin-snips, pinking shears, nail scissors, pliers, leather punch, shears, hedge clippers, wallpaper scissors, paper, twig, tin, wire

Method

1 Classify the scissor-like tools into three groups.
   (a) Handles as long as the blades. The force on the load is the same as the effort applied, but the sharpened wedge edges of the blades make them efficient at cutting. Used where the load is easy to cut and a lot has to be cut at once.
   (b) Handles a little longer than the blades. The force on the load is a bit more than the effort applied, and sharp wedged edges help the cutting process. Used for slightly tougher jobs.
   (c) Handles a lot longer than the blades. Here the force on the load, which is much nearer the fulcrum, is much greater than the effort applied a long way from the fulcrum. Sharp wedge edges assist cutting. Used for heavy cutting jobs.

2 Use each kind of scissors with the material it is designed to cut. What would happen if you used it for the wrong material? Write an account of how each tool is suitable for its job.

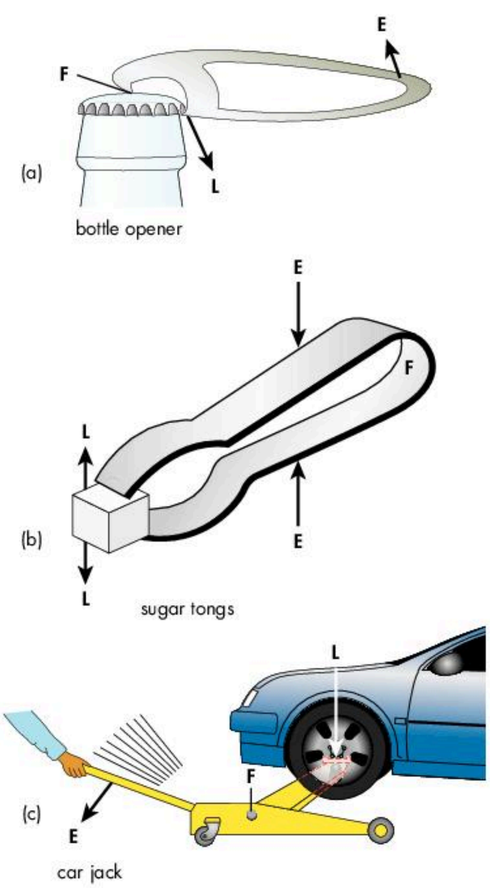




Scissors being used and sketch to show the positions of the effort, load and fulcrum

12.22 Sorting levers

For each of the levers:
1 identify if it is a force multiplier or a distance multiplier
2 list which class of lever it is
3 draw a sketch to show the positions of the effort, load and fulcrum.



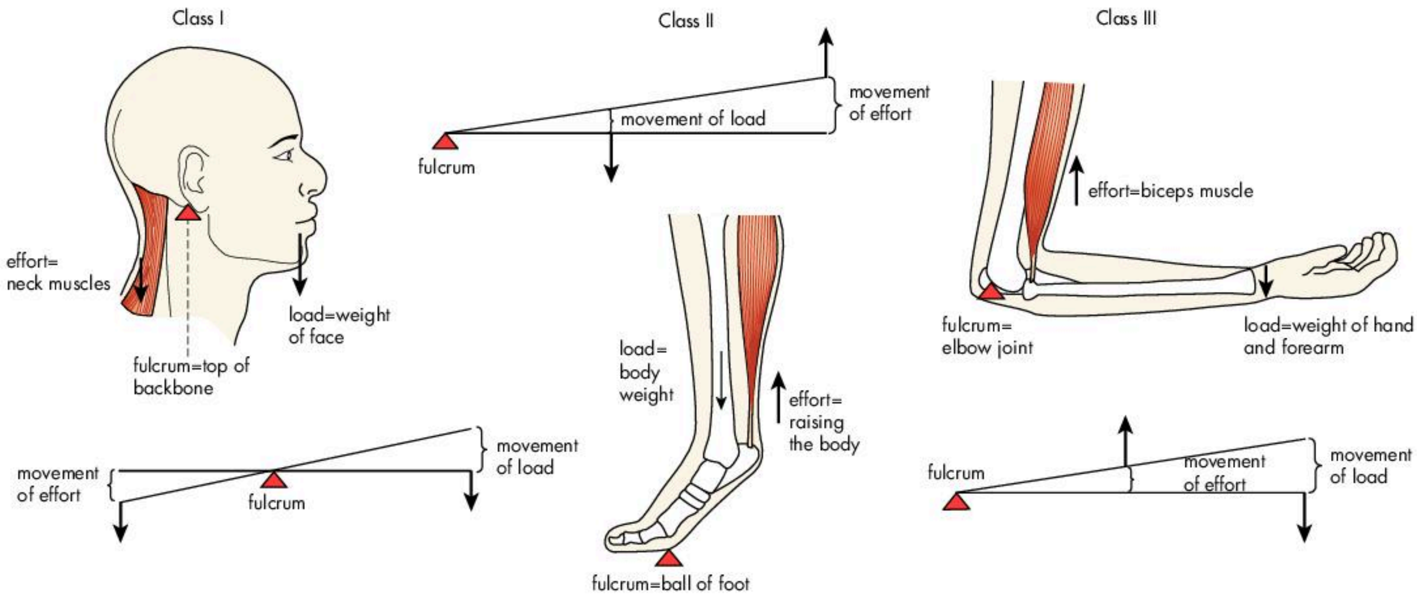
Levers in the human body

We can find each of the classes of lever in the human body.

Class I: fulcrum is between the effort and the load, e.g. balancing the head on the top of the backbone.

Class II: load is between the fulcrum and the effort, e.g. standing up on tiptoe.

Class III: effort is between the fulcrum and the load, e.g. raising and lowering the arm.

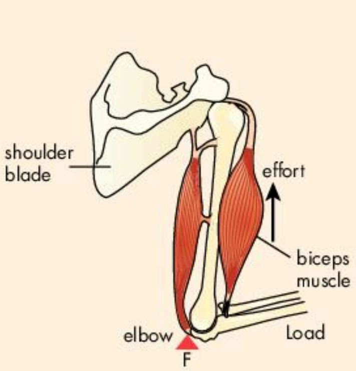


12.23 Making a model arm

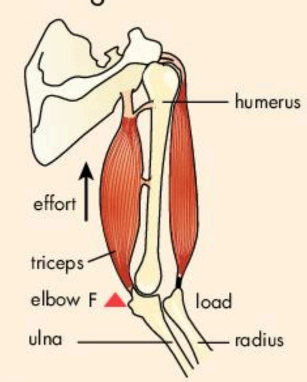
Materials: cardboard, scissors, two rubber bands, a split pin

Method

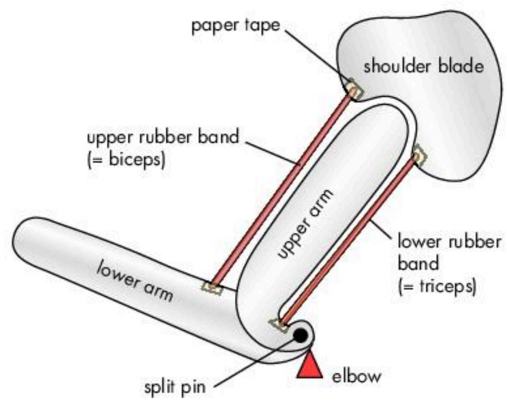
Use the Engineering design process and the diagrams below to make a model arm that can be raised and lowered. One idea is shown on the right.



Biceps contracts (arm raised)



Triceps contracts (arm straightens)



A model arm

▸ **See Workbook Using levers.**

Quick check ☑

A __________ can be used to move another __________. The __________ doing the work is called the __________ and the __________ moved is the __________. Movement occurs around the __________. There are three classes of __________ and these are also found in the human __________.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

effort **lever** **force**

load **body** **fulcrum**

Motion

Motion is change in position over a period of time.

Inertia

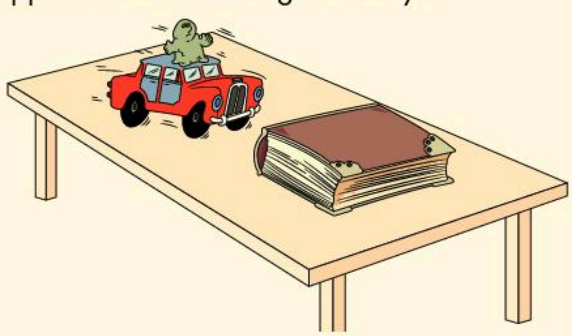
You may feel like staying in bed in the morning – you feel a certain inertia towards getting up. You want to stay where you are and may need a force to get you started!

- An object at rest (stationary) has inertia. It stays that way unless acted on by an unbalanced force.
- When an object is moving, it also has inertia. It tends to stay as it is – moving in the same direction at the same speed – unless there is another force to slow it down, change its direction, or stop it.

12.24 Inertia

Materials: toy car, modelling clay, large book
Method

1. Make a model figure out of modelling clay and stand it on top of the car. On a flat surface push the car towards the book so the car crashes into it.
2. What happens to the model figure? Why?



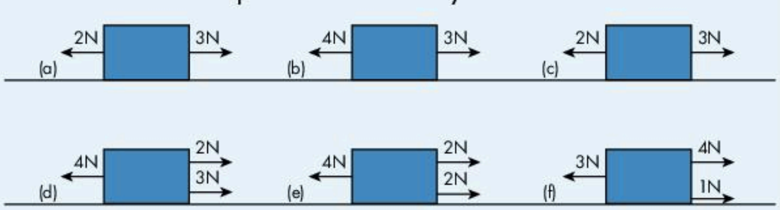
Balanced and unbalanced forces

No motion occurs without an unbalanced force.

- Forces can be shown by arrows.
- The tail-end of an arrow begins where the force pushes or pulls and points in the direction of the force.
- The length of an arrow shows its strength and can be labelled with its force in newton, e.g. 3N or 5N.
- Arrows acting in the same line can be added and subtracted.

12.25 Forces

Which of these objects moves? Why and in which direction?



Objectives

- Draw and do calculations with simple force diagrams.
- Describe and give examples of scalar and vector quantities.
- Distinguish between distance and displacement, and speed and velocity.
- Determine acceleration.
- Solve problems about the motion of a body.

Scalar and vector quantities

- A scalar quantity can be described by its size, e.g. time, distance and speed; it does not have a direction.
- A vector quantity is described by both its size and its direction, e.g. force, displacement and velocity.

12.26 Scalar and vector quantities

Work in small groups:

1. Discuss the following quantities and find out the SI unit for each one: Time, mass, length (distance), force, displacement, velocity, temperature, speed, acceleration. ICT
2. Make a table of your results, and add a column to record if each measurement is a scalar or vector quantity. (Is direction important in order to describe it? If yes, then it is a vector quantity.)

Questions

1. Why do we wear seatbelts for safety in a car?
2. If you are standing in a bus and it stops suddenly, what happens and why?
3. How is friction important when an object (a) starts moving, (b) is already moving?
4. A student described the speed of an object as travelling from east to west. What is wrong with this statement?

Distance and displacement

Distance is a scalar quantity: it is how much ground an object has covered, e.g. how far a person walks. It does not take any account of the direction of movement.

Displacement is a vector quantity: it is how far out of place an object is, e.g. how far away from the starting point. It takes account of direction, so if a person starts to walk back towards the starting point, they reduce their displacement even though they increase the distance they have walked.

12.27 Distance and displacement

Materials: toy car, paper marked in cm squares, pencil, ruler
Method
Work in groups:
1 You are going to move the car on the piece of paper and record its movement from the starting point.
(a) Person 1 moves the car a whole number of centimetres.
(b) Person 2 says and records the distance moved, e.g. 2 cm.
(c) Person 3 says and records the direction of movement, e.g. North.
(d) Person 4 draws the line that shows the movement.
2 Person 1 moves the car to a new position, and persons 2–4 describe its motion as before.
3 Person 1 now does the following: moving the car west 5 cm and west another 5 cm, compared to moving it 5 cm west and then 5 cm east.

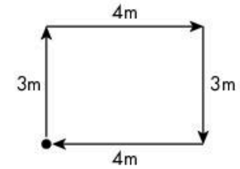
Look at the sheet of paper and your table of records:
1 When you say an object moves a certain distance, why is this insufficient information?
2 What is the effect of an object travelling east and then west by the same amount?

4 Turn over the graph paper and change places for the jobs.
(a) The new person 1 makes a clear mark on the paper to show the staring point and then moves the car.
(b) The new persons 2–4 do similar jobs as before.
(c) Your group records:
(i) the total distance the car has covered, e.g. 5 cm
(ii) its displacement (distance and direction) from the starting point.
5 Repeat step 4 above, by moving the car again and make new group records.
6 Now find a route and directions to bring the car back to its starting point.

3 (i) What is the total distance your car has covered?
(ii) What is its final displacement?
4 Explain the difference between distance and displacement.

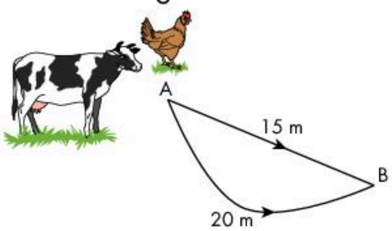
Distance and displacement

1 A girl walks as shown in the diagram, north, then east, south and west.



(a) What is the distance she walks?
(b) What is her displacement at the end of her walk? Why?

2 A cow and a chicken take different routes in moving from A to B.



(a) What distance did the (i) chicken and (ii) cow travel?
(b) What is the displacement of (i) the chicken and (ii) the cow?

3 A car travels round a race track with a circumference of 500 m.

(a) Once round the track, what distance has the car covered?
(b) Once round the track, what is its final displacement?
(c) Twice round the track, what distance has the car covered?
(d) Twice round the track, what is its final displacement?

4 A man walks 10 m from A to B and then 5 m from B to C.
(a) What distance does he walk?
(b) What is his displacement in m? Why can this not be answered?
(c) Draw a diagram to show the route: A, B and C, and calculate the displacement.
(d) Draw a different diagram that could also be true and calculate the displacement.

Speed and velocity

Speed is a scalar quantity: it is how fast an object is moving. It is not concerned with direction. To calculate average speed we need the distance covered and the time it takes to do it. In SI units, speed = metres (distance)/ seconds (time) = m/s. We would say the speed of a cyclist was 6 m/s.

Velocity is a vector quantity: it is the rate at which an object changes its position, so it depends on displacement. To calculate average velocity we need the distance covered, the time taken and the displacement away from the starting point. We would say the velocity of a cyclist was 6 m/s west.

12.28 Speed and velocity

1 View videos of situations where speed is measured, e.g. athletics events, Olympics, Paralympics, racing car events.
2 Your group picks a certain event, e.g. Paralympics for the past year and finds information on the **ICT**
(i) length of the course for 4 different races
(ii) time taken by women and men to cover the course.
3 Record this information in a table and work out the speed for each group of athletes.
4 For a different event and year, find the length of the track and the speed of the winner. **ICT**
Use this information to work out their times for covering the track.

1 (a) How do we calculate speed?
(b) If we know the speed and distance how do we calculate the time taken?
(c) If we know the speed and the time taken how do we calculate the distance?
2 List other ways of describing speed as well as m/s.
3 The girl in Question 1 on page 126 walked a total of 14 m in 14 s. At what speed did she walk?

6 A man is running due north with a velocity of 5 m/s. Explain what this means. How is this different from saying he ran at a speed of 5 m/s?
5 A truck is moving with a velocity of 80 km/hr due east. What is his speed? How is his speed different from his velocity?

Velocity = change in position/ time = displacement/ time
4 The girl who walked around the track of 14 m in the time of 14 s, and came back to her starting point has:
(i) what displacement? (ii) what velocity?
5 The cross country team ran around the 5 km track in 30 minutes. What is their:
(i) speed in km/hr? (ii) displacement at the end of the run?
(iii) velocity in km/hr?

Speed and velocity

1 Speed is distance travelled divided by time taken. Calculate the speed of the following.

	Distance	Time taken
(a) Olympic runner	100 m	10 s
(b) Horse	600 m	40 s
(c) Cheetah	400 m	10 s
(d) Car	150 miles	3 hr
(e) Jet aeroplane	3000 km	3 hr

2 The planets all move at different velocities in their orbits. Use the information to make a bar chart.

Planet	Velocity (km/s)
Earth	30
Jupiter	13
Mars	24
Mercury	48
Neptune	5.5
Saturn	10
Uranus	7
Venus	38

(a) Does your bar chart show a pattern?
(b) What is true about the relationship of distance from the Sun and the velocity of the planets?
(c) Suggest a reason for this.
3 Starting from her home, a cyclist travels 9 km in 30 minutes. Assume that her speed is constant.
(a) What is her speed in km/hr?
(b) How far will she travel in
(i) 120 minutes?
(ii) 10 minutes?
(iii) 20 minutes?
(c) How much time will it take her to go
(i) 27 km?
(ii) 15 km?
(d) It takes her 3 hours to return home.
(i) What distance has she travelled?
(ii) What is her average velocity?

Velocity and acceleration

Velocity is a vector quantity: it is the speed (m/s) in a certain direction. The velocity (displacement per time interval) can stay constant, e.g. travelling south at a steady velocity of 2 m/s is not accelerating. An object can have a very high velocity, e.g. an aeroplane flying east with a velocity of 1000 km/hr, but if its velocity is not changing then it is not accelerating.

Acceleration is a vector quantity; it is the rate at which an object changes its velocity as it moves. Acceleration is when an object goes faster and faster, or slower and slower. Note that speeding up takes the object further from its starting point, and slowing down (also called deceleration or retardation) brings it closer to its starting point.

An object has uniform or constant acceleration if its velocity changes by equal amounts in equal periods of time (getting faster and faster or slower and slower). In SI units we measure acceleration in m/s/s or m/s^2. For example, an acceleration of 2 m/s^2 means that each second the velocity changes (increases or decreases) by 2 m/s.

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken (s)}}$$

12.29 Velocity and acceleration

1 Two students perform this skit for the class.

Learner: What do you use to make the car go faster?
Instructor: The gas pedal or accelerator.

Learner: What causes the car's velocity to change from 40 km/hr to 80 km/hr?
Instructor: The gas pedal or accelerator.

Learner: What do you use to go slower?
Instructor: The brake.

Learner: What causes the odometer's needle to move from 80 km/hr to 40 km/hr?
Instructor: The brake.

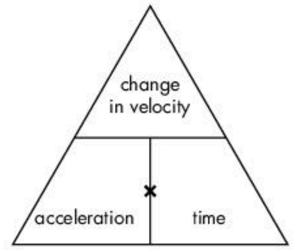
Learner: What do you use to change the velocity of the car?
Instructor: The accelerator (gas pedal) or the brake.

In groups discuss and answer these questions:

1 How do we (a) increase the velocity of a car? What effect does this have?
(b) decrease the velocity of a car? How is friction involved?
2 Does a car's velocity change when it speeds up?
3 Does a car accelerate when it speeds up?
4 Does a car's velocity change when it slows down?
5 Does a car accelerate when it slows down?
6 Write your own definition for acceleration. Can it take you further away or closer to your starting point?

Velocity and acceleration

The triangle shows the relationship between acceleration, change in velocity and time taken.



$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

change in velocity = acceleration × time

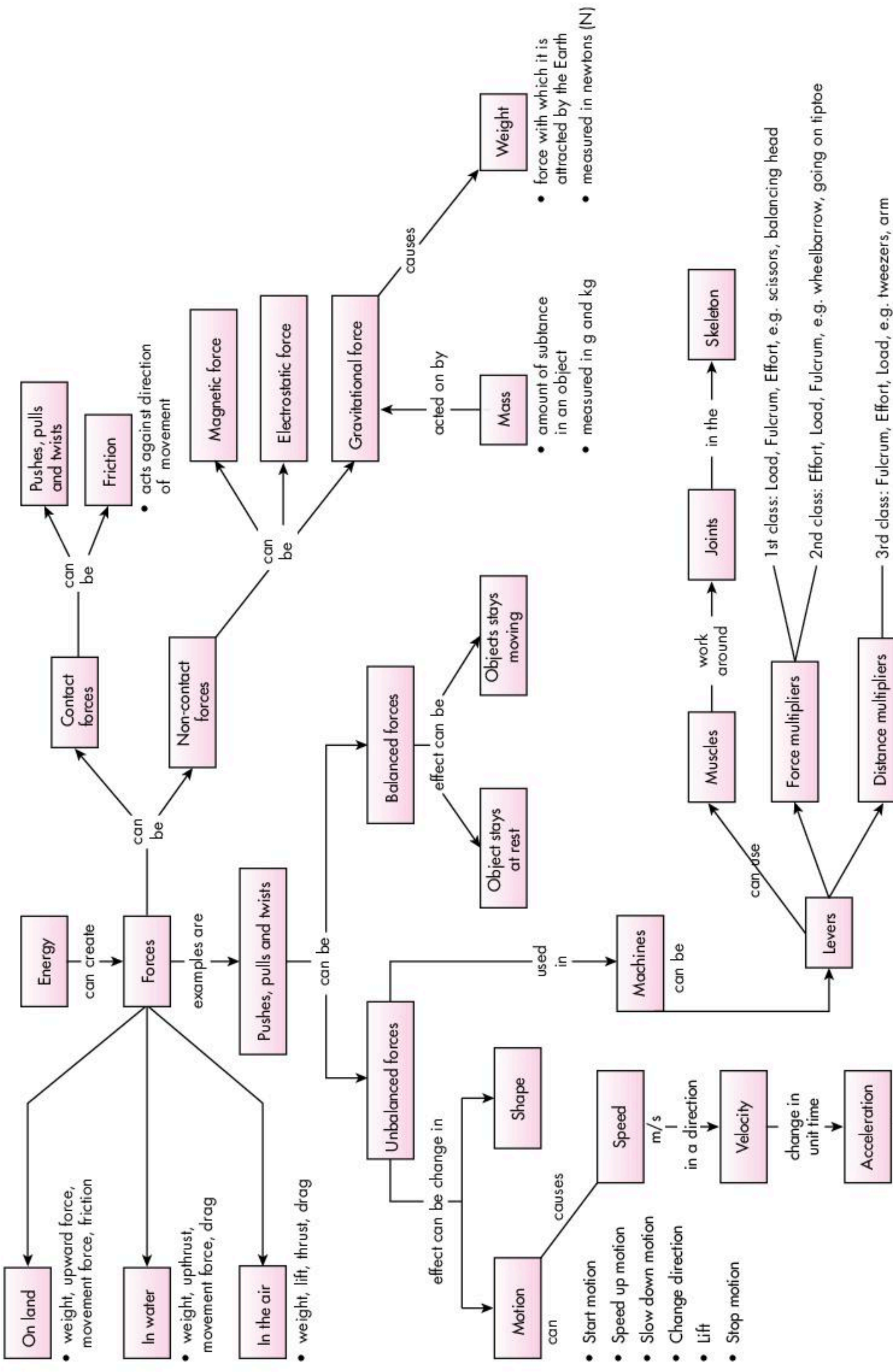
$$\text{time} = \frac{\text{change in velocity}}{\text{acceleration}}$$

(a) If an object's velocity changes by 20 m/s in 2 s, what is its acceleration?
Acceleration is the change in velocity in one second so this is:
Acceleration = change in velocity / time
= 20 m/s divided by 2s,
so acceleration = 10 m/s/s or 10 m/s^2

(b) A car is travelling at 30 m/s. It accelerates at 2 m/s^2. How fast will it be (what will be its velocity) 6 s later?
Change in velocity = acceleration × time
= 2 m/s^2 × 6s
= 12 m/s
So the total velocity is 30 + 12 = 42 m/s

1 If an object's velocity changes by 30 m/s in 15 s, what is its acceleration?
2 If a cyclist's velocity changes by 2 m/s in 30 s, what is her acceleration?
3 A stationary object accelerates at a rate of 3 m/s^2. What will be its velocity after 3 s?
4 A cyclist has a velocity of 6 m/s and is accelerating at a rate of 1 m/s^2. What will be the velocity after 30 s?
5 An object moving at 40 m/s changes its velocity to 80 m/s in 20 s.
(a) What is the change in the object's velocity? (b) What is its acceleration?
6 An object moving at 60 m/s changes its velocity to 40 m/s in 5 s. What is its acceleration?

Summary on Forces and motion (Unit 12)



Quick check ☑

An object at rest or moving has ________: it continues as it is unless acted on by an ________ force. Distance is a ________ quantity and displacement is a ________ quantity. Speed is measured in ________ and ________ is speed in a certain direction. The rate of change of velocity is ________, a ________ quantity measured in ________.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

scalar **vector** **m/s**
unbalanced **inertia** **m/s/s**
acceleration **velocity**

Questions

Answer these questions in your notebook

For questions **1–32** answer **A**, **B**, **C** or **D**.

1 For an object at rest on a table, which force balances the force of gravity?
A the movement force
B the weight
C upward force from table
D friction

2 A force can
A start things moving
B slow things down
C change an object's shape
D all of the above

3 In order to make an object move, the forces acting on it must be
A very strong
B balanced
C unbalanced
D working in opposite directions

4 In which of these is force measured?
A newton **B** g
C kg **D** amps

5 Which of these is a contact force?
A frictional force
B gravitational force
C magnetic force
D electrostatic force

6 What force is felt when two similar poles of magnets are brought close together?
A pull **B** push
C twist **D** turn

7 A mass of 350 g will have a weight of
A 35 g **B** 3.5 g **C** 35 N **D** 3.5 N

8 What is the mass of an object with a weight of 550 N?
A 5.5 kg **B** 55 kg
C 550 g **D** 550 kg

9 What is another name for a spring balance?
A newtonmeter **B** anemometer
C lever-arm balance **D** kitchen scales

10 The mass of an object that is 2 cm × 1 cm × 1 cm is 10 g. What is its density?
A 10 g **B** 2 cm^3
C 20 g/cm^3 **D** 5 g/cm^3

11 When a ship is loaded, what will happen?
A the weight of the boat increases
B the density of the boat increases
C the amount of air decreases
D all of the above

12 What keeps a parachutist suspended in air?
A weight **B** air resistance
C movement force **D** all of the above

13 Which of these would NOT decrease the amount of friction between two surfaces?
A using oil
B using wheels
C pushing the surfaces closer together
D putting a layer of ball bearings between the two surfaces

14 In which of these situations is friction least useful? When
A operating machinery
B lighting a match
C operating the brakes on a car
D removing a screw-top lid from a bottle

15 When do objects float in water? When
A buoyancy exceeds upthriust
B weight exceeds upthrust
C weight and drag are equal
D upthrust exceeds weight

16 Which of these forces tends to oppose the forward movement of an aircraft?
A thrust **B** drag
C weight **D** lift

17 What creates lift?
A the force of the aircraft's engines
B the streamlined shape
C the wings with their aerofoil shape
D the resistance from the air

18 How does a streamlined shape affect movement?
A increases it by reducing water resistance
B increases it as it makes the object lighter
C increases it as it makes the object more powerful
D decreases it by increasing air resistance

19 In a lever system what does E stand for?
A energy **B** effort
C electro **D** load

20 A lever can be made to operate using
A muscles **B** electrical circuits
C electronic circuits **D** all of the above

21 Which of these is the arrangement found in a pair of scissors?
A fulcrum, load, effort
B fulcrum, effort, load
C load, fulcrum, effort
D load, effort

22 The elbow joint is most similar to which of these kinds of machine?
A fishing rod **B** pair of scissors
C wheelbarrow **D** pulley

23 Inertia is a characteristic of a body
A at rest **B** moving slowly
C moving quickly **D** all of the above

24 Which of these is a vector quantity?
A distance **B** temperature
C displacement **D** mass

25 A girl goes directly from A to B 5 km south while a boy detours to his grandma's and walks 8 km to get from A to B. Which statement is NOT true?
A the displacement of the girl is 5 km
B the displacement of the boy is 5 km
C the displacement of the boy is 8 km
D the distance walked by the boy is 8 km

26 The sports team runs twice round the track that has a circumference of 200 m. Which is true?
A distance run 200 m, displacement 200 m
B distance run 400 m, displacement 200 m
C distance run 200 m, displacement 0 m
D distance run 400 m, displacement 0 m

27 A car travelled 660 m in 3 s. What is the speed?
A 220 m/s **B** 330 m/s
C 660 m/s **D** 330 m/s^2

28 Which is NOT a definition of velocity?
A distance divided by time
B displacement divided by time
C distance south divided by time
D change in position divided by time

29 Acceleration is
A change in velocity divided by time
B change in speed divided by time
C a measurement of objects increasing in speed
D a measurement of objects decreasing in speed

30 Acceleration is measured in
A m/s **B** m/s^2
C ms **D** ms/s^2

31 If an object's velocity changes by 2 m/s in 4 s, what is the acceleration?
A 2 m/s **B** 2 m/s^2
C 0.5 m/s **D** 0.5 m/s^2

32 A stationary object accelerates at a rate of 2 m/s^2. What will be its velocity after 10 s?
A 2 m/s **B** 2 m/s^2
C 20 m/s **D** 20 m/s^2

For questions **33–48** write full answers in your notebook.

33 Explain your answers in each case.
(a) Can one force on an object make it move?
(b) Will two forces make an object move?
(c) What effects do forces have?

34 (a) What force has to be overcome for an object on land, before it will start to move? (b) What determines the size of this force?

35 Name a non-contact force. Describe how you would demonstrate this force to a partner.

36 (a) Name two advantages and two disadvantages of gravity. (b) How does gravity on the Moon differ from that on Earth? (c) Why is it different?

37 (a) Find out what a newtonmeter has to do with apples. (b) Why is 'newtonmeter' a good name for it? (c) It is also called a spring balance and a force-measurer. Why are these also good names for it?

38 (a) Describe two places where friction is useful. (b) Describe two places where friction is a nuisance and for each one say how it can be reduced.

39 Describe four everyday examples where pushes, pulls and twists are important. Illustrate your answer with a simple diagram.

40 Describe the forces at work (a) on land, (b) in the water and (c) in the air that make objects stay at rest or float.

41 (a) Describe how a streamlined shape assists movement through water. (b) List three living or non-living things that show these modifications.

42 (a) Draw a diagram of an aircraft. Add labels to it to show the four forces that are involved in flight. (b) For each force, describe why it is important. (c) How is lift produced? (d) List three living or non-living things that use lift.

43 Imagine that you are a trainee airline pilot. (a) What do you need to consider when you come into land? (b) Why do you think that some very large planes cannot land on short runways? (c) Planes have to have their tyres replaced after a short time. Explain why you think this is.

44 (a) What is a force multiplier? When would you use it? (b) What is a distance multiplier? When would you use it? (c) Use diagrams and examples to describe the differences between the three classes of lever.

45 (a) Choose an example of a scissor-machine. Describe all the features that make it useful for its job. (b) Compare its features to another named scissor-machine used in a different way.

46 Explain with the use of a diagram the difference between distance and displacement.

47 (a) How is distance travelled important when working out average speed? (b) How is displacement from a starting point important when working out average velocity?

48 (a) What is the definition for acceleration? (b) Explain what is meant by an acceleration of 2 m/s^2.

Key ideas

- Forces are pushes, pulls and twists.
- Forces start and stop objects and change their speed, direction and shape.
- An object at rest or at constant speed has balanced forces acting on it.
- Forces are contact forces, such as friction and air resistance, or non-contact forces such as magnetism and gravitational force.
- Mass (in kg and g) is a measure of the amount of substance in an object.
- Weight (in newton: N) is the force with which an object is attracted by the force of gravity. A 1 kg mass has a weight of about 10 N on Earth.
- Friction opposes motion between two surfaces. It has to be overcome to get an object moving.
- Friction can be reduced, e.g. by using oil, ball bearings, wheels or a streamlined shape.
- In water and in the air there is a supporting upthrust force of buoyancy or air resistance.
- Movement is assisted by a streamlined shape and aerofoils
- In the air, four forces are acting, lift and weight vertically, and thrust and drag horizontally.
- On a balanced ruler, force × distance on one side = force × distance on the other.
- Levers have a pivot (fulcrum) and an effort force used to move a load.
- Levers can be force multipliers (1st and 2nd class levers) or distance multipliers (3rd class levers). The body moves mainly by using 3rd class levers.
- Joints are where bones meet and where movement can occur using lever action.
- Objects at rest or moving at a constant speed have inertia and will continue as they are unless acted on by an unbalanced force.
- Scalar quantities, e.g. mass have size only; vector quantities, e.g. force also have a direction.
- Distance is how far a thing travels; displacement also involves direction from a starting point.
- Speed in SI units is distance in m ÷ time in s.
- Velocity is speed in a certain direction; it is displacement divided by time.
- Acceleration is change in velocity divided by time, measured in m/s^2. Acceleration can be an object going faster and faster, or slower and slower.

▸ **See Workbook Forces and motion.**

Problems

1 As a class project use the Engineering design process to find and improve on the best design for a model plane made out of a sheet of paper. Use the scientific method to test and compare your designs.

(a) Search the Internet for different designs. You will find several ideas that you can download and make. ICT

(b) Make some of the suggestions and then set up a fair test to compare them. What is the effect of

(i) the kind of paper used: lightweight, standard, or heavier weight?

(ii) balancing by using or not using a paper clip at the front of the plane?

(iii) folding or not folding part of the 'wings'?

(c) How will you measure and compare the flights of different designs?

(i) will it be how high the plane can go, or how far?

(ii) will everyone just have one flight, or will you find out the average of three flights for each plane?

(d) Have a competition to find who can make the best design and display your models.

2 Half the class can prepare a large chart called 'Forces in action'.

(a) Research on the Internet the effects of forces and make notes. ICT

(b) Collect pictures from magazines and newspapers that show action where forces are involved.

(c) Make a rough outline of your chart, collect short descriptions for the examples, and then find or draw pictures to illustrate each one.

(d) When you know where everything will fit, then make the final version and make it attractive.

3 The other half of the class can prepare a large chart called 'Motion'. You will have to discuss what will go on one chart and which on the other.

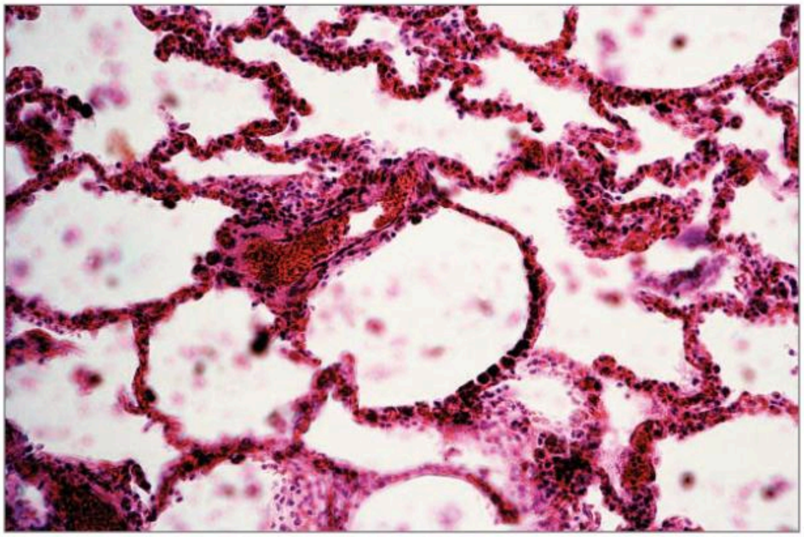
(a) Research on the Internet the different examples of motion you have studied. ICT

(b) Your list can include distance, displacement, speed, velocity and acceleration. For each one you should include a description and an example.

(c) Design and make your finished chart.

Unit 13

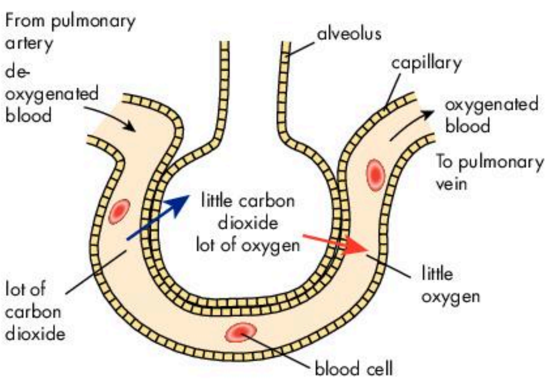
Gas exchange and respiration



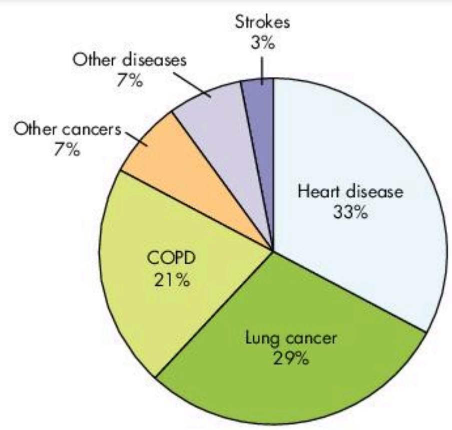
1 *How is lung tissue suited for its functions?*

This unit will help you to:

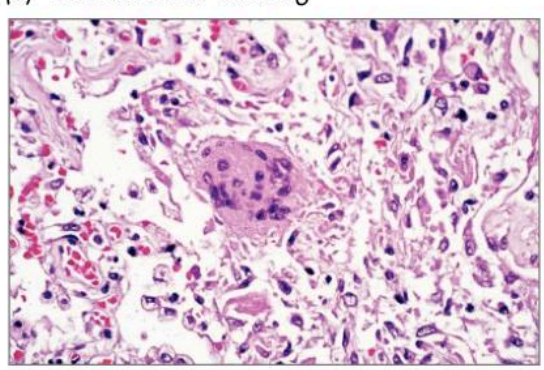
- describe the process of breathing
- explain gas exchange of oxygen and carbon dioxide in the alveoli
- research causes of diseases of the respiratory system
- explain the importance of energy for all living things
- investigate energy release from food by respiration in living things
- appreciate the role of the circulatory system in respiration
- identify and investigate aerobic and anaerobic respiration
- compare photosynthesis and aerobic respiration



2 *How are gases exchanged in the alveoli? Describe what happens to (a) carbon dioxide and (b) oxygen.*



(a) Deaths due to smoking



(b) Lung tissue of a smoker

3 *What are some of the effects of smoking cigarettes?*

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.

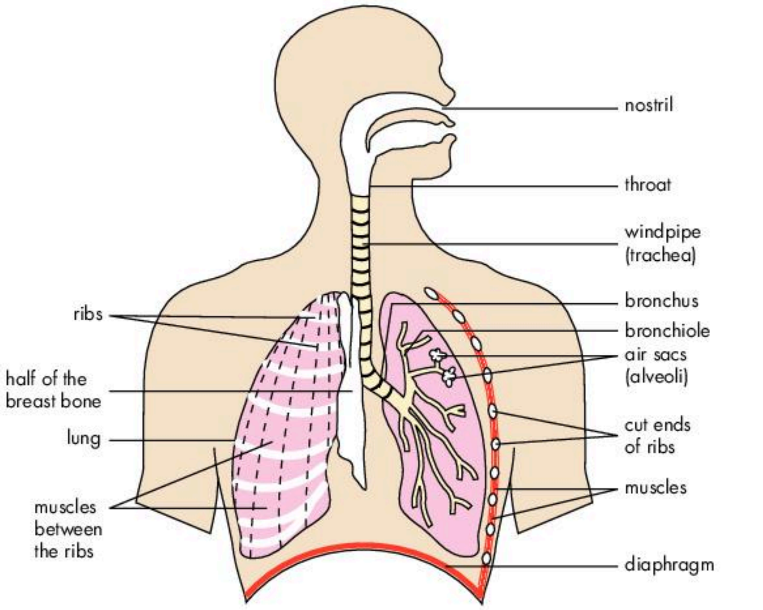
Breathing and gas exchange

Living cells need energy released from food using oxygen during respiration. This also produces carbon dioxide, water and other wastes. How is the respiratory system involved?

The respiratory system

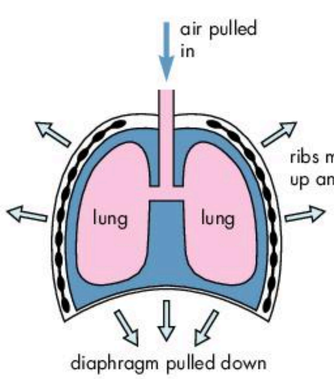
Air enters through the nostrils where it is warmed, and dust is trapped by small hairs. We also breathe in through our mouth. In the throat the air goes into the **trachea**. This branches into the **bronchi** which go to the lungs. The air tubes divide into **bronchioles** until they end up as small air sacs called **alveoli.**

The lungs are enclosed in the **ribcage**, which is made from the ribs, breast bone (in front) and backbone (behind). Below the lungs is a muscular sheet, the **diaphragm**.

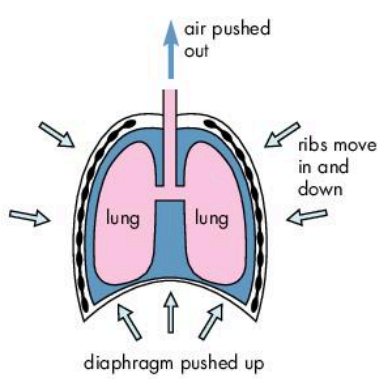


Breathing

The ribs are moved by muscles, and the diaphragm contracts and relaxes. Air is pulled in and pushed out of the lungs.



Breathing in: Inhalation



Breathing out: Exhalation

Objectives

- Draw and label the respiratory system and demonstrate and explain inhalation and exhalation.
- Describe gas exchange in the alveoli and in plants and aquatic organisms.
- Research respiratory diseases.

What does it mean?

Breathing: The movements of the ribs and diaphragm to take air in and out of the lungs.
Gas exchange: In the alveoli, oxygen passes into the blood and carbon dioxide passes out of the blood.
Respiration: In the cells, the chemical reaction where food and oxygen react to give carbon dioxide, water and energy.

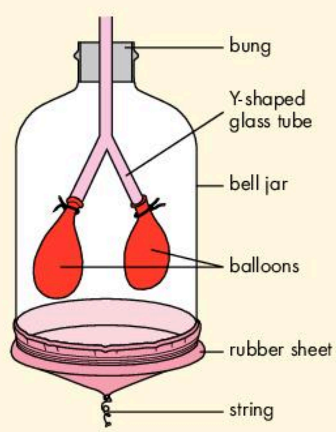
13.1 Breathing model

Materials: bell jar with bung, Y-shaped glass tube, balloons, string, rubber sheet

Method

1 List the structures in the pathway of air from the nostrils to the alveoli.

2 Set up the apparatus as shown. How does it compare to the real system?



3 Use the string to pull down on the diaphragm. Explain what happens.

4 Push up on the diaphragm. Explain what happens.

13.2 Breathing and exercise

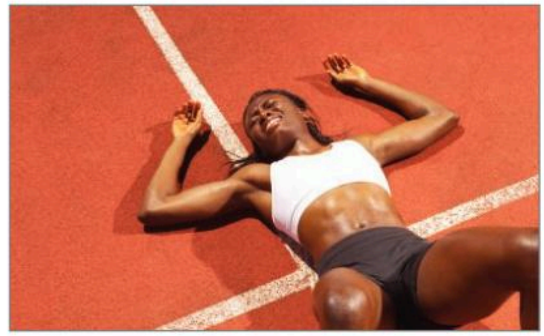
Materials: video clips of athletic activities, stopwatch
Method
View the video clip. Discuss how the athletes are breathing before and after a race. Why is breathing necessary? Would someone with larger lungs be a better athlete? Explain your answer.

1 Work in pairs. Count the number of breaths taken by your partner in a minute by observing the movement of the chest.
2 Now run on the spot for 3 minutes and immediately count the number of breaths in a minute. Change places and repeat.
3 Combine the class results to make a table of breathing rates before and after exercise (you can keep the results of boys and girls separate).
4 Design and draw bar charts of your results.

Brainstorm how gender, state of health and different types of exercise can affect breathing rate.

13.3 Gas exchange in the alveoli

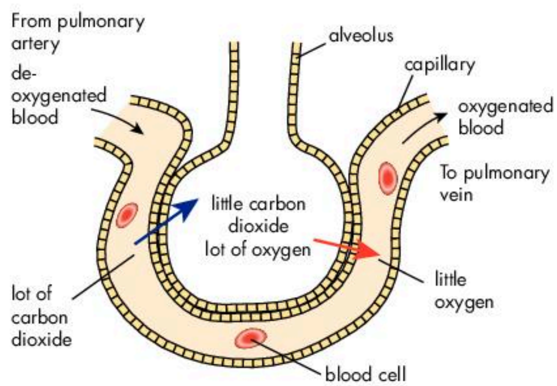
1 View diagrams, photos, animated pictures of lung tissue. Do you notice a lot of air spaces, thin walls and blood vessels? Why are these important for gas exchange?
2 The following are characteristics of the alveoli. Discuss and record how each one will help gas exchange.
   (a) They are blind-ended sacs.
   (b) There are millions of them.
   (c) They are covered in capillaries from the pulmonary artery (this has a high concentration of carbon dioxide and a low concentration of oxygen: de-oxygenated blood).
   (d) They are at the end of very small bronchioles and in contact with the bronchi and trachea.
   (e) They expand when the person breathes in fresh air.
   (f) Their walls are only one-cell thick and kept moist.
   (g) They are covered in capillaries from the pulmonary vein (this has a lower concentration of carbon dioxide and a higher concentration of oxygen: oxygenated blood).
   (h) They contract when the person breathes out stale air.
3 Use the list above to describe what happens in gas exchange so that:
   (i) carbon dioxide diffuses from the blood in the capillaries of the pulmonary artery into the alveoli and
   (ii) oxygen diffuses from the alveoli into the blood in the capillaries of the pulmonary vein.
4 Define diffusion. How is it important for what happens in the alveoli?
5 Why do we call what happens in the alveoli 'gas exchange'?



Why do you think the athlete is breathing deeply after the race?

Fun facts

- There are about 300 million alveoli in one average lung.
- Emphysema, caused by tobacco smoke, weakens the alveoli walls so that breathing becomes more difficult.



Use the diagram to write an account of how gas exchange occurs in an alveolus

Comparing inhaled and exhaled air		
	Inhaled air	**Exhaled air**
Oxygen	21%	17%
Carbon dioxide	0.03%	4%
Nitrogen	78%	78%
Noble gases	1%	1%

Note: The 79% of the air that is nitrogen and noble gases enters and leaves the body unchanged. Oxygen is reduced and carbon dioxide is increased by the same amount. Discuss in your group the reasons for the other differences recorded between inhaled and exhaled air

13.4 Comparing inhaled and exhaled air

Materials: mirror, blue cobalt chloride paper, thermometer, two identical jars with lids, bucket, water, rubber tubing, two candles stuck on lids, matches, limewater, evaporating dishes, straws

Method

Record your results in a table for inhaled and exhaled air.

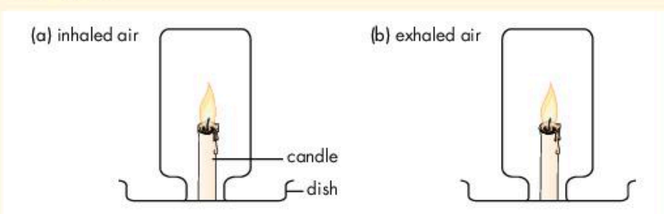
1 Water: (a) Look at the surface of the mirror. What does it look like? Test it with blue cobalt chloride paper.
(b) Breathe exhaled air out onto the mirror. What does it look like? Test it with blue cobalt chloride paper.

2 Warmth: (a) Use a thermometer to record the room temperature.
(b) Breathe out exhaled air onto the thermometer, watching the scale. Record the temperature.

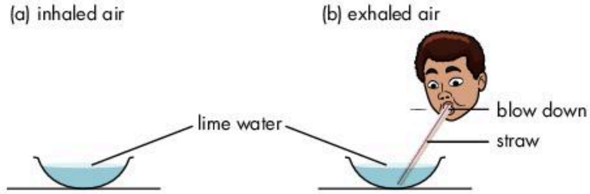
3 Oxygen: (a) Leave one jar open to the air. This will collect inhaled air. Put on the lid.
(b) One student collects exhaled air for the class.

Fill the other jar completely with water and put on the lid. Hold the jar upside down in a bucket of water as you take off the lid. Using the rubber tube, breathe air out into the jar until it is full. Put on the lid while the jar is under water.

Now light the two candles. At the same moment, take the lids off both jars and put the jars quickly over the candles. Record how long the candles burn in the inhaled and exhaled gas.



4 Carbon dioxide. This gas turns limewater milky.
(a) Pour a small amount of limewater into an evaporating dish and put it on the bench. Record if there is carbon dioxide in the air (inhaled air) to make it go milky.
(b) Each student has their own straw. Pour a small amount of limewater into another evaporating dish. Use your straw to blow exhaled air into it. Record what happens.



▸ **See Workbook Breathing and gas exchange.**

Fun facts

- When you are resting, you breathe in and out about 15 times a minute.
- Each breath contains about half a litre of air.
- Tight vests are used by athletes while they train. These make the rib muscles and diaphragm work harder.

Collecting exhaled air

Questions

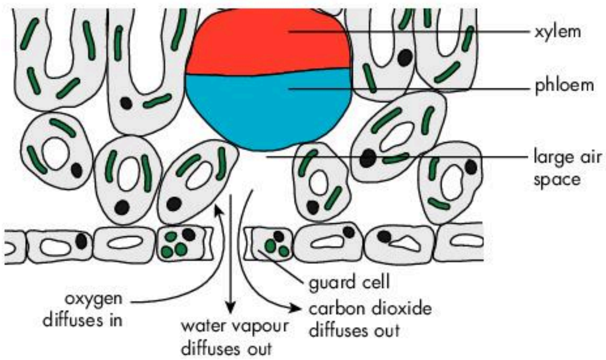
1 Water: is there more water vapour in inhaled or exhaled air?
2 Warmth: which was warmer, inhaled or exhaled air?
3 Oxygen: based on how long the candles burned, is there more oxygen in inhaled or exhaled air?
4 Carbon dioxide: based on the limewater test, is there more carbon dioxide in inhaled or exhaled air?
Record your results in a table.

Notes:

- Cell respiration produces water, so the air we breathe out is usually saturated with water vapour (more than in inhaled air).
- Cell respiration releases energy. Some of the heat is lost as we breathe out: exhaled air is about 37 °C (more than inhaled air).
- Differences for oxygen and carbon dioxide on page 135.

Gas exchange in flowering plants

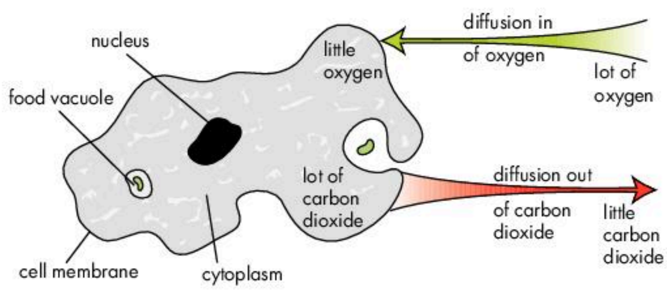
Plants are not as active as animals. They do not need muscles and lungs for breathing movements. The gas exchange that plants need to provide the raw materials for photosynthesis (page 29) and respiration can be carried out by the diffusion of gases to and from the cells of the leaf.



Diffusion of gases in and out of the leaf during respiration

Gas exchange in an amoeba

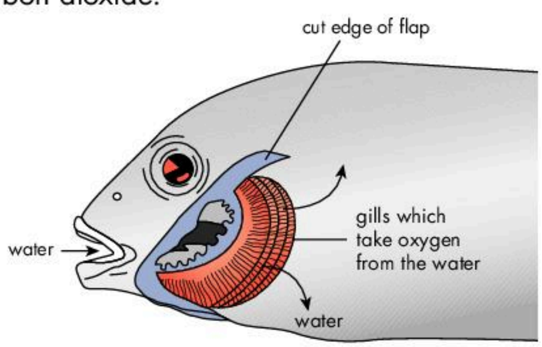
Simple aquatic organisms, such as amoeba, are surrounded by water in which oxygen and carbon dioxide are dissolved. They have a large surface area compared to their volume and the gases can diffuse in or out of the cell depending on the concentration gradients.



Amoeba can exchange gases by diffusion

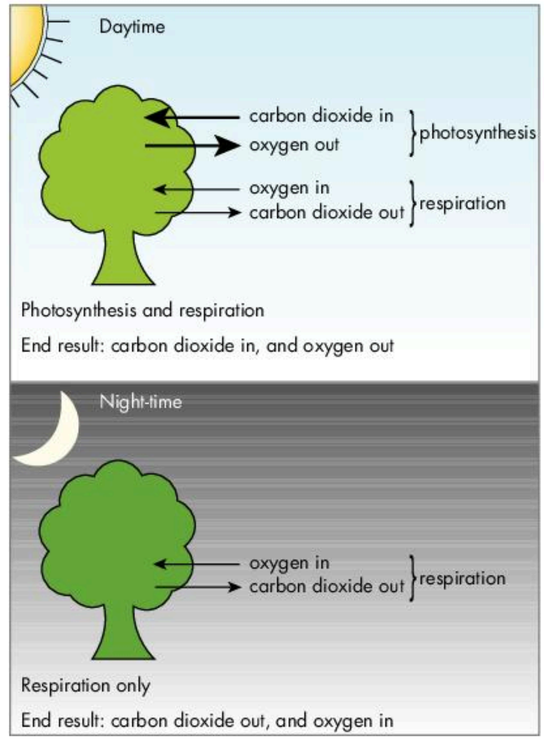
Gas exchange in fish

Fish are complex organisms and are very active. They need a constant supply of oxygen from the water, and have to get rid of carbon dioxide. They have gills for the exchange of oxygen and carbon dioxide.



How a fish takes oxygen from the water

Flowering plants



How plants affect the gases in the air during the daytime and the night-time

Gases dissolved in water Solubility (cm³/ 100 cm³ water)		
	20 °C	40 °C
Oxygen	3	2.5
Carbon dioxide	92	57

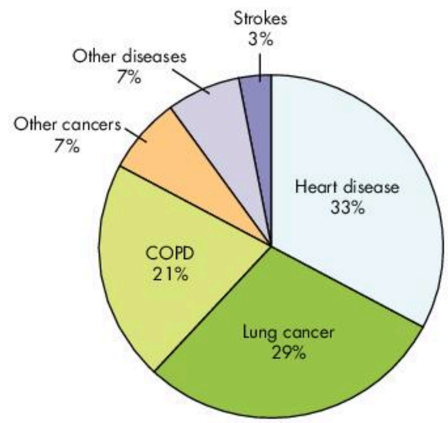
Questions

1 How does temperature affect the solubility of gases?
2 Which is more soluble in water, oxygen or carbon dioxide?
3 Why might fish in tropical waters find it hard to get oxygen from the water?
4 Research the structure, arrangement and function of gills in a fish. List three ways in which the gills are efficient for gas exchange. **ICT**
5 How are amoeba and a fish (a) similar and (b) different?
6 In the day-time how is gas exchange in humans and flowering plants (a) similar and (b) different?
7 In the night-time how is gas exchange in humans and flowering plants (a) similar and (b) different?

Diseases of the respiratory system

We are continually breathing in air – so any **pollutants** in the atmosphere or at the workplace, or disease-causing **micro-organisms**, will also come into our bodies. They can affect any part of the respiratory system and other organs. The effects may be short- or long-term. We might develop a respiratory disease and need medication.

Added to that are the problems associated with **cigarette smoking**, or of passive smoking where we breathe in other people's exhaled smoke. The chemicals in the smoke can cause short- and long-term damage to the respiratory system (see Grade 7, Unit 6, pages 166–7).



Causes of death from cigarette smoking in the USA from 2005-09

Affects of respiratory diseases

Smoking affects mainly the respiratory and circulatory systems. The pie chart on the right shows figures from the USA for the period 2005-09, for the percentages of deaths from cigarette smoking due to different diseases.

13.5 Chronic respiratory diseases

A major cause of chronic respiratory diseases is cigarette smoking. Research has been carried out comparing mortality rates from chronic respiratory diseases and changes over time for males and females in several Caribbean countries (Global diseases burden: Health Grove: shown below).

	Males		Females	
	Mortality rate per 100 000	**Change 1990–2013**	**Mortality rate per 100 000**	**Change 1990–2013**
Jamaica	36.9	+20%	15.7	–29%
St Lucia	40.1	–3%	15.7	–29%
Trinidad & Tobago	35.8	+14%	14.4	–20%
Barbados	30.1	–24%	16.8	–31%
Grenada	32.8	–17%	15.8	–36%
The Bahamas	26.6	–2%	14.2	–13%

For Jamaica:

1 Compare the mortality rates per 100,00 for males and females. Suggest any reasons for the difference.

2 Compare the percentage changes from 1990–2013 for males and females. Suggest any reasons for the difference.

3 Jamaica has the greatest male/ female difference. Suggest any reasons for this.

Which island:

4 Has (a) the lowest mortality rate (b) the highest mortality rate from respiratory diseases?

5 Has the greatest improvement for (a) males, (b) females.

13.6 Research

Search for Chronic respiratory diseases in Jamaica. **ICT**

Prepare group reports on:

1 How do respiratory diseases vary according to
   (a) age? What is the pattern? Does it take time for respiratory diseases to develop? Does smoking in the teens and twenties only show damage in the 50s and 60s?
   (b) gender? How do males and females compare? Why might this be? How much is an effect of the past and how much due to recent changes in behaviour?
   (c) occupation? Are some occupations or locations more dangerous than others for suffering from respiratory diseases, e.g. factories, farming, cities?
   (d) lifestyle? Do our choices make a difference? For example if someone smokes cigarettes and how many? Or if you live with someone who smokes?

2 What could be done to encourage people to stop smoking? The figures in column 1 show that from 1990–2013, the males in Jamaica and Trinidad and Tobago were the only groups with an increase in death rate from respiratory diseases. Females, in all islands, showed marked reductions. So there can be change – how do we encourage it?

Some respiratory diseases

Symptoms for diseases may over-lap. For full information you will need to refer to a medical dictionary or doctor.

COPD (chronic obstructive pulmonary disease): almost always caused by smoking. Long-term damage causing breathlessness.

- chronic bronchitis: bronchi become inflamed and damaged and contain extra mucus, so air-flow is restricted.
- emphysema: the alveoli become enlarged, so the surface area is reduced and they are less efficient at gas exchange.

Damage caused is usually irreversible, but if a person stops smoking and takes inhalants or other medications the amount of phlegm or sputum (mucus that is coughed up) may decrease.

Acute bronchitis: usually caused by viruses with smoking as a risk factor. Often occurs in people who are already unwell. It causes additional mucus, chest pains and wheezing (noise made when breathing through narrow lung passages). Can be followed by a bacterial infection that is treated with antibiotics.

Pneumonia: usually caused by bacteria with smoking and alcohol abuse as risk factors. Some of the alveoli are inflamed and filled with white cells and secretions. If the infection is widespread it can be life threatening. Antibiotics are usually effective, but there are some resistant strains of bacteria; pneumonia caused by viruses have to be treated with antiviral medications.

Asthma: an allergic reaction to cigarette smoke, pollen dust mites etc. Muscles of the bronchi contract, and the walls become inflamed so that breathing becomes difficult. Inhaled medications can be used to widen the air passages.

Lung cancer: usually caused by smoking and work-related factors. Research shows that the more cigarettes a person smokes the greater is their risk of developing lung cancer. Also, that a person who stops smoking decreases their risk. There are several different types that develop at different rates and are more or less likely to spread in the blood (metastasise) to other organs.

The damage begins in lung cells that start to grow in an uncontrolled way to form a **tumour.** Symptoms are a new or changed cough sometimes with blood, chest pain, shortness of breath and wheezing. Early treatment is important.

Scary facts

- Smoking cigarettes contributes to causing bronchitis, COPD, lung cancer and heart disease.
- Chewing tobacco contains at least 30 cancer-causing chemicals.
- E-cigarettes also produce cancer-causing chemicals.

Advantages of exercise

Exercise is any physical activity in which we breath deeply, raise our heart rate and get warm and sweaty, for example running, swimming, digging.
Some benefits:

- Lungs: You breathe more deeply and so strengthen your chest muscles. Your lungs become stronger and their capacity increases. You also breathe out stale air and pollutants. Your muscles get more oxygen and you work better and are less fatigued.
- Heart: Aerobic exercise ('cardio') requires extra pumping of oxygenated blood to the muscles, so both the heart function and the lung function is improved. Exercise also widens the arteries so reducing any plaque, and improves circulation in the veins.
- Overall functioning: Muscles benefit from extra work and become 'toned'. Joints move more easily. Regular exercise and an energy-controlled diet lead to a healthy mass that does not put strain on the heart. All body systems work better with exercise, e.g. digestion and bowel movements. Extra sweating also gets rid of wastes. Exercise also gives you a feeling of 'well-being'.

Quick check ☑

__________ is the movements of the ribs and diaphragm. Gas exchange takes place in the __________. Air rich in __________ is taken in, and air with more __________ is passed out. Inflammation and infections can cause __________ diseases; __________ is a major cause.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

oxygen **breathing** **alveoli** **carbon dioxide** **smoking** **lung**

Energy release in respiration

Respiration is the only way in which living things get energy for their needs. Plants do not get energy from photosynthesis: they also have to carry out respiration all the time.

Aerobic respiration

Respiration using oxygen is called **aerobic** respiration.

13.7 Is carbon dioxide released in respiration?

Materials: boiling tubes, hydrogencarbonate indicator, pond snail, pondweed, rubber bungs, marker

Method

Work in groups. Precautions: Wash your hands and wipe the bench with disinfectant after handling living things. Return the living things unharmed to their habitat after use.

1 Half fill the boiling tubes with hydrogencarbonate indicator and record the colour.
2 In tube A put a small pond snail and in tube B some pondweed. Leave tube C without an organism.
3 Put on all three bungs and leave the tubes in a dark cupboard for half to one hour. Record colour changes.

Questions

1 What happened in tube A. Did the snail produce carbon dioxide? Was it important to leave it in the dark?
2 What happened in tube B. Did the plant produce carbon dioxide? Was it important to leave it in the dark?
3 What is the reason for tube C. Was there a colour change? Explain your answer.

13.8 Is energy released in respiration?

Materials: peanut, test tube, support, water, pointed needle, match, measuring cylinder, thermometer, glass rod

Method

1 Set up the apparatus as shown on the right. Record the starting temperature of the water.
2 Light the peanut so it burns under the end of the test tube. When it has finished burning, stir the water with the glass rod and take the temperature.

Questions

1 By how much did the water increase in temperature? Why was this?
2 Use this equation to calculate the energy from the respiration of the peanut:

Energy released (J) = mass of water (g) x rise in temperature (°C) x 4.2 (Note: 1 cm^3 water = 1 g)

Objectives

- Identify and investigate aerobic and anaerobic respiration and write word equations.
- List where they both occur and how they are useful.
- Describe the structure and function of mitochondria.

13.9 Energy

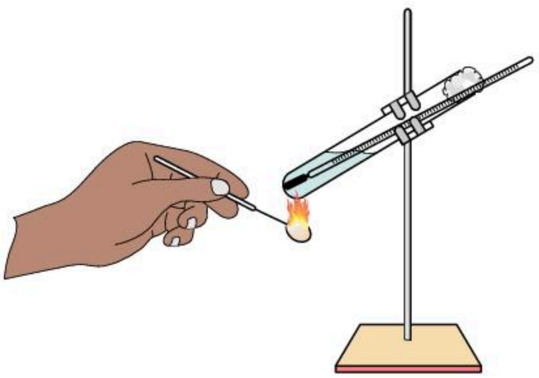
Work in groups:

1 Brainstorm why humans and other living things need energy. Make as full a list as you can.
2 Now divide your list into parts:
   (a) energy for staying alive
   (b) energy for growth and repair
   (c) energy for other activities.
3 Check your lists with other groups and make an overall list on which you all agree.

Hydrogencarbonate indicator

This is not a specific test for carbon dioxide. It is an indicator that changes colour in acidic conditions from orange-red to yellow. When carbon dioxide dissolves in water it forms carbonic acid – so the indicator changes colour.

▶ **See Workbook Energy release in respiration.**



Do you think that all the energy released from the peanut was used to heat the water? Suggest ways in which the experiment might be improved.

Anaerobic respiration

This is respiration without using oxygen. The food molecule, e.g. glucose, is partially broken down to release a small amount of energy (less than one tenth the amount released in aerobic respiration).

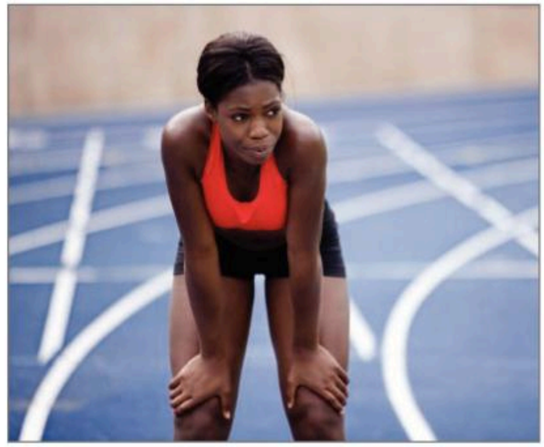
Anaerobic respiration occurs, for example in:

- Muscles. During heavy exercise insufficient oxygen may reach the muscles. Chemical changes occur to release some of the energy from the food, but this produces **lactic acid**, which makes the muscles ache.

  Glucose → Lactic acid + a little energy

  When exercise stops, additional oxygen is needed to combine with the lactic acid to release additional energy, carbon dioxide and water. This additional oxygen is called the **oxygen debt** and is part of the reason why sprinters take deep breaths when they have finished their race.
- Yeast fermenting sugar. This reaction is used to release carbon dioxide used in making bread and when using the yeasts on grapes to make alcohol.

  Glucose → Carbon dioxide and ethanol + a little energy



After a race, more oxygen is needed to overcome the oxygen debt

Carbon dioxide produced during the fermentation of yeast helps bread rise

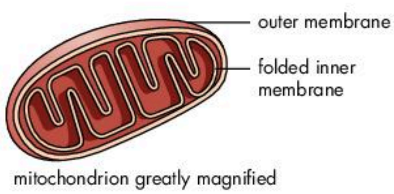
Comparing aerobic and anaerobic respiration

Aerobic respiration, anaerobic respiration in muscles and fermentation in yeast all start in a similar way by carrying out chemical changes on glucose in the cytoplasm of the cells.

The production of lactic acid and alcohol and the limited amount of energy that is released occurs in the main part of the cytoplasm of the cells.

In aerobic respiration in plants and animals, the chemicals then travel into the mitochondria and it is here that additional reactions occur, with oxygen, to release larger amounts of energy. This is then made available for the cell's activities.

Glucose + Oxygen → Carbon dioxide + Water + a lot of energy



Mitochondrion: greatly magnified

Respiration and combustion

Aerobic respiration is similar to the burning of fossil fuels. Oxygen is used and energy, carbon dioxide and water are produced. You saw energy released as heat when you burned a peanut. You also feel warm after you have eaten a heavy meal or been exercising.

On page 136, you found that the air you breathe out contained more carbon dioxide and water vapour than the air you breathe in. These gases come from respiration in the cells.

Quick check ☑

__________ occurs all the time to release energy from food. __________ respiration occurs without oxygen, and in muscles produces __________ and in __________ produces carbon dioxide and __________. Aerobic respiration is completed in the __________ and releases additional energy.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

respiration **anaerobic** **alcohol**
mitochondria **lactic acid** **yeast**

Photosynthesis and respiration

13.7 Plants in light and dark

Materials: boiling tubes, hydrogencarbonate indicator, pondweed, rubber bungs, marker, black cloth

Method

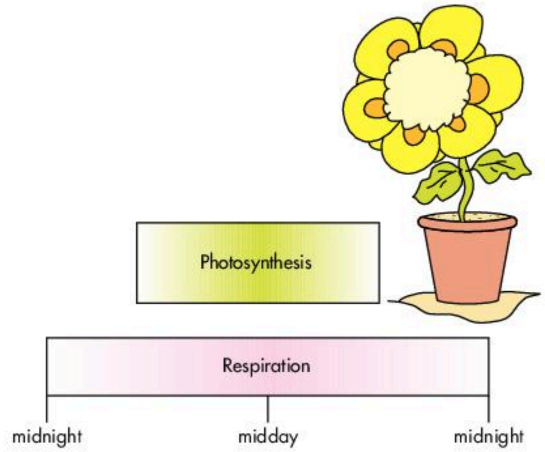
Set up boiling tubes with hydrogencarbonate indicator and record the colour. Add equal amounts of pondweed. Cover one test tube and leave the other uncovered side by side near a window for half to one hour. Record any colour changes.

Questions

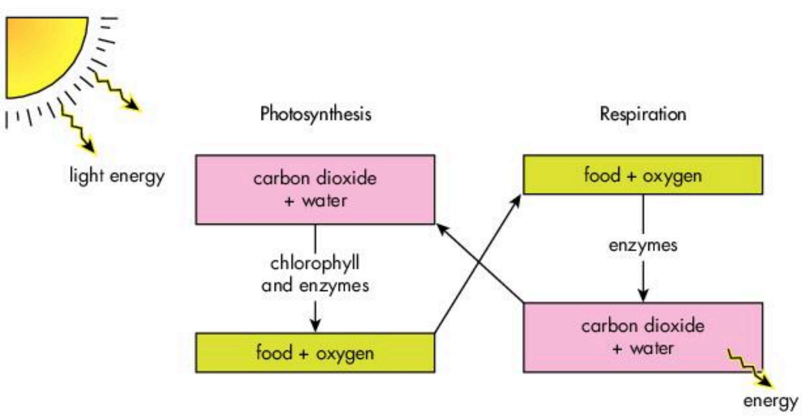
What happens in both tubes? Explain your results.

Objectives

- Investigate plants in the daytime and the night time.
- Compare photosynthesis and aerobic respiration.



	Photosynthesis	Respiration
Substances used	Carbon dioxide, water and energy	Food and oxygen
Substances produced	Food and oxygen	Carbon dioxide, water and energy
Organisms	Green plants	Plants and animals
When occurs	During the day	All the time
Energy	Energy needed	Energy released
Conditions needed	Chlorophyll and enzymes	Enzymes
Word equation	Carbon dioxide + Water + Light energy = Food + Oxygen	Food + Oxygen = Carbon dioxide + Water + energy



Plants in the daytime use more carbon dioxide in photosynthesis than they produce in respiration. So they take up carbon dioxide and release oxygen. **Plants at night time** are only carrying out respiration, so they take in oxygen and release carbon dioxide.

We can see that:

- The substances used in respiration (food and oxygen) are those produced in photosynthesis.
- The substances used in photosynthesis (carbon dioxide and water) are those produced in respiration.
- The two processes make a cycle for oxygen, carbon dioxide and water.
- The energy released in respiration is **not** recycled to be used in photosynthesis. Energy is used up along the food chains. A continual supply of light energy is needed for photosynthesis.

Quick check

__________ occurs only in the __________ time in green plants. It uses the Sun's __________. __________ occurs all the time. __________ and water are used in __________ and produced in __________. __________ and food are produced in __________ and used in __________.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

respiration **carbon dioxide** **day** **energy** **photosynthesis** **oxygen**

Questions

Answer these questions in your notebook

For questions **1–22** answer **A, B, C** or **D**.

1 Which of these is in the correct order?
A breathing, gas exchange, respiration
B respiration, breathing, gas exchange
C breathing, respiration, gas exchange
D gas exchange, breathing, respiration

2 The respiratory system consists of the
A trachea, bronchi and ribcage
B bronchi, ribcage and lungs
C trachea, bronchi, lungs, ribcage and diaphragm
D trachea, bronchi, lungs, ribcage, diaphragm and heart

3 Which of these is in the correct order of size (largest one first)
A trachea, bronchi alveoli, bronchioles
B trachea, bronchi, bronchioles, alveoli
C trachea, bronchioles, bronchi, alveoli
D bronchi, trachea, bronchioles, alveoli

4 Which of these happens in inhalation?
A the ribs move up and out
B the diaphragm goes down
C the volume in the chest cavity increases
D all of the above

5 Air is pushed out of the lungs because
A the volume of the lungs is increased
B the volume of the lungs is decreased
C the ribs move up and out
D more blood comes to the alveoli

6 What makes up the main part of the air we breathe in?
A oxygen **B** carbon dioxide
C noble gases **D** nitrogen

7 The volume of which of these is increased in the air we breathe out?
A oxygen **B** carbon dioxide
C noble gases **D** nitrogen

8 Which is true? Blood comes to the lungs
A de-oxygenated blood in the pulmonary artery
B de-oxygenated blood in the pulmonary vein
C oxygenated blood in the pulmonary artery
D oxygenated blood in the pulmonary vein

9 In the alveolus
A carbon dioxide diffuses into the pulmonary vein
B carbon dioxide diffuses out of the pulmonary vein
C oxygen diffuses into the pulmonary vein
D oxygen diffuse out of the pulmonary vein

10 Which of these carry out gas exchange
A flowering plants **B** amoeba
C fish **D** all of the above

11 A major cause of chronic respiratory diseases is
A cigarette smoking
B industrial pollution
C alcohol consumption
D heart disease

12 In Jamaica, who has more respiratory disease?
A females **B** males
C both the same **D** not possible to say

13 Which is NOT due to a micro-organism?
A bronchitis **B** pneumonia
C lung cancer **D** all of the above

14 Exercise can help to improve
A lung function **B** muscle strength
B heart function **D** all of the above

15 What happens to hydrogencarbonate indicator when the carbon dioxide concentration increases?
A changes from orange to red
B changes from yellow to orange/ red
C changes from orange/ red to yellow
D there is no colour change

16 What does a burning seed release?
A energy **B** carbon dioxide
C water **D** all of the above

17 Which of these is NOT a difference between aerobic and anaerobic respiration?
A food substance as a starting material
B amount of energy released
C substances produced
D place where it occurs

18 Aerobic respiration occurs in
A animal cells only
B animal and plant cells
C plant cells only
D the alveoli

19 For aerobic respiration which are important?
A cytoplasm **B** chloroplasts
C mitochondria **D** nuclei

20 Which of these is a difference between photosynthesis and respiration?
A raw materials **B** products
C where they occur **D** all of the above

21 What do plants release in the night time?
A oxygen **B** inhaled air
C carbon dioxide **D** all of the above

22 Which things produced in respiration are re-used in photosynthesis?
A carbon dioxide and water only
B carbon dioxide, water and energy
C oxygen and food
D oxygen, food and energy

Key ideas

- Movements of the ribs and diaphragm during inhalation and exhalation change the volume of the lungs so air is drawn in or pushed out.
- Inhaled air contains 21% oxygen and 0.03% of carbon dioxide, with less water vapour and cooler.
- Pulmonary artery contains de-oxygenated blood (less oxygen and more carbon dioxide).
- Gas exchange takes place in the alveoli. Oxygen diffuses into the blood, and carbon dioxide diffuses into the alveoli to be breathed out.
- Pulmonary vein contains oxygenated blood (more oxygen and less carbon dioxide).
- Exhaled air contains 17% oxygen and 4% carbon dioxide, with more water vapour and warmer.
- In plants, gas exchange occurs via the stomata, and the gases diffuse to and from the cells.
- Fish, for example, have gills for gas exchange.
- Many respiratory diseases have cigarette smoking as a main risk factor.
- Oxygen and sugars go to the cells in the blood.
- Aerobic respiration occurs mainly in mitochondria and produces energy, carbon dioxide and water.
- Anaerobic respiration occurs without oxygen e.g. in muscles and yeast and produces much less energy,
- Oxygen and food produced in photosynthesis are used as raw materials in respiration.
- Carbon dioxide and water released in respiration are used as raw materials in photosynthesis.
- Energy is not recycled. It is used up along the food chain. More sunlight is needed for photosynthesis

▶ **See Workbook Gas exchange and respiration.**

For questions **23–34** write full answers in your notebook.

23 Name in order all the structures that air passes through as it leaves an alveolus until it is breathed out though the mouth.

24 Explain the process of (a) inhalation and (b) exhalation.

25 (a) State one difference between inhaled and exhaled air, (b) how it is caused, (c) how you would show it occurs.

26 Explain the difference between breathing, gas exchange and respiration.

27 Draw a diagram of an alveolus and its blood supply. Explain what happens including the words: pulmonary artery and vein, oxygenated and de-oxygenated blood, concentration gradients, oxygen and carbon dioxide.

28 How can smoking affect the respiratory system?

29 How do (a) flowering plants, (b) amoeba and (c) fish exchange gases?

30 Describe an experiment with plants to show that respiration had occurred.

31 (a) Why is respiration so important? (b) Write a word equation for aerobic respiration.

32 Prepare a table to compare aerobic and anerobic respiration.

33 Prepare a table to compare photosynthesis and aerobic respiration.

34 Draw a diagram to show the linkage between photosynthesis and aerobic respiration.

Problems

Work in groups:

1 Refer to the table on page 138 and consider the data on chronic respiratory diseases in Jamaica. Explain what is meant by the following:
(a) Mortality rate per 100 000
(b) Change 1990–2013 (for males) of + 20%
(c) Change 1990–2013 (for females) of – 29%
Discuss:
(a) what might have caused the differences.
(b) how past behaviour with regard to smoking may have contributed to the results.
(c) why the figures for males are worse than for females, and worse than other Caribbean islands.
Discuss, plan and design a poster or leaflet that would appeal to young males and discourage them from cigarette smoking.

2 Discuss and research the benefits of any exercise that can help to increase our fitness. Which organs of the body can be improved by exercise? **ICT**
Carry out research on aerobic or cardio exercise, regarding what it is, how it differs from other exercise, some examples of it and possible benefits.
(a) Record your findings in a report.
(b) List recommended exercises with the number of calories that are used for each one.
(c) Discuss, plan and design a poster or leaflet that would appeal to (a) females and (b) males to encourage them to increase cardio exercises.

Unit 14

Space science

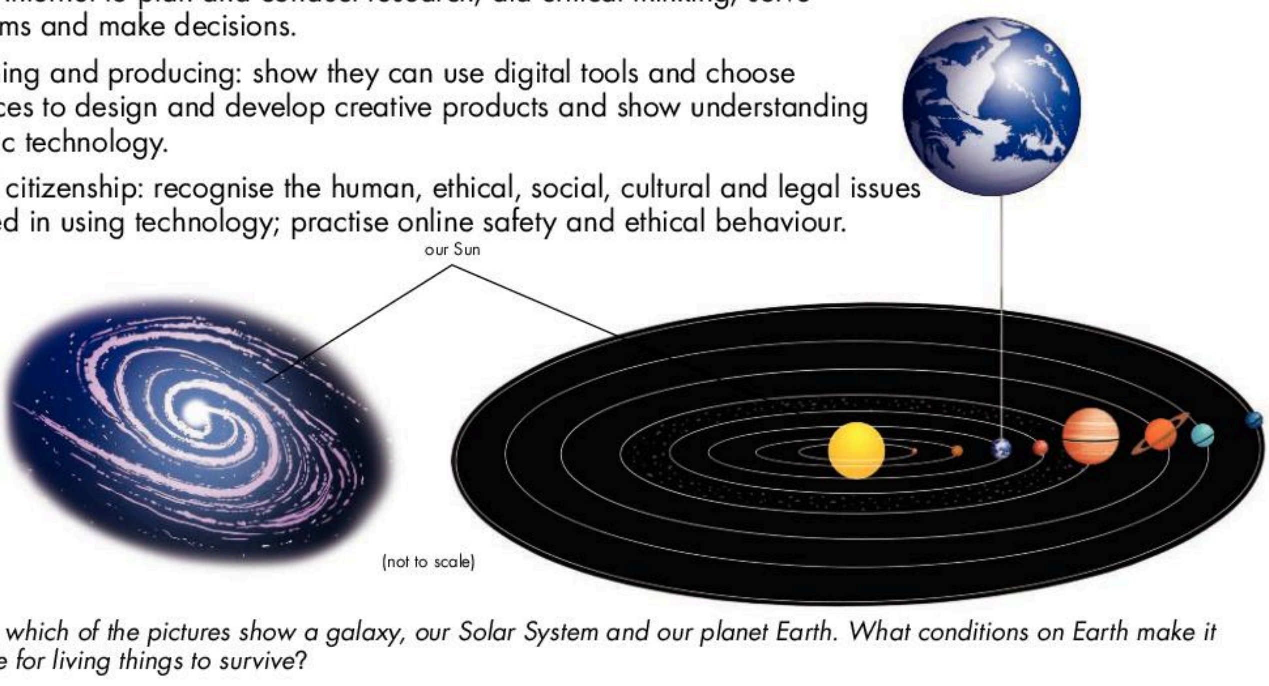
1 The astronaut is floating in space high above the Earth. What changes in clothing and training does an astronaut need?

This unit will help you to:

- appreciate the place of the Earth in our Solar System and galaxy and in the Universe and the importance of motion and gravity
- appreciate the vast distances and how we use light-years to measure them
- distinguish the characteristics of various bodies in space
- describe bodies in our Solar System and make models of the planets
- distinguish and make models of lunar and solar eclipses
- appreciate the problems and challenges of exploring space
- make models of tools and equipment used in exploring space.

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.



2 Identify which of the pictures show a galaxy, our Solar System and our planet Earth. What conditions on Earth make it possible for living things to survive?

Overview of the Universe

The Universe contains all the matter and energy that exist. The study of the Universe is called Astronomy. Within the Universe there are more than 100 billion galaxies. The galaxies themselves each contain billions of stars. The galaxy to which our own star, the Sun, belongs is called the Milky Way galaxy. It is like an enormous spinning spiral, and it contains about 300 billion stars. The Sun travels round the galaxy at 900 000 km/h, taking all its planets, including Earth, along with it.

Stars, such as our Sun, consist of glowing gases. Within the core, hydrogen atoms are crushed together in a nuclear reaction. This forms helium gas and very large amounts of energy as intense heat and light that are radiated into space. The Sun has enough hydrogen fuel for another 5 billion years.

It is only stars that produce light and that has to travel across space for us to see it. We can develop telescopes to help us, but some stars are so far away that it will take billions of years for us to see their light and it will be extremely faint. So we can never hope to see all the stars.

14.1 Luminous and non-luminous objects

We cannot see anything if it is completely dark; we need light to see. Objects that provide light are called luminous; those that we can only see when light is reflected from them are called non-luminous.

1 Look around you inside and outside the classroom. List objects that make their own light. You can include matches that are lit and things that use electricity to make light when switched on.
2 List ten non-luminous items. How do we see them (a) in the daytime and (b) at night?
3 How do we see (a) the Sun and (b) the Moon? Why do you think the Moon seems to change its shape?

14.2 Distance and brightness

Materials: three candles on dishes (or flashlights), matches
Do this activity outside in groups of four.

1 One student is the observer, and stays still. The other students should light their candles (or put on their flashlights) and walk away from the observer for different distances, e.g. five paces, ten paces and fifteen paces.
2 The observer has to see at which distance the source of light seems to be the largest and brightest.
3 Discuss how this relates to the apparent size and brightness of the Sun compared to other stars in the sky and why we cannot see stars that are in the sky.
4 Why do we not see stars in the daytime?

Objectives

- State that the Universe contains billions of galaxies and each contains billions of stars.
- Distinguish amongst stars, planets and natural satellites.
- Identify some constellations.
- Calculate distances in light-years.

The Milky Way galaxy, in which our Sun and Solar System are found

Fun facts

- The Sun is 100 times the diameter of Earth, and over 300 000 times its mass.
- The Sun is powered by nuclear fusion, with a surface temperature of 6000 °C and internal temperature of 15 million °C.
- The Sun's energy, every second, could supply the world's energy needs for millions of years.

Streetlights: notice how the more distant lights appear to be smaller and less bright

Describing long distances

The distances in space are difficult for us to appreciate. There are two things we can do:

- compare the distances to other distances so we get some idea of scale, and
- use the way of describing numbers called 'standard form' that mathematicians and scientists use.

Standard form

A number is written with two parts: a numeral between 1 and 10, multiplied by a power of 10:

- For large numbers, the powers of 10 are positive, e.g. $4.3 \times 10^{10} = 43\,000\,000\,000$
- For small numbers, the powers of 10 are negative, e.g. $0.00067 = 6.7 \times 10^{-4}$

To do calculations:

- To add and subtract, change to ordinary numbers, do the calculation, and then change back to standard form.
- To multiply or divide, work with the two parts separately:
  – to multiply, add the powers together, e.g.
  $(4.2 \times 10^7) \times (3 \times 10^8) = (4.2 \times 3) \times (10^7 \times 10^8) = 12.6 \times 10^{15}$, then this in standard form is 1.26×10^{16}
  – to divide, subtract the powers, e.g.
  $(4.2 \times 10^7) \div (3 \times 10^8) = 1.4 \times 10^{-1}$

Making comparisons

When describing the distance of stars away from the Earth, astronomers often use **light-years**. Light travels so fast it can go several times round the Earth in one second! In one year, light travels about 9.5 million million km (or 9.5 trillion km), so a light year = 9 500 000 000 000 km = 9.5×10^{12} km.

We can then work out how far, in light-years, various bodies are from the Earth.

An example

Apart from the Sun, our closest star is Proxima Centauri which is 40 trillion km away = 40 000 000 000 000 = 4×10^{13} km in standard form. To get the number of light-years we divide this by 9.5×10^{12} km.

$(4.0 \times 10^{13}) \div (9.5 \times 10^{12})$

$= 0.42 \times 10^1 = 4.2$ light years

14.3 Student-minutes

To help you understand 'light-years' as a measurement of distance you can do this activity to find 'student-minutes'.

1 Set up a marked distance of 10 metres. Record how far a student can walk in one minute (to the nearest metre). You should find the average of three separate walks.
2 How far (in m) is a student-minute?
3 How far would (a) 10 and (b) 10^{12} student-minutes be?

Fun facts

- The observable Universe has more than 100 billion galaxies.
- Astronomers calculate there may be 70 billion trillion stars (7×10^{22}).
- On a dark night with no light pollution, the naked eye could see 4 500 stars but it would be impossible to count them.

Distances in space

- Our Milky Way galaxy is about a million light-years wide. So light would take 100 000 years to cross from one side to the other – travelling at 9.5×10^{12} km each year.
- Light from our Sun only takes about 8 minutes to reach Earth, and from the next nearest star about four years.
- When we look at stars in the sky, the light we see now left the stars a very. very long time ago. We cannot see some stars because their light has not yet reached us or it is too dim.

Calculating light-years

The table below gives the distances in km of some stars in the Milky Way from Earth. Work out how far away they each are in light-years. Show your working.

Star	Distance in km
(a) Alpha Centauri	41.3 trillion km
(b) Sirius	81.5 trillion km
(c) Vegas	2.4×10^{14} km
(d) Polaris	4.1×10^{15} km
(e) Betelgeuse	6×10^{15} km

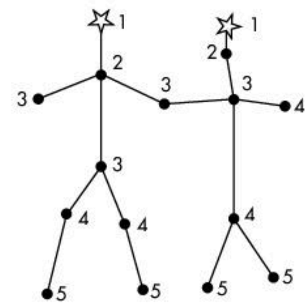
Questions

1 In what ways are student-minutes (a) similar and (b) different to light-years?
2 The Sun is about 150 million km (150 000 000 = 1.5×10^8 km) from Earth. How many light-years is this in standard form?
3 Voyager 1 has a velocity of 60 000 km/hr. How long would it take to get from Earth to Proxima Centauri?

Patterns of stars

If you look up at the night sky you will see very many twinkling stars. At first they seem to be scattered, without any patterns. But from the times of ancient stargazers, called **astronomers**, patterns of stars have been noticed in the sky. These are called **constellations**. The stars that make up the constellations are all moving, and so the patterns change very, very slowly. Some patterns can be identified and many of them have been given names. You can find out the legends associated with the constellations. **ICT**

Figure **(a)** on the right shows the constellation called the twins, or Gemini. The heads are made of two bright stars.



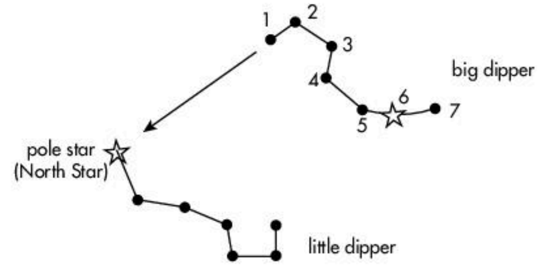
(a) The constellation called Gemini

14.4 Looking for constellations

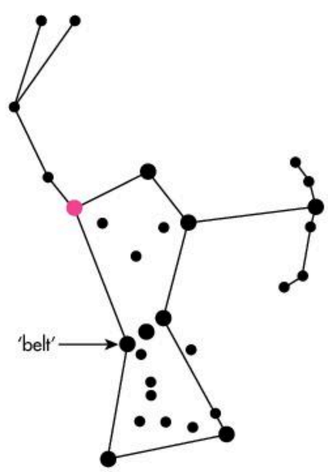
Method

You will need to do this activity at night.

1. Choose a place where there are not too many lights. On a clear, dark night look towards the north above the horizon.
2. You should see seven stars making an upside-down dipper. (A 'dipper' is a deep serving spoon.) Four of them make the bowl of the spoon and three make the handle. Two stars in the bowl point towards a bright star called the pole star or North Star. The pole star is the end of the handle of the smaller (little) dipper. See figure **(b)**.
3. Also look for Orion **(c)**. The three stars that make up his belt can be seen, and also the bright red star on the left.



(b) Two stars in the big dipper point towards the pole star



(c) The constellation called Orion, the hunter: look for the three stars in his belt

What's what in the night sky?

The Moon This orbits the Earth. It does not make light. It seems large because it is relatively close. At different times of the month it reflects different amounts of sunlight. This is why it appears to change shape: the **phases** of the moon.

The stars Made of burning gases. They are so far away that their light is dispersed by the atmosphere. This is why stars 'twinkle'. Check in books or with the Astronomical Association to find star maps for the constellations for each month.

The planets They do not make light. They reflect sunlight. Venus appears as a bright white ball in early morning and early evening. Mars may be seen as a reddish orange ball. The planets were called 'wanderers' as they change their position in the sky against the background of the stars.

Meteors They are sometimes called 'shooting stars'. They are seen as bright, very fast moving lights. They show the path of a meteoroid (a piece of rock from space) being burned up in our atmosphere.

Questions

1. From largest to smallest what is the correct order: galaxy, moon, star, solar system, constellation, Universe, planet.
2. The Sun is only a medium sized star, so why does it look so big?
3. Why don't we see stars during the daytime?
4. Even with the most powerful telescopes, why will we never see some of the stars?

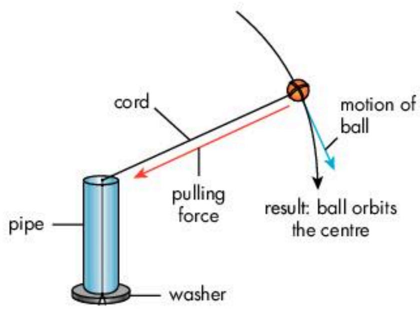
14.5 Investigating orbits

Materials: foam ball with a hole through the centre, a plastic tube, e.g. 1-inch PVC pipe, cord or string, washer

Method

Work in groups:

1 Tie one end of the cord to the washer Pass the other end through the plastic tube and tie the ball securely to it.
2 Now, holding the piece of pipe securely, spin it around in a circle.
3 Take turns spinning the ball and record your observations.



Arrangement for spinning the ball

Questions

1 What stops the ball from flying off when spun around?
2 What happens as you slow the speed at which the ball is traveling around you?
3 Compare the model satellite to the Earth orbiting the Sun.
4 What other movements does the Earth make as it orbits the Sun that give us day and night?
5 What keeps the Earth and other planets from flying off into space?
6 How are both motion and gravity important in keeping the Moon orbiting the Earth, and the Earth and other planets orbiting the Sun?
ICT
7 Watch a video or research the importance and meaning of gravity in the Universe and then write your report.

▸ **See Workbook Overview of the Universe.**

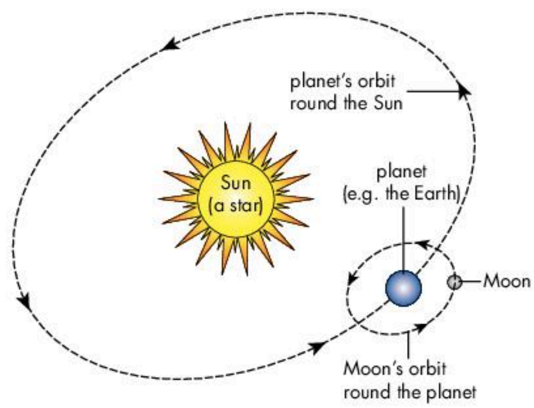
What does it mean?

Stars: Only these make light from nuclear reactions.

Planets: Are much smaller than stars and dark. We only see them as they reflect light. They travel around (orbit) the Sun.

Natural satellites: Are smaller bodies, called moons that orbit planets. The Earth's Moon travels anti-clockwise once around Earth about every month. Most of the planets in our Solar System have moons.

Artificial satellites: Instruments such as weather satellites put by humans in orbit around plantes and moons.



The Moon orbits the Earth, and the Earth orbits the Sun

KWL

In your group set up a KWL chart for our Solar System: What you know and what you want to learn.
Discuss what you know and record it. Then you can research on the Internet and other sources to find answers to what you want to learn.
ICT

Quick check ☑

The Universe contains billions of ________ , each one containing billions of ________ . Only the ________ produce light. The ________ can be seen in groups called ________ . Distances in space are measured in ________ . ________ can ________ a star, and many of these may have ________ that ________ them.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

light-years **natural satellites** **galaxies** **planets** **stars** **orbit** **constellations**

Our Solar System

Our Solar System consists of the **Sun** at the centre, and eight orbiting **planets:** Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Pluto was listed as a planet, but has been renamed a **dwarf planet**. Make a memory aid to remember the planets: M, V, E, M, J, S, U, N, e.g. Many value early morning joggig, some until nightfall.

Asteroids are mainly found in the 'asteroid belt' between Mars and Jupiter. They are lumps of rock orbiting the Sun. They range in size from a few metres to about 1000 km. Ceres, the largest asteroid, contains one-third of the total mass of asteroids. It has been renamed as a dwarf planet.

Comets are large lumps of ice, frozen gas and dust that orbit the Sun in elliptical paths (an ellipse is a squashed oval). They travel very fast when they are close to the Sun and have a long tail where the comet's ice and dust change to gas.

Meteoroids are pieces of rock travelling through space. They vary from specks of dust to large rocks weighing several tonnes. If they are caught by Earth's gravity, they heat up and begin to glow: they are seen as **meteors**. Any meteoroids that survive and hit the ground are called **meteorites**.

What holds the Solar System together?

Why do the planets keep orbiting the Sun? The same reason we do not fall off the surface of the Earth: bodies attract each other with a force that is called the **force of gravity**.

Large bodies, like the Sun, have a very strong force of gravity; and the closer a planet is to the Sun the greater is that force. The forward movement of the planets could take them off into space, but they are pulled back by the force of gravity and the result is that they continue in their orbits. In a similar way, the force of gravity of the Earth keeps our Moon in orbit around us. Our Solar system orbits round our galaxy. The galaxies are also moving apart but also attract each other by gravity.

14.6 Planets

1 How can you explain the different velocities of the planets in our Solar System?

Planet	Velocity in orbit (km/s)	Planet	Velocity in orbit (km/s)
Mercury	48	Jupiter	13
Venus	38	Saturn	10
Earth	30	Uranus	7
Mars	24	Neptune	5.5

2 Earth takes one year to orbit the Sun. How long do you think Mercury and Venus take? And how long do all the other planets take compared to Earth?

Objectives

- List the planets in the order in which they orbit the Sun.
- Describe the importance of gravity and distinguish mass and weight.
- List and compare the major characteristics of the planets.
- Make models of our Solar System using appropriate scales.

Questions

1 How are the Solar System in which we live, a star and a galaxy linked?
2 Imagine you were able to travel through the Solar System. Write a story about some of the things you would see and some problems you might have.
3 Write down the complete address of your school, ending with 'The known Universe'.
4 What are some problems in trying to find out about our Solar System?

This is a model of a robotic lander developed by the European Space Agency to explore Mars

Mass and weight

The Sun contains over 99% of the mass of the Solar System. It therefore exerts a very strong force of gravity to keep the planets in their orbits.

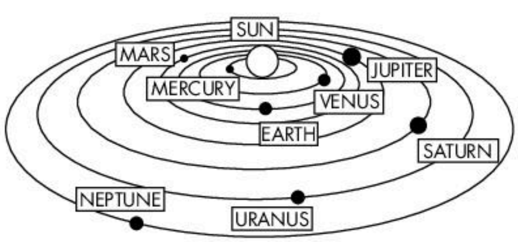
Every object on Earth is attracted by the Earth's force of gravity. The more substance or **mass** in an object, the more strongly it is attracted. This force of attraction is measured in newton (N).

On Earth it is found that a mass of 100 g is attracted by a force of gravity of about 1 N. This is its **weight**.

14.7 Modelling the Solar System

Materials: names of the planets, chalk
Method
Do this activity outside in the yard.

1 One student stands still in the middle of the space available, to represent the Sun.
2 Eight students take the names of the planets, and each one (except for Mercury and Venus) must choose another student to be one of their 'moons'.
3 Now the planets and moons should spread themselves out in a line, with Mercury closest and Neptune furthest away from the Sun. The rest of the class can be asteroids in orbit between Mars and Jupiter.
4 Each Moon walks anticlockwise around its planet. At the same time each planet walks anticlockwise around the Sun along a chalk line that shows their 'orbit'.
5 Make sure the planets stay in their right orbits (so, for example, the Earth and its moon should always be between Venus and Mars).
6 Which of the planets returns to its starting position first? Earth takes one year to orbit the Sun. Which planets do you think take (a) less than a year and (b) more than a year to orbit the Sun?
7 The Sun is extremely hot. Which of the planets would you expect to be (a) warmer and (b) cooler than Earth?



Questions

1 How do the following compare: an asteroid, a dwarf planet and a planet?
2 Distinguish between a comet, asteroid meteor, meteoroid and meteorite.

What does it mean?

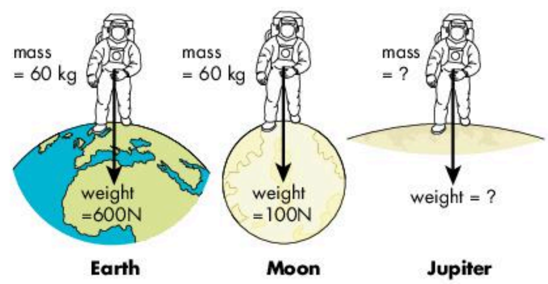
Mass: This is the amount of substance in an object. It is measured in grams (g). It does not vary.

Weight: This is the force with which an object is attracted by gravity. It is measured in newton (N). It can vary from place to place.

Travelling in space

The amount of substance in an object remains the same wherever the object is. Its mass is constant. For example an astronaut of mass of 60 kg would have that same mass whether he was on the Earth, the Moon or Jupiter.

But the Earth, the Moon and Jupiter are very different in size and they have different forces of gravity. The force of gravity on the Moon is only one sixth that on Earth. So the astronaut's weight on the Moon would be one sixth that on Earth. Mass and weight are compared below.



The force of gravity on Jupiter is about 2.5 times that on Earth. What would be the mass and weight of the astronaut on Jupiter?

Students, representing the planets, can walk in anticlockwise orbits around the Sun

▶ **See Workbook Our Solar System.**

Fact file for the planets

Apart from Earth, all the planets are named after Roman and Greek gods. The planets fall into two groups.

The four inner planets are all fairly small and made of rock.

Mercury

This planet is closest to the Sun and travels the fastest. It was therefore named after Mercury, the messenger of the gods.

- Distance from the Sun: 58 million km (0.38 AU (Astronomical units)).
- Diameter: 4880 km (less than half that of Earth). There are no moons.
- Orbits the Sun in 88 days (so it has a very short 'year' compared to Earth).
- Spins once in 58 days, so a Mercury 'day' is very long.
- Atmosphere and temperature: As it has almost no atmosphere to protect it, Mercury is very hot in the 'day' (465 °C) and very cold at night (–184 °C).

It is a small, rocky planet with no air or water. It has a thick core of iron and a thin crust. It looks a lot like our moon, with lots of craters. It was photographed by a space probe, Mariner 10, in 1974 and 1975. A space probe, Messenger, was sent by NASA in 2004 and orbits Mercury from 2011, after several flybys.

Venus

This planet looks bright and beautiful. It was named after Venus, the goddess of beauty.

- Distance from the Sun: 108 million km (0.72 AU). It is our nearest planet, but impossible for life. After the Sun and Moon it is the brightest object in the sky.
- Diameter: 12 104 km (very similar to that of Earth). There are no moons.
- Orbits the Sun in 225 days (which is about two-thirds of an Earth 'year')
- Spins once in 243 days, so the Venus 'day' is by far the longest in the Solar System.
- Atmosphere and temperature: There is a thick cloud of carbon dioxide, nitrogen and sulphuric acid. The clouds trap the Sun's heat to raise the temperature to 449 °C.

Venus is covered by hundreds and thousands of volcanoes. The first space probe was Mariner 2 in 1962. Since then there have been over 20 more, including the Soviet's Venera 7, which was the first one to land on a planet, and the European Space Agency's Venus Express, orbiting since 2006.

Earth

It was not until the sixteenth century that it was understood the Earth is just a planet.

- Distance from the Sun: 149.6 million km. This distance is one astronomical unit (AU).
- Diameter: 12 756 km (the largest inner planet, and the fifth largest overall).
- Orbits the Sun in 365 and a quarter days (this is why we have a 'leap year' every 4 years).
- Spins once in 24 hours (our Earth day).
- Atmosphere and temperature: Nitrogen, oxygen, argon and carbon dioxide. The average temperature is 14 °C. These conditions are suitable for life.

The Earth has one natural satellite, our Moon. Unlike the other inner planets, the Earth's crust is divided into separate plates that can move and give rise to earthquakes and volcanoes.

Mars

This planet looks red in the sky: the colour of blood. It is named after Mars, the god of war.

- Distance from the Sun: 228 million km (1.52 AU).
- Diameter: 6794 km (about half that of the Earth). There are two moons.
- Orbits the Sun in 687 days.
- Spins once in 24 and a half hours (so it is similar to our Earth day).
- Atmosphere and temperature: There is a thin atmosphere of carbon dioxide, nitrogen and argon. The rest has disappeared because of the planet's weak gravity. The average temperature is about –55 °C, but it can vary from a high of 27 °C to a low of –133 °C.

Mars has much higher mountains and deeper canyons than on Earth: it has the largest mountain in the Solar System. The first space probe was Mariner 4 in 1965. Since then there have been several more orbits, and landings since 1976, including the Mars Rover in 2011. Several Mars orbiters are in operation.

The four outer planets are all large, cold gas giants. They all travel slower but spin more quickly than the inner planets. They all have rings and many moons.	
Jupiter 	This is the largest planet. It was named after Jupiter, the king of the gods. • Distance from the Sun: 778 million km (5.2 AU). • Diameter: 142 984 km. It is visible for many months in the year. • Orbits the Sun in 11.9 years (nearly 12 times as long as Earth). • Spins once in 9.8 hours. It is the largest planet and it spins the quickest. • Atmosphere and temperature: The atmosphere is mainly of hydrogen and helium. The average temperature is –153 °C. • The planet has no solid surface. The pressure of the atmosphere means it gradually becomes a liquid, and further in it becomes solid. It has a giant red spot showing a raging storm. • Jupiter was first orbited by Pioneer 10 in 1973. The Voyager 1 and 2 probes, launched in 1977, flew by all of the gas planets. It has a faint system of rings, and at least 69 moons (51 of them with names).
Saturn 	This planet was named after Saturn, the god of agriculture. • Distance from the Sun: 1429 million km (9.54 AU). The main feature is its amazing rings made of bands of dust and ice. • Diameter: 120 536 km (roughly 10 times that of Earth). • Orbits the Sun in 29.5 years and spins once in 10.2 hours. • Atmosphere and temperature: Like Jupiter it is about 75% hydrogen and 25% helium and has no solid surface. The average temperature is –184 °C. • Saturn was first orbited by Pioneer 11 in 1979. The probe, Cassini, the size of a bus, was launched in 1997 and spent 13 years orbiting Saturn. Saturn has at least 62 moons.
Uranus 	It was named after the ancient Greek god of the heavens. • Distance from the Sun: 2870 million km (19.2 AU). • Diameter: 51 118 km (four times that of Earth). • Orbits the Sun in 84 years. • Spins once in 17 hours, but is unusual in that it lies on its side. • Atmosphere and temperature: Hydrogen, helium and methane. The maximum temperature is –184 °C. • It has a surface soup of water and other chemicals, and perhaps a small solid rock core. So far, the only space probe was Voyager 2 in 1986, which photographed the thin rings. It has at least 27 moons.
Neptune 	It was named after Neptune, the god of water. • Distance from the Sun: 4504 million km (30 AU). • Diameter: 49 532 km (a similar size to Uranus). • Orbits the Sun in 165 years. • Spins once in 19 hours and has the fastest winds in the Solar System • Atmosphere and temperature: Neptune is blue, like Uranus, because of methane clouds; it also contains hydrogen and helium. The average temperature is –223 °C. • There may be a small, solid rock core surrounded by liquids. It has a giant storm. The only space probe so far was Voyager 2 in 1989. Titon, the largest of its 14 moons is the coldest place in the Solar System, as low as –235 °C.

Movements of the Earth and the Moon

You will work in groups to make models of how the Earth and Moon move in relation to the Sun. You need to work in a dark area, e.g. set up your models inside a large box or under a table with a cloth laid over it.

You need a strong flashlight to represent light from the Sun, a football (Earth) and tennis ball (Moon), or a grapefruit (Earth) and lime (Moon).

PS 14.8 Modelling movements

Method

Day and night

At any time during the Earth's 24-hour 'day', half the world has light (daytime) and half is dark (night time). Why?

1 Mark the large ball (Earth) with N (North pole) and S (South pole) and a ring round the centre for the equator. Mark an X for the Caribbean.
2 Turn on the flashlight and tilt the ball a little towards it. Notice the light and dark areas. Turn the ball in an anticlockwise direction to show day and night **(a)** in the Caribbean.

Phases of the Moon

During the 28 days of the lunar month, a different amount of the Sun's light is reflected from the Moon to Earth. The Moon seems to change shape: these are the phases of the Moon.

3 Set up the large ball as before, but also hold up the small ball (Moon) so the flashlight shines on it.
4 Move the small ball around the large one and look from the large ball towards the small one to see how the amount of light that ii seen can change **(b)**.

Every month the Moon passes between the Sun and the Earth, but only sometimes are they directly in line so that the Sun's light can be blocked. We describe things related to the Sun as 'solar', and those related to the Moon as 'lunar'.

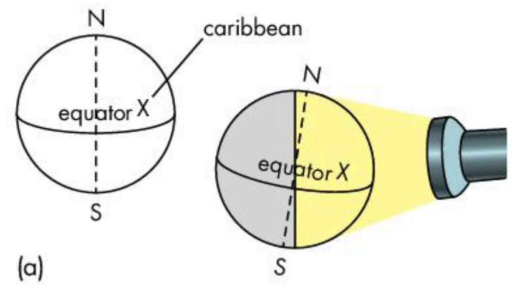
Solar eclipse

5 Place the large ball at a fixed distance in front of the flashlight. Now bring the small ball between them and record what you see.
6 Look from the 'Earth' towards the 'Sun'. What do you observe? **(c)** This is a solar eclipse.

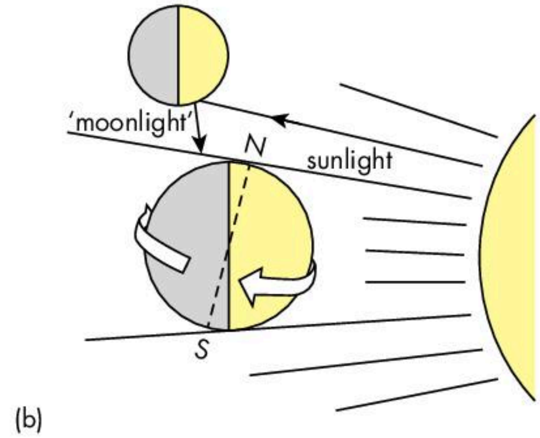
Lunar eclipse

7 Now place the small ball at a fixed distance in front of the flashlight. Bring the large ball between them and record what you see.
8 Look from the 'Earth' towards the 'Moon'. What do you observe? **(d)** This is a lunar eclipse.

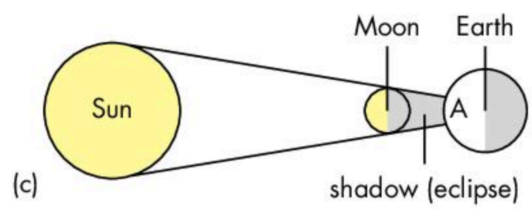
Write up all your observations and explain the results of the various movements.



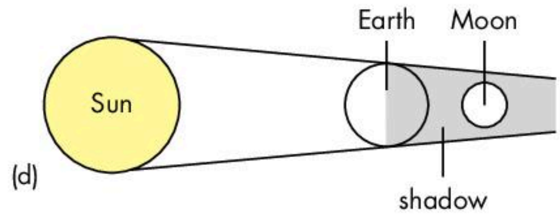
Only half the Earth is lit up at any time



As the Moon orbits the Earth we see different parts that were lit by the Sun



At place A on Earth, the Sun cannot be seen. This is a solar eclipse.

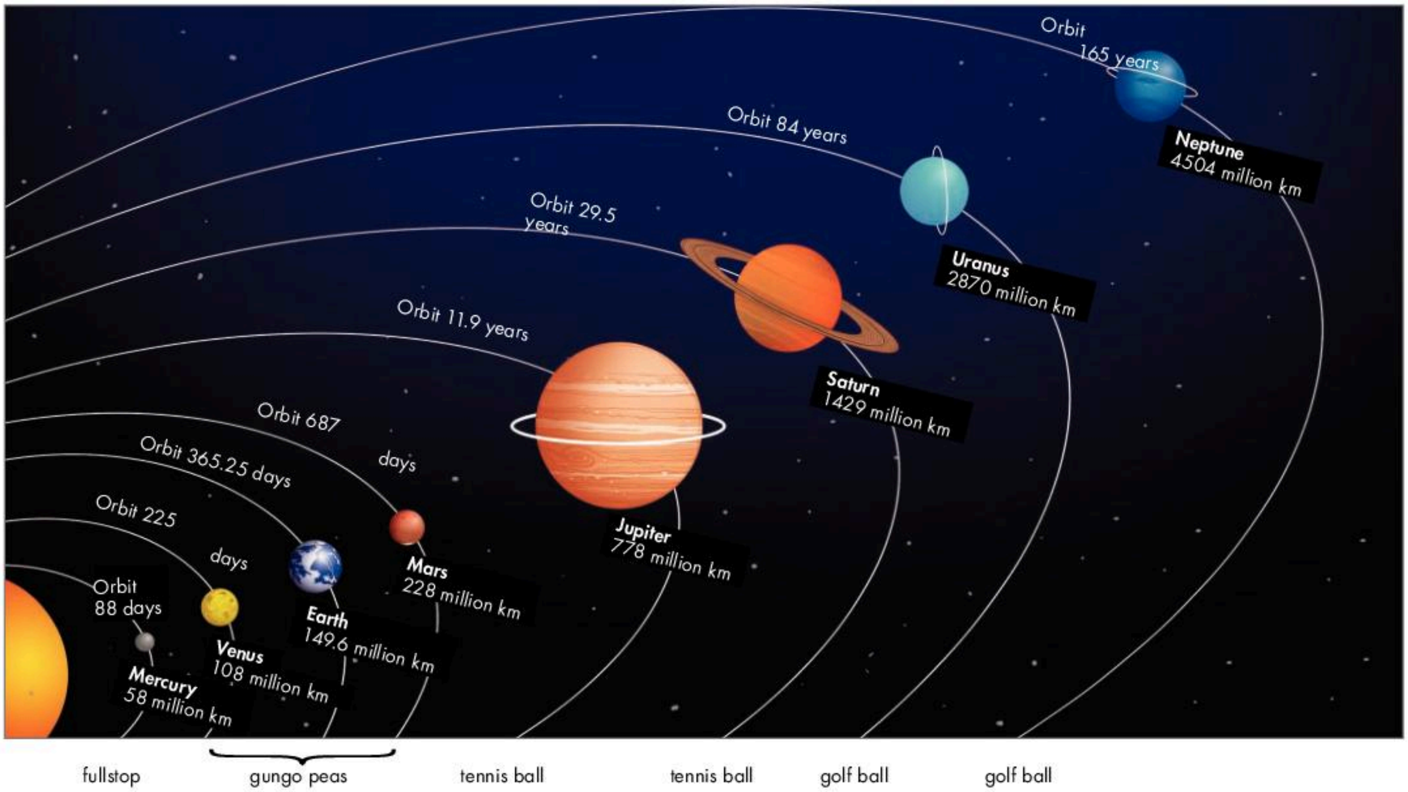


The Moon travels into the shadow cast by the Earth. This is a lunar eclipse.

What does it mean?

Solar eclipse: The Sun's light is blocked by the Moon from reaching Earth. The Moon is between the Sun and the Earth.

Lunar eclipse: The Moon is in shadow. The Earth blocks light from the Sun from shining on the Moon.



The planets of our solar system showing their diameters and the times they take to orbit the Sun. Beneath each planet is the name of an object that describes roughly how large the planet is compared to the Sun as a large beach ball.

Is there life elsewhere in the Universe?

We do not know. The other planets in our Solar System could not have living things like on Earth because they are too hot or too cold, do not have oxygen or liquid water, have poisonous gases or atmospheres with too much pressure. But some of their moons might be a possibility.

So far, astronomers have found over 500 stars in our galaxy with solar systems. There is a certain distance from a star where water is liquid, and this is one place where life could develop.

Astronomers have begun listening for possible radio messages from space, but nothing has been heard so far. In 1974 a radio message was sent from Earth towards a certain constellation. But if there is anyone there and they replied straight away, our descendants would not get their message until nearly 50000 years from now!

Questions

1 What have you learned about our Solar System? Complete your KWL chart.
2 On pages 152–3 the distances of planets from the Sun are listed using AU (astronomical units). (a) What are they and how long is one? (b) How are they different from light-years?
3 What is the relationship between mass, weight and the size of a planet?
4 Name a planet that
   (a) orbits in less than an Earth year
   (b) is nearest to the Earth
   (c) travels most slowly
   (d) has the longest 'year'.

Quick check ☑

The largest planet in our Solar System is ________ and the smallest is ________ . ________ and ________ keep the Solar System together. In a ________ eclipse the Moon is between the Sun and the Earth; when the ________ is in shadow it is a ________ eclipse.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

gravity **Jupiter** **motion** **solar** **Mercury** **Moon** **lunar**

Space exploration

We use telescopes and weather stations on Earth to explore space, but we get better data if we put these in orbit around the Earth as **artificial satellites**. We also send unmanned **probes** and manned **spacecraft** into space. These contain instruments, e.g. gyroscopes and cameras for controlling and detecting conditions in space. There are also robot landers and rovers that are sent to collect samples from other planets.

How are space vehicles launched?

If we throw a ball up into the sky, it falls down. An object must travel very quickly to counter-balance the force of gravity. Rockets are used that can travel very, very fast to launch artificial satellites, and space probes and spacecraft.

- A rocket can launch a satellite or space shuttle into orbit **(a)**.
- The rocket has to travel even faster **(escape velocity)** to launch space probes to the planets, and spacecraft to the Moon **(b)**. The space probes and craft will continue to travel until the force of gravity of another body attracts them.

Artificial satellites

There have been over 8000 man-made satellites launched from Earth. Research the problems faced in getting artificial satellites into orbit and keeping them there. What happens when the satellites slow down? What can be done about 'space junk' left in orbit? ICT

All artificial satellites have common features:

- Outer case: for protection of the other parts.
- Payload/cargo: the reason for the satellite, e.g. satellite dish, cameras or sensors for X-rays and infrared rays.
- Direction finders: to keep the satellite on the right path.
- Data control: to keep a communication link with Earth.
- Power: mainly produced by panels of solar cells.
- Temperature control: to regulate the temperature.

There are three main uses for satellites:

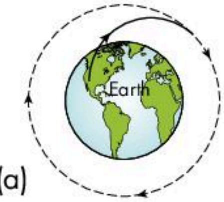
Communications satellites collect signals from one part of the world and send them to another. They transmit phone calls and TV programmes. They are often in **geostationary orbit**. This means that they travel at a speed (11 000 km/h) that keeps them above the same place on the Earth's surface.

Observation satellites study land, sea and space. They collect information for scientific research (for example to identify oil resources), and for weather forecasting and spying. They can also be space telescopes, looking away from the Earth and using heat sensors (infra-red cameras). The telescopes get a clearer view above the atmosphere.

Navigation satellites, such as the Global Positioning System (GPS). This is used by people such as airline pilots, sea captains and car drivers to work out where they are.

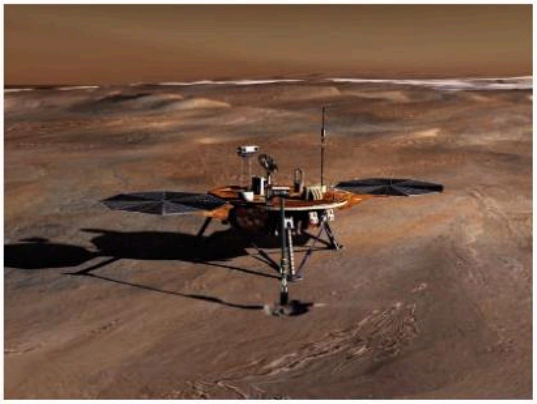
Objectives

- Recognise the importance of rockets in launching space vehicles.
- Investigate and make models of tools and equipment for space exploration.
- Discuss the requirements for life that must be provided for humans in space.



(a) A rocket is used to launch a satellite. The rocket has to travel at about 28 000 km per hour to launch it. This speed is sufficient for the satellite to get into orbit.

(b) A rocket is used to launch a spacecraft. The rocket has to travel at over 40 000 km per hour to launch it. This spacecraft will then escape the Earth's force of gravity.

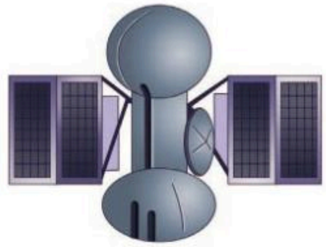


This Mars lander collected rocks from Mars in 2008

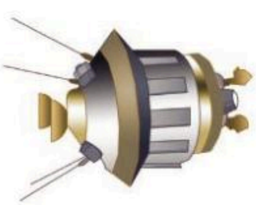
14.9 Space science

1. Research what is meant by 'Space science'. ICT
2. Describe, with pictures or photos, one use of an artificial satellite in orbit around Earth.
3. Describe, with details, the dates and journey of a named space probe.
4. List and describe five tools or equipment used by space vehicles.

Hubble Space Telescope launched in 1990 by NASA. It sweeps around Earth every 97 minutes. May be in orbit until 2020.

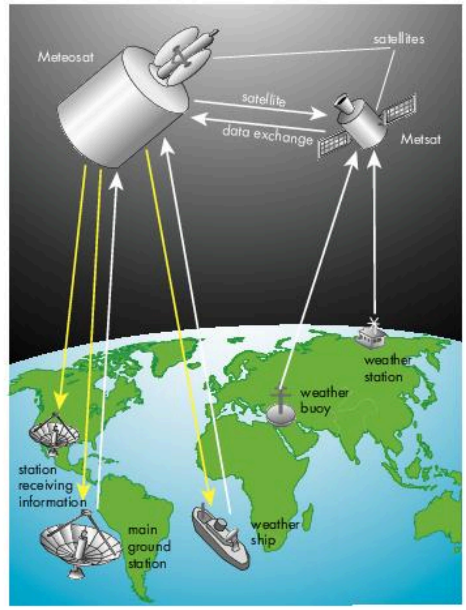


Soviet Venera 9, 1975, which sent back pictures of Venus. In 1970, the Venera 7 had been the first space probe to land on anothe planet.



Soviet Luna 3, 1959, flew around the hidden side of the Moon and sent back photographs

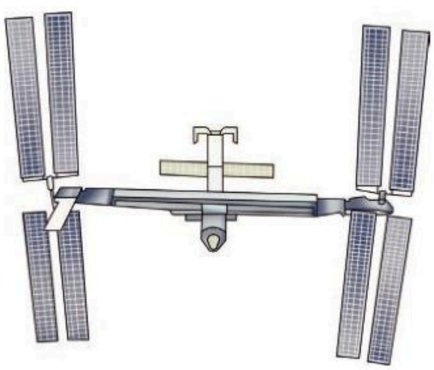
A Viking space probe, 1976, which orbited and landed on Mars to photograph, and test samples



The main weather satellite (Meteostat) collects and transmits information

Space stations and space shuttles

The International Space Station (ISS) project began in 1998 and involved over 15 countries. Its length and width are similar to a football pitch. It was assembled in space, in orbit around the Earth. The modules were mainly sent up on Space Shuttles and then connected to the parts already there. Its electricity supply comes from solar cells in enormous solar panels. Research can be carried out in the absence of gravity. It may operate until after 2022.

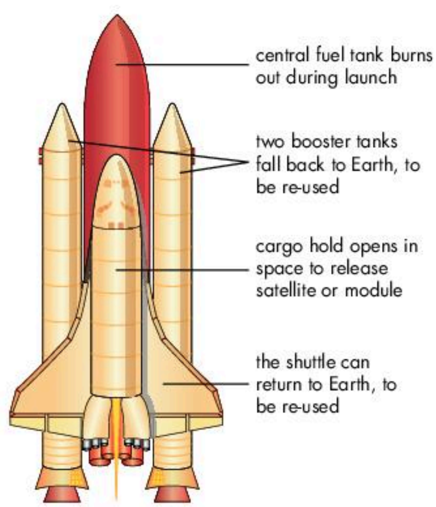


There is no gravity in the ISS, but the inside is decorated with carpets on the 'floor' and pictures on the 'walls'

The National Aeronautics and Space Administration (NASA) launched its first Space Shuttle in 1981. It was a re-usable spacecraft that took astronauts, satellites and building modules into orbit. It was launched on a rocket as powerful as 140 jumbo jets. This rocket burned out, but two booster rockets supplied power and then fell back to Earth to be reused. The shuttle opened up in space to discharge its cargo. The shuttle could then fly like an airplane, and land back on Earth, to be reused. The last flight was in 2011. People and supplies are now mainly transported by Russian spacecraft.

Fun facts

- Galileo identified the four largest moons of Jupiter in 1610.
- First artificial satellite was the Soviet *Sputnik 1*, launched in 1957.
- First man in space was Yuri Gagarin in the Soviet, *Vostok 1*, in 1961.
- Ten people have walked on the Moon, but the latest visit was in 1972.
- Space probes have been sent to all the planets in our Solar System. In 2019, NASA will send a probe to the Sun.



▶ **See Workbook Space exploration.**

Preparing humans for space

In order for humans to stay alive they need:

1 Water to drink, or they will dry out and die.
2 Oxygen for respiration to release energy for living.
3 Food as a source of energy.
4 A suitable temperature and pressure.
5 Arrangments for removal of urine and faeces.

So humans also need these things when they go into space.

Training for astronauts

Astronauts learn how to use the instruments in the spacecraft. They also practise with the conditions in space, which are imitated or **simulated** for them on Earth.

Acceleration

When a rocket takes off it accelerates very quickly. Blood tends to collect in the lungs and legs. Very little can reach the head and supply it with oxygen. The person may become dizzy or even unconscious. Astronauts are swung round on a centrifuge to simulate the acceleration force.

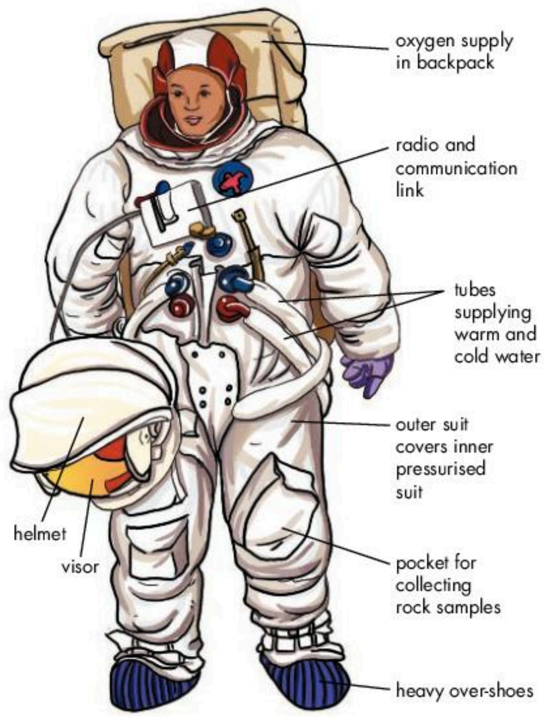
Temperature changes and vibrations

The side of a spacecraft facing the Sun can get very hot, and the other side very cold. The spacecraft turns slowly to even out these differences. When an astronaut is outside the spacecraft, water is circulated in the spacesuit to keep the temperature constant. On re-entry to Earth's atmosphere, the spacecraft vibrates and heats up. So on Earth, astronauts are tested with vibrations and extreme temperatures.

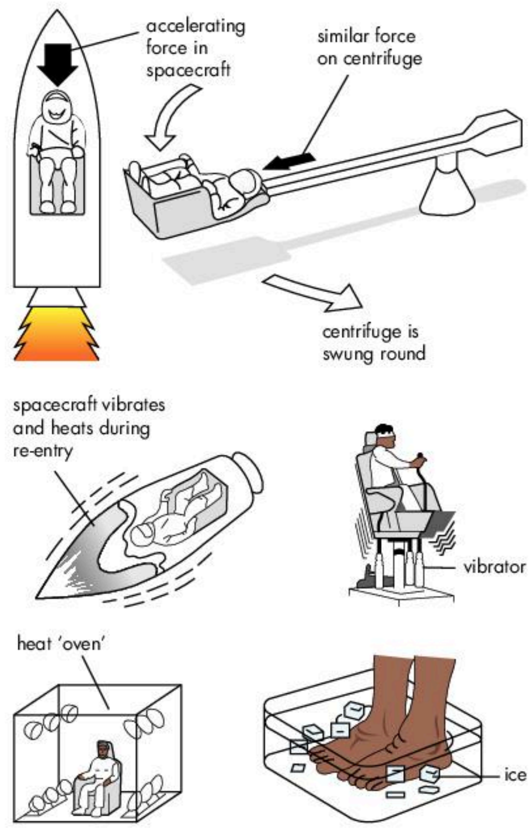
Weightlessness

Out in space the astronauts will not feel the force of gravity. Everything is very light and easy to pick up. Things that are unattached float in the air, as they are not pulled down by gravity. So this 'weightlessness' feeling is also simulated.

Astronauts float around in weightless conditions. This was done on Earth to simulate conditions in space.



The suit provides the astronaut with oxygen and a suitable temperature and pressure



Simulations for acceleration, vibrations, and extremes of temperature

▶ **See Workbook Space exploration.**

The effects of space travel

After long periods at zero gravity the body suffers from under-work: it does not have to work against gravity. The muscles become limp, the nerves that usually give information about the effects of gravity have nothing to do, and the heart does not have to beat so strongly. The muscles used in breathing may also become weaker. To help overcome these difficulties the astronauts have to keep on exercising.

Another interesting result of long space trips is that when the astronauts return they are slightly shorter! This is because they slowly lose material from their bones with lack of exercise, and new bone is not made because the weightlessness does not stimulate the body to make more.

In addition, the astronauts have to carry out all their activities in a very small space. They have to be able to work well together to cerry out the work of the spacecraft.

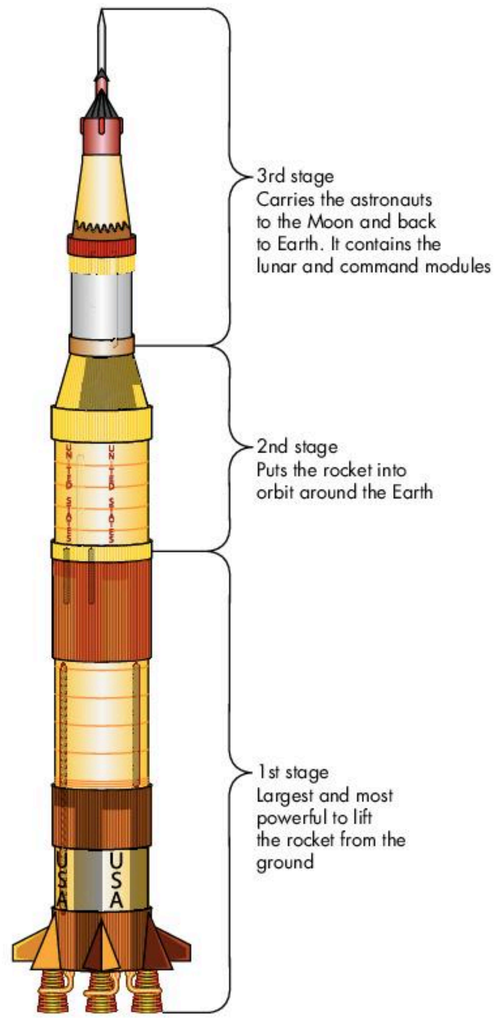
After a few weeks back in Earth's gravity the effects of the space travel wear off. But if humans were to travel for very long periods in space it may be that they would have to be kept in special conditions when back on Earth as they could no longer cope with Earth's force of gravity and air pressure.

Rockets and fuels

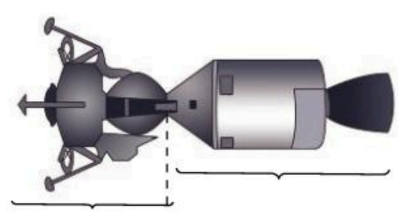
Aircraft that fly within the atmosphere make use of its oxygen. Rockets that travel above the Earth's atmosphere have to carry their own oxygen with them. The oxygen is used to burn the fuel and release energy. As the gases escape from the back of the rocket there is an equal and opposite push or thrust forwards.

Opposite is a diagram of Saturn V, the rocket used to launch the Apollo spacecraft that landed astronauts on the Moon. It is a three-stage rocket, and each stage has fuel and oxygen. Fuel in the first stage is used to get the rocket off the ground. This part of the rocket then falls away. A similar thing happens to stages two and three, leaving the command module and the lunar module (below right).

The lunar module lands on the moon while the command module orbits around it. When the exploration is complete the lunar module returns to the command module, which has engines to take it back to Earth. The astronauts parachute the last part into the sea and are picked up by waiting ships.



Saturn V, the three-stage rocket that first sent astronauts to the moon in 1969. There have been five other landings, the last one in 1972



Quick check ☑

__________ are needed to launch satellites, space probes and __________ . Satellites are used for communication, __________ and __________ . Astronauts train with __________ to prepare them for space. When returning from the Moon, the __________ velocity is less than on Earth.

Use these words to fill in the spaces as you write the sentences in your Exercise book.

spacecraft escape observation rockets simulations navigation

Questions

Answer these questions in your notebook

For questions 1–37 answer A, B, C or D.

1 Which of these is the largest?
A galaxy **B** Universe
C solar system **D** star

2 What is the name of our galaxy?
A Orion **B** Solar system
C The Sun **D** Milky Way

3 Which of these is luminous?
A The Earth **B** Venus
C The Sun **D** The Moon

4 What is a light-year?
A he distance light travels in a year.
B The distance from Earth to the Sun.
C The distance from Mercury to the Sun.
D The time taken for Earth to orbit the Sun.

5 What is an astronomical unit?
A The distance light travels in a year.
B The distance from Earth to the Sun.
C The distance from Neptune to the Sun.
D The time taken for Earth to orbit the Sun.

6 Apart from the Sun about how far from Earth is the closest star?
A 4 light-years **B** 4 AU
C 4×10^4 km **D** 4×10^{10} km

7 What is 1400 000 in standard form?
A 14×10^5 **B** 14×10^6
C 1.4×10^5 **D** 1.4×10^6

8 What is 9.5×10^{12} km in metres?
A 9.5×10^{12} m **B** 9.5×10^{13} m
C 9.5×10^{14} m **D** 9.5×10^{15} m

9 Which constellation has a belt of three stars?
A Gemini **B** Little Dipper
C Orion **D** Big Dipper

10 Venus is an example of a
A planet
B star
C solar system
D natural satellite

11 The Moon is an example of a
A planet
B star
C solar system
D natural satellite

12 Planets are kept in orbit by the Sun's
A solar energy **B** radiant energy
C gravity **D** light

13 Which of these planets takes less than an Earth year to orbit the Sun?
A Mercury **B** Mars
C Jupiter **D** Neptune

14 Which of these planets would you expect to have the lowest temperatures?
A Uranus **B** Mars
C Jupiter **D** Neptune

15 Any meteor that lands on earth is called a
A lucky meteor **B** meteorite
C meteoroid **D** asteroid

16 An example of a dwarf planet is
A Pluto **B** Mercury
C Mars **D** Moon

17 Which of the following sentences is correct?
A The Moon orbits the Earth and the Sun
B The Moon orbits the Sun and the Earth
C The Moon orbits the Earth, and the Earth orbits the Sun
D The Moon orbits the Earth, and the Sun orbits the Moon

18 Natural satellites are in orbit around
A a planet **B** the Sun
C the Moon **D** another natural satellite

19 The force of gravity on the Moon is one sixth that on Earth. A person of mass 72 kg on Earth would have which of the following on the Moon?
A mass of 72 kg and weight of 720 N
B mass of 72 kg and weight of 120 N
C mass of 72 kg and weight of 7.2 N
D mass of 12 kg and weight of 1.2 N

20 Which of these do all inner four planets have?
A moons **B** rings
C rocks **D** soil

21 Which is the largest planet?
A Earth **B** Jupiter
C Uranus **D** Neptune

22 Which of these of NOT shared by all the outer planets?
A methane **B** rings
C gas atmosphere **D** many moons

23 Day and night are caused by
A the Earth orbiting the Sun
B the Moon orbiting the Earth
C the Sun orbiting the Earth
D the Earth turning on its axis

24 In a lunar eclipe
A the Moon is between the Earth and Sun
B the Earth is between the Sun and Moon
C the Moon is closest to the Sun
D the Moon is fully lit up by the Sun

25 Natural and artificial satellites
A orbit the Sun
B orbit the Earth
C escape the Earth's gravity
D escape the Sun's gravity

26 Which planet has the longest year?
A Earth B Uranus
C Neptune D Saturn

27 Which planet has the largest rings?
A Earth B Uranus
C Neptune D Saturn

28 Which planet would it take the longest for a probe from Earth to reach?
A Earth B Uranus
C Neptune D Saturn

29 What is the escape velocity from Earth?
A 11 000 km/h B 22 000 km/h
C 28 000 km/h D 40 000 km/h

30 Which of these statements is correct?
A All artificial satellites are the same.
B Navigation satellites are used to transmit telephone calls.
C The ISS is an artificial satellite.
D The moon is an artificial satellite.

31 A rocket needs to take which of the following into space with it?
A Fuel B Fuel and oxygen
C Oxygen D Fuel and nitrogen

32 What was the MOST important characteristic about the Space Shuttle?
A It had three fuel tanks
B It could carry satellites and probes into orbit
C The shuttle could return to Earth to be re-used
D Modules for the ISS could be carried by it

33 Which of these do humans need to stay alive?
A Suitable temperature
B Oxygen
C Water
D all of the above

34 Which part of the Saturn V rocket reached the Moon's surface?
A First stage B Second stage
C Third stage D Lunar module

35 Which part of the Saturn V rocket stayed in orbit around the Moon?
A Third stage B Lunar module
C Command module D Booster rocket

36 Which of these conditions must astronauts get used to during training?
A weightlessness
B acceleration
C high temperatures
D all of the above

37 Which statement is correct? Gravity:
A on Earth is smaller than that on the Moon
B on Earth is larger than that on the Moon
C on Earth is the same as that on the Moon
D is not important for the return from the Moon

For questions **38–59** write full answers.

38 Where does the Earth belong in the Universe? Draw a labelled picture to show your answer.

39 What are the differences between a star, a planet and a moon?

40 Which star can we see in the daytime? Why do we not see any other stars in the daytime?

41 How do see the Moon? Can we sometimes see the moon in the daytime? Explain your answer.

42 Why does the Moon appear to change its shape during the month? Does it really change shape?

43 (a) What is a constellation? (b) Find out how one constellation got its name.

44 What is a light-year? How is it used?

45 What is an astronomical unit? How is it used?

46 (a) Why do the planets stay in orbit around the Sun? (b) Describe an activity to explain your answer.

47 (a) Write the names of the eight planets in order. (b) Make up your own sentence to help you remember the order. (c) Why is Pluto no longer listed as a planet?

48 An object has a mass of 120 kg. What would be its mass and weight (a) on Earth? (b) on the Moon? (c) in space between the Earth and the Moon?

49 (a) Write one interesting fact about each of the planets. (b) Record the year for each one when it was first visited by a space probe.

50 Do you think there is life elsewhere in the Universe? Why is it so difficult to find out?

51 What is a satellite? Briefly describe a natural satellite and an artificial satellite.

52 Describe the use of a named artificial satellite.

53 What is a geostationary orbit?

54 (a) How would the velocity of an artificial satellite be slowed down? (b) What would happen if it was travelling too slowly?

55 Name and explain the use of one instrument used for space exploration.

56 Write five sentences to say what you have learnt about space travel in this unit.

57 How would you feel (a) to train as an astronaut, (b) to travel to the Moon and (c) to actually set foot on the Moon?

58 What are the functions of these parts of a Saturn V rocket going to the Moon? (a) Fuel (b) command module (c) lunar module.

59 When returning from the Moon the command module needs smaller engines and less fuel than when the Saturn V rocket leaves Earth. Explain why.

Key ideas

- The Universe contains billions of galaxies, and each of these contains billions of stars.
- Our Sun is a star in the Milky Way galaxy. It has eight planets in orbit around it.
- The large distances in space are described in standard form, light-years and astronomical units.
- Patterns of stars are called constellations.
- The Sun makes light from nuclear fusion. It is a luminous object.
- We only see the Moon and planets when they reflect the Sun's light; they are non-luminous.
- The planets in our Solar System that orbit the Sun are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.
- Pluto is a dwarf planet.
- Planets stay in their orbits because of motion and gravity.
- The Earth has particular features that make it suitable for living things, e.g. oxygen, water, suitable temperature and pressure.
- Mass is the amount of substance in an object. It is measured in kg and g. It does not vary depending on where the object is.
- Weight is the force of gravity on an object. It is measured in newton (N). It changes depending upon where the object is.
- A mass of 1 kg has a weight of about 10 N.
- The Earth spins to give us day and night.
- Phases of the Moon are when we see different amounts of the Moon's lit surface from Earth.
- A solar eclipse is when the Moon blocks off the Sun's light from reaching Earth.
- A lunar eclipse is when the Earth's blocks the Sun's light reaching the Moon.
- Satellites orbit the planets. They may be natural satellites (like our Moon) or artificial satellites, e.g. communications and weather satellites.
- Humans carry out space exploration. Space probes have visited all the planets and several moons. Humans have visited the Moon.
- Rockets going into space have to travel very fast to escape Earth's gravity:
- During training, astronauts experience some of the similar conditions to those in space.

▶ **See Workbook Space science.**

Problems

1 As a class:

(a) Discuss the problems of how humans find out about the conditions and bodies in space, e.g. enormous distances, only stars are luminous, the need for instruments sensitive to X-rays and infrared waves.

(b) Distinguish between rockets, probes, spacecraft, robots and humans. How is each one useful in exploring space? What would be the special problems?

(c) The maximum present velocity of a space vehicle is 60 000 km/h and it would take 76 000 years (over 2500 human generations) for us to travel 4.2 light-years to Proxima Centauri. What does this tell us about the problems of space travel?

(d) In the middle of February, 2018, Voyager 1 had been travelling for 40 and a half years, was 141 AU (21 billion km) from Earth and was still sending back data. What would be the problems of communication with Earth?

2 In groups:

Each choose a planet and research and write an illustrated account about it. ICT

3 In groups:

(a) Research tools and equipment that are used in the exploration of space. Here are some ideas, telescopes, gyroscopes, robots, cameras, rockets, various sensors and detectors, and equipment for communication. ICT

(b) Create a mini-booklet on 'Space Exploration Tools', including names, pictures and how they are used. Share and critique booklets.

(c) Research vehicles used to collect information in the exploration of space. Here are some ideas, airborne and orbital telescopes, probes, fly-by spacecraft, orbiters, landers and rovers. ICT

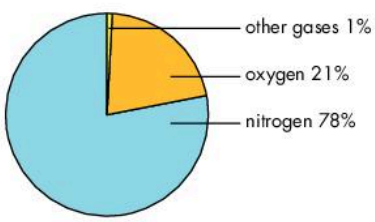
(d) Create a mini-booklet on 'Space Exploration Vehicles', including names, pictures and how they are used. Share and critique booklets.

(e) Select a tool, equipment or vehicle. Use the Engineering design process to make a model. You should research sizes, list your constraints and give a scale for your drawings. Display your models.

Unit 15

Water and the Earth's atmosphere

1 *Why can we use neon in the lights used for advertising signs?*



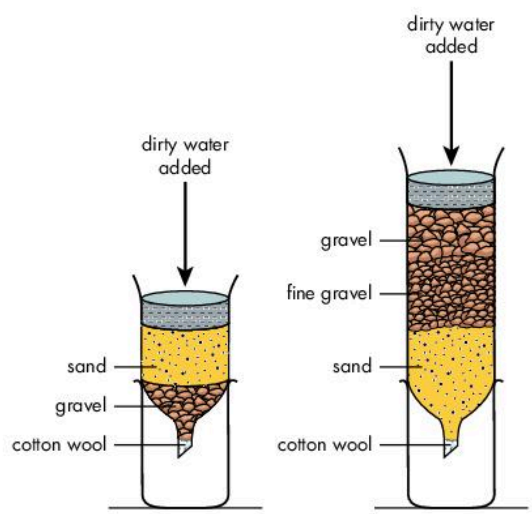
2 *Pie chart showing the composition of air. What are the gases present in the 1%? List a use of each gas in the air.*

This unit will help you to:

- identify sources of water
- appreciate the importance of water to plants and animals
- investigate the properties and uses of water
- be aware of the role of humans in the pollution of water and air: causes and consequences
- investigate purification of water
- be aware of the need to conserve water
- describe the composition of air
- identify the properties and uses of gases in the air
- understand that gases in the air are recycled.

ICT

- Communication and collaboration: use technology to communicate ideas and information; work well with others.
- Research, critical thinking and decision making: find information on the Internet to plan and conduct research, aid critical thinking, solve problems and make decisions.
- Designing and producing: show they can use digital tools and choose resources to design and develop creative products and show understanding of basic technology.
- Digital citizenship: recognise the human, ethical, social, cultural and legal issues involved in using technology; practise online safety and ethical behaviour.



3 *In which set-up do you think the water will be made cleaner? Explain your answer. What unseen pollution is still present? How could it be dealt with?*

Water: sources and properties

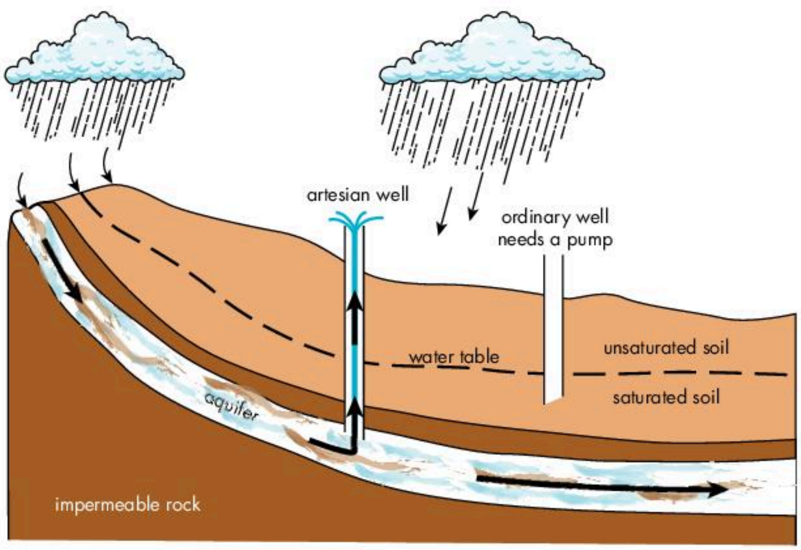
Sources of water

The ground is made up of loose particles of rock and soil. When rain falls, the water seeps into the spaces between the particles. It forces the air out. The water carries on down through the soil and rocks, until it reaches rocks it cannot go through. These are called **impermeable** rocks. The water that settles underground is called **groundwater**. It is trapped and cannot go any deeper.

The **water table** is the level below which the rocks and soil are saturated with water. The water table will rise when it has rained a lot. The water table will be lower when it has been dry and the plants have taken water from the soil.

In some places the water can run within rocks that have large spaces between them. These are called **aquifers**. Aquifers are like an underground irrigation system. Water can travel long distances in aquifers and provide water for large cities.

Wells can be dug to tap the groundwater. An ordinary well is sunk to below the water table. It will only receive water when the water table is high, and a pump will be needed. These wells can run dry. But if a well is sunk into an aquifer, there is a constant supply of water that rises up under its own pressure. This is called an **artesian** well.



Other sources of water are underground rivers and lakes, and **springs**. Springs form in places where water flows out through natural rock openings. In most areas, springs have cold water.

But where there are permeable hot volcanic rocks, **hot springs** and **geysers** are found. When the pressure of steam builds up underground, it forces out the hot water. There are hot mineral springs in Jamaica in Bath, Milk River, Black River, Little Bay and Rockfort, and in St Lucia (Sulphur Springs) and Dominica (Boiling Lake). Because they are associated with volcanic rocks they contain special salts, have a particular taste and smell, and, at the right temperature have health benefits.

Objectives

- Describe groundwater and surface sources of water.
- Recap the processes involved in the water cycle.
- Show the importance of water to living things.
- Investigate the properties and uses of water.

Fun facts

- Water that evaporates from the sea is pure water. So the water that falls as rain is fresh water.
- Groundwater dissolves salts as it travels through rocks and soil, and above ground in streams and rivers. The salts remain behind when the water evaporates, so the sea becomes more salty.

Boiling Lake, Dominica. This can change in temperature quite quickly and it is not safe to swim in it. It is associated with volcanic activity.

Questions

1 What is groundwater?
2 Why are aquifers important?
3 Name and describe the differences between two kinds of well.
4 What are the natural groundwater and surface sources of water in (a) your neighbourhood, (b) your city?
5 How are above and below ground sources of water connected?
6 What is artificial aquifer recharging?
(a) When does it become necessary?
(b) How does it work?

Surface sources of water

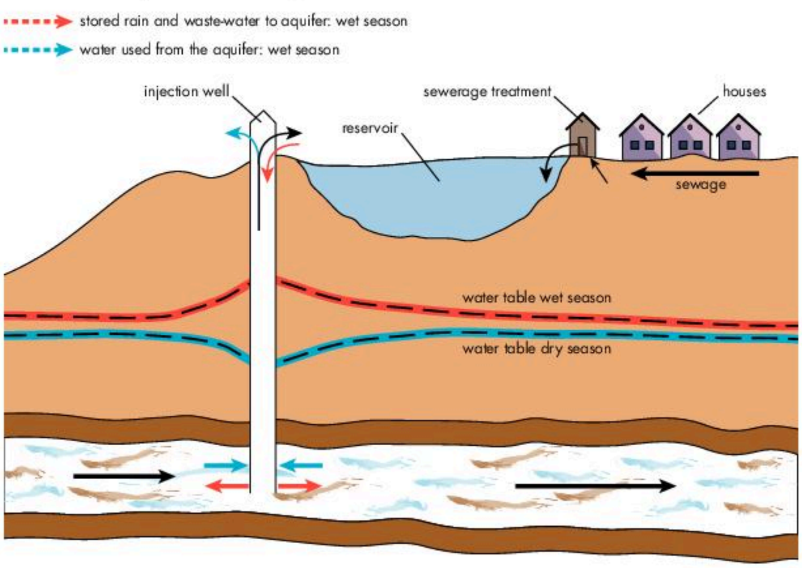
Some examples are streams, rivers, ponds and lakes. Humans also build dams and reservoirs. Many houses have water tanks, which store the rainwater that has fallen on the roof; this can then be used as water for the garden. Seawater from the oceans can also be used as a source of freshwater; the salt has to be removed in **desalination** plants (page 175). Most of the freshwater on Earth is actually locked up at the poles and in icebergs in the form of ice.

From whatever source, the water needs to be treated at a **waterworks** (page 175) before we can drink it. The impurities are removed and chemicals are added to kill any bacteria.

Recharging of the aquifers

Groundwater is our underground reservoir of water. The natural situation is that the groundwater is replenished as it is used. Water falls as rain and will runoff the surface of the soil into cracks, and other water will seep down through the soil. At the same time water is being taken from the soil by plants and lost by transpiration, evaporation and respiration from plants and animals. So the amount of water that goes back into the soil will be a balance between rainfall, and transpiration/ respiration/ evaporation. When there is a drought, or for months of the year when there is a dry season, we still need water but the groundwater may not be replenished. The water table (below which soil is saturated with water) will drop and wells may run dry. What can be done?

Artificial aquifer recharge



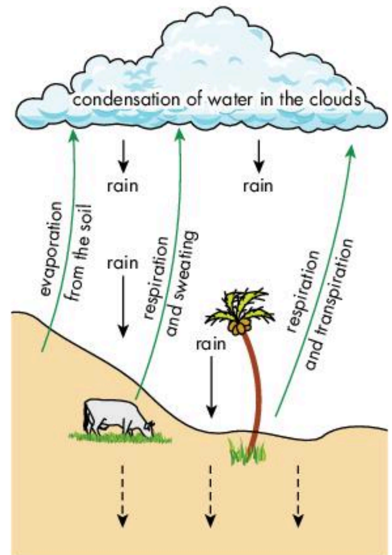
Artificial aquifer recharge

▶ **See Workbook Water: sources.**

Natural aquifer recharge

This occurs if rainfall and percolation of water through the soil exceed transpiration/evaporation and respiration losses of water.

Rainwater will also enter any natural wells and add to the aquifer.



if rain exceeds the other processes then the aquifers will be refilled

Artificial aquifer recharge

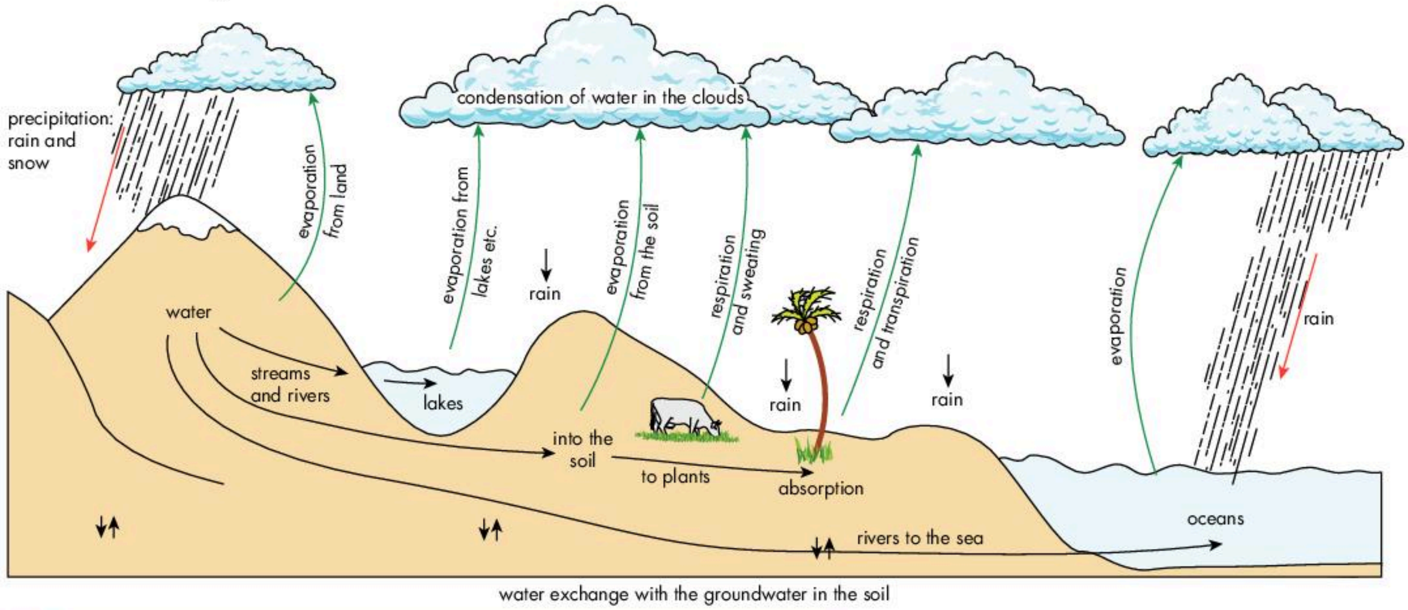
How does it work?

1 Water must be captured and retained when it rains and especially during the wet season. So reservoirs are built for this purpose.
2 Water from household use and sewage can also be treated in a sewerage works and added to the reservoir.
3 During the wet season excess water is pumped down an injection well and this sends water to the aquifer.
4 This water percolates into the rocks, increases the amount of soil that is saturated and raises the water table.
5 In the dry season, the usual use of the water from wells takes water from the soil and the water table is lowered.

For the process to work, it needs:

- initial costs for the reservoir, sewerage works and injection well.
- sufficient rain in the wet season to cover the dry season demands.

The water cycle



15.1 Processes in the water cycle

In your group discuss what you remember from Grade 7 (page 57) about the water cycle and then answer these questions.

1 Why is the water cycle important for (a) plants, (b) animals, including humans?
2 Why can the water circulate?
3 (a) What change of state occurs in evaporation? How is evaporation involved from (b) non-living and (c) living things?
4 (a) Why does water vapour rise up into the air? (b) What happens to it when it rises up higher?
5 What process occurs to make clouds?
6 (a) What is precipitation? (b) Why does rain fall? (c) What is snow and what happens to it when it reaches the ground? Why?
7 How do (a) plants and (b) animals get the water they need? (c) What special arrangements do humans make to get the water they need?
8 How are the groundwater aquifers (a) used and (b) replenished in the natural cycle?
9 Why is artificial recharge of aquifers sometimes needed?

15.2 Modelling the water cycle

Work in groups:
You will use the Engineering design process to make a model to illustrate the processes involved in the water cycle. Make your plans and draw your designs. Choose the best one. Consider the things you will need and find and use them.

Also decide on a way you will evaluate your model. Make, test, improve and evaluate your model.

Humans and the water cycle

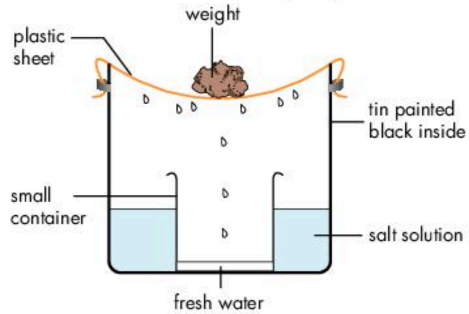
What will be the effects of each of these actions by humans?

- We break the natural cycle to take water for washing and industries.
- We use water for farming: for crops and livestock.
- We pollute the water with chemicals from farming and industry.
- We build reservoirs and dams.
- We clear forests and harvest crops.
- Our world population numbers are increasing so much, and everyone needs water for life.
- In Newfoundland they 'harvest' icebergs (ice is cut from the Greenland ice-shelves and floats in the currents).

Why is it important that humans use water wisely and recycle it?

A model water cycle

Here is an idea from one group.



Water in living things

Is water present in plants and animals? You can find out.

15.3 Is there water in plants?

Materials: pieces of cotton cloth about 20 cm^2, bread ties, pieces of watermelon, food items, dishes, ruler, plastic bags, chemicals for testing for water

Method

1 Put a small piece of watermelon inside a piece of cloth.
2 Hold it over a dish and squeeze the food and cloth. What comes through the cloth? Test it for water.
3 Cut and measure two equal pieces of the same food.
  (a) Place one piece in a dry plastic bag, and the other in a dish.
  (b) Put both outside in the Sun for three hours.
  (c) What has happened to the size of the piece of food left open in the dish? Why do you think this happened? Do you think water loss caused the change in size?
  (d) What can you see inside the plastic bag of the other piece of food? Where did it come from? Test it for water.

▶ **See Workbook Water: sources.**

15.4 Is there water in animals?

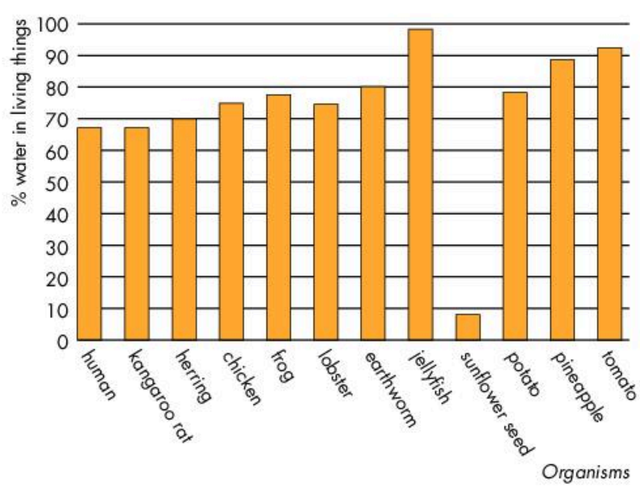
Materials: plastic bag, chemicals for testing for water

Method

1 Lightly hold a plastic bag over one of your hands for ten minutes. What do you see? How can you test it?
2 Carry out your test. What does it show? How can you explain it?

Percentage of water in animals and plants

Accurate measurements were made of the mass of fresh (but dead) material and then its mass after all the water was removed. The percentage of water was found, as shown below.



How to test for water

Certain chemicals change their colour when water is added to them.

- Dry, white copper sulphate crystals turn blue with water.
- Dry, blue cobalt chloride paper turns deep pink with water.

Fun facts

- A mature oak tree draws 90 litres of water out of the soil each day.
- A barrel cactus is 90% water. You can chop off the top and squeeze out liquid as a drink.

Questions

Use the bar chart on the left.

1 What percentage of a herring is water?
2 Which contains more water: a tomato or a pineapple?
3 Which animals contain the least percentage of water?
4 If you eat 100 g of tomatoes, how much water do you eat?
5 Which organism contains least water? Why is this? Would the adult organism be the same? Why?
6 How would you find out the % of water of an organism?
7 Write a general statement about the amount of water in living things.

Properties of water

15.5 What are the properties of water?

Your teacher will set up activities for the groups. Complete each activity in turn and record your results. Leave each area tidy and clean for the next group.

1 Adhesion
(a) Place a drop of water on a glass slide and place another glass slide on top.
(b) Try to separate the slides. What do you notice? How can you explain it?

2 Cohesion and capillary action
(a) Place capillary tubes of different widths upright into coloured water. What happens?
(b) Do you notice any pattern? How can you explain it?

3 Surface tension
(a) Gently place a paper clip flat on a water surface. What happens? How can you explain it?
(b) Add a little soap powder or drop of washing-up liquid. What happens? Why do you think this is?

4 Water droplets
(a) Dip a finger into the water in the beaker and then place the water onto the plastic sheet.
(b) What happens? Can you make droplets of five different sizes? Can you explain what happens?

5 Solubility
When a substance breaks up and disappears in water, it has dissolved. It is soluble in water. If, instead, we can still see the substance in the water, it is insoluble.
(a) You have been given powdered chalk, salt and brown sugar. Add small amounts of each to separate test tubes of water.
(b) What happens in each case? Describe your results using: insoluble, soluble, solute, solvent, solution.

6 Density
(a) Drop the paper clip and the ice cube into the water. What happens to the paper clip? Why? Is this different from Activity Part 3 above? Explain why.
(b) What happens to the ice cube? Explain why.

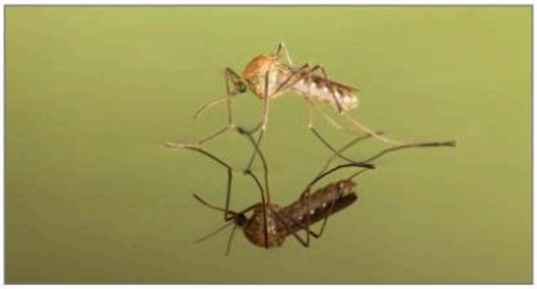
7 Melting point
(a) Put some of the ice cubes from the thermos flask into the beaker. Record the temperature at which they melt.
(b) What change of state has occurred?

8 Boiling point
(a) Heat the water and find and record the boiling point.
(b) What change of state has occurred?

▶ **See Workbook Water: properties.**

Fun facts

- Pure water has no smell, taste or colour. It is the only substance that can be gas, liquid and solid at everyday temperatures.
- It can dissolve more substances than any other liquid.
- Ice is slightly less dense than liquid water, which is why icebergs float.



The mosquito is supported by surface tension. Surface water molecules pull strongly on each other to create a 'film' that supports lightweight insects.

What does it mean?

Adhesion The attraction between water molecules and a surface.

Cohesion: The attraction between water molecules.

Solute: This is the substance, such as salt, which dissolves in water.

Solvent: This is the liquid in which a substance dissolves. Water is a very good solvent for many substances.

Solution: The solute and solvent together are called a solution. So, salt + water makes a salt solution.

Questions

1 How are both adhesion and cohesion needed for capillary action to occur?
2 Why is the water surface in a measuring cylinder curved downwards?
3 What shape is a water drop running down a window when it rains? Why?

How can we explain the properties of water?

First we will find out the composition of water: what is in its molecules.

15.6 What is water made of?

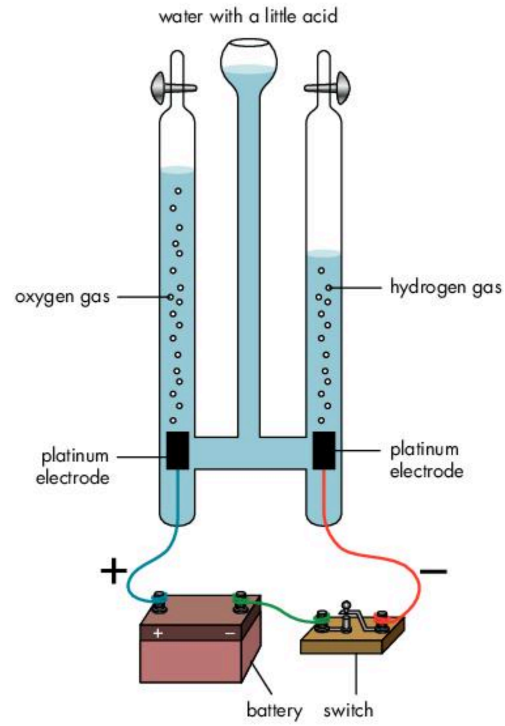
Your teacher may do the following activity as a demonstration or you may observe a video online. Equipment called a Hofmann voltameter is used to pass electricity through water to break it up into its parts.

1 On the diagram:
   (a) identify where water is put in: it has had a little acid added to it so that it conducts electricity better.
   (b) find the battery and switch that control the electric current passed through the water.
   (c) notice the two electrodes that make the contact between the electric current and the liquid.
   (d) Identify the left-hand side that is marked + (positive +ve electrode).
   (e) Identify the right-hand side that is marked – (negative –ve electrode)
2 (a) What has ben produced at the +ve electrode?
   (b) What has been produced at the –ve electrode?
   (c) How do the volumes of the two gases compare?
3 Which of these do you think is the chemical formula for water? Explain your answer based on the experiment.

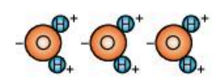
   HO   OH H_2O_2 H_2O HO_2

Using this and other experiments it is found that water molecules are made up of hydrogen and oxygen atoms, with twice as many hydrogen as oxygen: the chemical formula is H_2O. The atoms share their electrons, but they are closer to the oxygen molecule, so that side becomes –vely charged, while the hydrogen side becomes +vely charged. We will now see how this helps to explain all the properties of water.

1 Adhesion: either the +ve or the –ve side of the water molecules are attracted to a surface. You can see this if you look at the curved surface of water in a measuring cylinder that goes upwards at the sides.
2 Cohesion and capillary action: the –ve side of one water molecule attracts the +ve side of another, and so on. As a molecule adheres to the surface, e.g. of a xylem vessel, it pulls along another water molecule by cohesion and so on, and capillary action occurs in narrow vessels.
3 Surface tension: The water molecules on the surface of water do not have molecules above them to hold onto, so they hold more strongly to each other and the molecules below. This make the surface 'film' or surface tension.
4 Water droplets: The outer layer of water molecules pull tightly on each other and the result is a spherical ball.



The breakdown of water into oxygen and hydrogen



Attraction between water molecules

5 Solubility: Water is a better solvent even than strong acids. Its –ve and +ve sides attract other molecules that have charges and they break apart or dissolve in water.
6 Density: floating ice. In liquid water the water molecules are closely attracted to each other. When ice forms it makes more open crystals that are less dense: so it floats.
   Paper clips. Their density is higher than that of water – so they sink. They only appear to float if they can take advantage of surface tension.
7 Melting point: Compared to other similar molecules, liquid water requires a lot of energy to rearrange the molecules to become frozen.
8 Boiling point: Compared to other similar molecules, water takes a lot of energy to warm up and cool down (this explains land and sea breezes). Water also has a higher boiling point than expected because the attraction between molecules has to be broken.

Uses of water in living things

The cytoplasm of cells is usually 70–90% water. Living things can live for only a few days without water.

1 Water is needed for the **reactions** of living things:
- plants need water for photosynthesis, seeds need water so they can use their food stores and germinate.
- animals use water to function properly, e.g. as part of saliva and other digestive juices to break down food.

2 Water is needed for **transport**:
- plants make use of adhesion, cohesion and capillary action as water and mineral salts rise up in the xylem.
- animals use blood, which is mainly water, and it flows in the circulatory system by means of a pump, the heart, that pushes it around the body.

3 **Surface tension** is used by small water animals on the surface of water, and pupae and larvae, e.g. of mosquitoes that hold onto the water surface. Oil on water can kill them as it breaks up the surface layer and they drown.

4 Water as a **solvent** is very important:

Solids:
- plants take in mineral salts dissolved in soil water into their roots and transport them to the leaves, also food is dissolved in cell sap to be transported in phloem.
- animals contain blood in which food substances dissolve and are taken to the cells. Urea, a waste produced in the liver, dissolves in the blood and goes to the kidneys to be excreted in liquid as urine.

Gases:
- plants need oxygen and carbon dioxide dissolved in water for respiration and photosynthesis, and the cell surfaces need to be moist for gas exchange to occur.
- animals need moisture in the alveoli so that oxygen can dissolve and diffuse through into the capillary of the pulmonary vein, and carbon dioxide can dissolve and diffuse from the capillary of the pulmonary artery into the alveolus. Carbon dioxide is also picked up from the cells of the body and transported in solution in the blood and taken to the lungs.

5 The **evaporation** of water needs energy:
- plant leaves lose water vapour that takes energy from the plant and so helps to cool it.
- animals have sweat glands that are supplied with blood capillaries. Water diffuses into the sweat gland and evaporates from the surface of the skin, using heat energy and so cooling the animal.

6 Water is used to keep plants **upright**, e.g. if a soft-stemmed plant has enough water in it, it can stand upright. If it does not, then it bends over or wilts.

▸ **See Workbook Water: properties.**

Humans need water

If we don't have enough water we can become dehydrated. In extreme cases this can cause death.
- In the hot Sun, we can suffer from heatstroke.
- If babies or humans have diarrhoea (runny belly) they lose water.

  If water loss is too great, we need to drink sweetened, slightly salted water. This helps to replace the water that has been lost.

Water for agriculture

Farmers need to supply water:

Animals for:
- drinking from troughs or a river
- cleaning during their lifetime
- cleaning meat for food preparation
- farming of prawns, lobsters, conch and the fishing industry.

Plants for:
- their daily needs by rainwater or setting up irrigation systems
- hydroponics (growing in water)
- cleaning fruits and vegetables for food preparation

15.7 Water for agriculture

ICT

Your group will do research on one of these projects. Then prepare an illustrated account using word-processing or Power point®.

1 What are all the ways that a farmer needs to use water? How could he reduce, reuse and recycle in order to make better use of his resources?

2 What is 'hydroponics'? How could it be used for growing tomatoes? Set up your own plants and see if you can grow them for two months. What needs to be added to the water? Explain your answer.

3 Research different irrigation methods. How are they useful? What are the expenses involved? Make a model farm and put in a simple irrigation system. Test it by growing some seeds into plants.

Water as a habitat

Aquatic plants and animals use the properties of water.

Plants

- Water as a solvent
  Carbon dioxide and oxygen dissolved in the water are used for respiration and photosynthesis. Mineral salts dissolved in the water are also taken in to make other substances.
- Water for support
  Several aquatic plants have large floating leaves, e.g. water lily, swollen leaf bases, e.g. water hyacinth, or bladders, e.g. seaweeds, to reduce their densities so they can float and receive the light they need for photosynthesis.

Animals

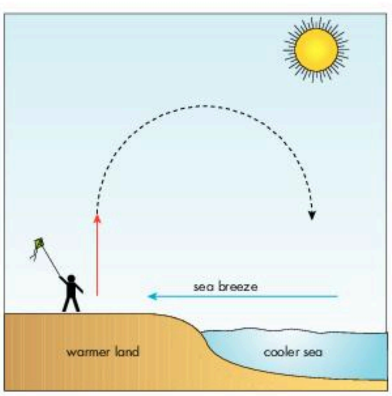
- Water as a solvent

  Gases: oxygen dissolved in the water diffuses in, and carbon dioxide diffuses out during respiration, e.g. through special organs such as the gills in fish.

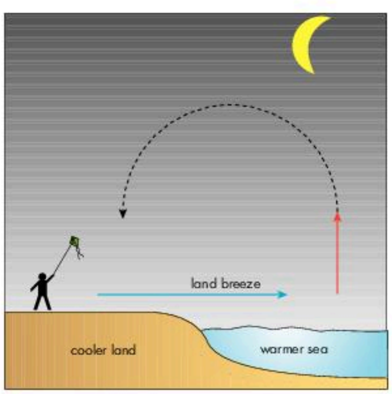
  Solids: rainwater and river water dissolve solids from rocks and soils and these pass into the water. Sea snails and corals make use of calcium salts for their shells or skeletons.

  Solutes in the water also raise the boiling point and lower the freezing point, so increasing the temperature range over which water is a liquid.
- Water for support: fish have swim bladders that help them to change their density so they can raise or lower themselves in the water.
- Density of ice: at 0 °C ice floats on water, while animals and plants continue living below the surface. If ice were denser than water, a pond or lake would freeze from the bottom upwards, and make life impossible.
- Slow to warm, slow to cool: water needs a lot of heat energy to break the attraction between the molecules, so sea water warms up more slowly than the land during the daytime. This produces a sea breeze.

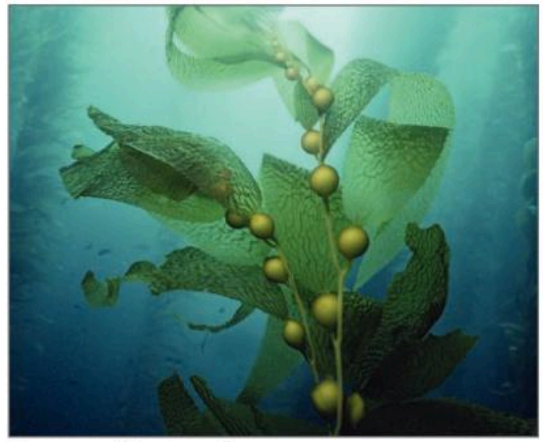
  At night the opposite occurs: the water retains its heat longer than the land, and this causes a land breeze.



Daytime: Sea breeze



Night time: Land breeze



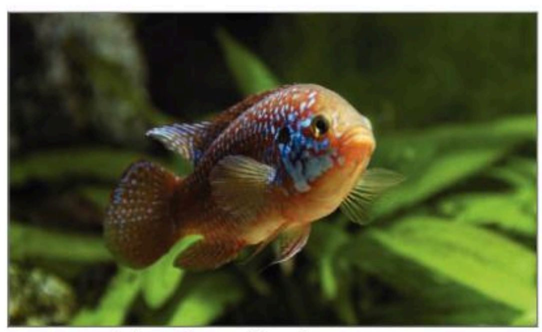
Seaweed floats in the water

15.8 Aquatic organisms

ICT

Your group will do research on one of these projects. Then prepare an illustrated account using word-processing or Power point®.

1 Plant adaptations: visit a pond, river or seashore and identify ways in which plants are adapted for life in water. List and illustrate their special features.
2 Animal adaptations: visit a pond, river or seashore and identify ways in which animals are adapted for life in water. For two named animals describe how they feed, move, are supported in the water and take in oxygen.
3 Why can't humans live underwater? What do we need to take with us if we spend time under water? What long-term problems would there be for humans to live under water, e.g. for a year?



How are fish adapted for living in water?

Industrial uses of water

Water is by far the most important solvent as it dissolves so many substances and is cheap and easily available. This is why it is widely used in industry to produce or manufacture things and for cleaning (to dissolve and wash away unwanted materials).

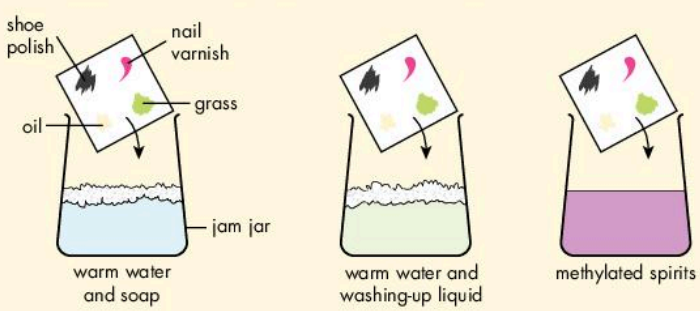
15.9 Using solvents for cleaning

Materials: three similar small pieces of cloth, cooking oil, grass, nail varnish, shoe polish, drinking straw, warm water, three jam jars, glass rods, soap, washing-up liquid, methylated spirits

Method

1 On each piece of cloth make similar stains of cooking oil, grass, nail varnish and shoe polish (use the drinking straw to pick up a little of the polish).

2 Set up your three jam jars with the liquids.



3 Put a stained piece of cloth into each jar. Use the glass rods to mix them around for about five minutes.

4 Take out the cloth. Rinse them in clean water and compare them. How well has each liquid cleaned the stains?

5 Explain three ways you made sure it was a fair test.

Explanation: Soap and washing-up liquid can be used with water to remove several stains. The substances dissolve in the water. But some other stains, such as nail varnish need a special solvent such as methylated spirits. This is an example of an organic solvent. These are used in the dry-cleaning industry.

15.10 Water for industry

Work in groups:
Discuss the following list and write down an explanation of how water would be used in each way.

Water for manufacturing:
- making household chemicals, e.g. bleach and washing-up liquid
- pest control
- paint production
- bottling and canning of fruits and vegetables
- fruit and vegetable juices
- aerated water and soda drinks
- beer and other alcoholic drinks

Water for cleaning
- meat processing
- poultry farms
- sugar industry
- laundry business
- washing houses and cars

Water for cooling
- over surfaces
- through machinery

Questions

1 List three ways in which water is used to dissolve substances for different purposes in the home.

2 Are other solvents besides water needed in the cleaning industry? Why? What is used?

3 In what ways might water leaving a factory cause pollution? Would this only be chemical pollution?

▶ **See Water: properties.**

Quick check ☑

Water circulates in the water ________ . ________ are porous rocks containing water. Water molecules are ________ and their charges are attracted to surfaces (________) or each other (________). Water habitats are called ________ . Water has many uses because it is a good ________ for ________ and ________ . Water is used in living things and in agriculture and ________ .

Use these words to fill in the spaces as you write the sentences in your Exercise book.

gases solids cycle H_2O aquatic solvent industry aquifers cohesion adhesion

Water: cleaning and conservation

Because water is such a good solvent, it dissolves substances that can be harmful. It also provides buoyancy, e.g. for oil and picks up dirt. Human activities produce harmful chemicals and this is called **pollution**. The substances are **pollutants**.

Water pollution

Humans depend on the soil for food, and change the land so it can be farmed. They also use fertilisers and pesticides to increase production and set up factories. They transport goods and materials in large ships. But the result of these things can be water pollution. For example:

- **Fertilisers.** Rain can wash excess fertilisers into streams, rivers and the sea. These cause an extra growth of algae. When the algae die, the bacteria causing decay take oxygen from the water. So the oxygen is reduced and this can lead to death of fish.
- **Pesticides.** These can also be washed into the water. They can damage or kill aquatic organisms.
- **Toxic chemicals.** These may come from factories, or from the careless dumping of waste chemicals. They can seep into the soil and get into the aquifers. People who use wells in the area can then be affected by the chemicals.
- **Sewage.** This can be from the careless disposal of faeces and urine, sometimes in pipes emptied into the sea. Untreated sewage is also sometimes dumped at sea, but it can be swept back to shore by the tides. Sewage can contain disease-causing micro-organisms that can affect humans and make them ill.
- **Acid rain.** Rain that has been made acidic by the action of polluting gases, e.g. sulphur dioxide, can fall into rivers. Here it can harm fish and other aquatic organisms. For example, it dissolves aluminium that harms the gills of fish and kills them.
- **Heat pollution**. Many factories use water to cool metal parts. The metal is cooled, but the water gets hotter. If this hot water is put into rivers, it raises the temperature. This means there will be less oxygen dissolved in the water and this can affect aquatic organisms.
- **Litter.** Swamps and beaches can be polluted by litter. For example, plastic waste can be dangerous for fish, who swallow it. Decaying food and broken glass can be dangerous for humans.
- **Crude oil.** Some ships empty their used oil at sea. Or there may be accidents where oil is spilled. Oil floats and forms a layer that stops oxygen getting to the organisms. It also damages gills and feathers. Fish and birds are killed. It takes a long time to clear the oil away.

Objectives

- List ways in which human activities add to the pollution of water.
- Investigate ways of cleaning water in the laboratory.
- Describe the purification of water.
- Suggest ways of conserving water.

Scary facts

- Once an aquifer is polluted, it can take up to 10 000 years for Earth processes to clean the groundwater.
- In Japan, a fertiliser factory deposited mercury compounds into the water, which killed 800 people.

Pollution of water by detergents

Polluted water

15.11 Reducing pollution

Discuss in groups how the following could reduce water pollution.

- Use compost instead of fertilisers.
- Use natural methods of pest control.
- Dispose of sewage safely.
- Install cooling towers in factories.
- Take care with litter disposal.
- Have rules for crude oil disposal.

Cleaning water

Water sources are likely to contain many things besides water. These are **impurities** such as soil, bacteria, fertiliser and detergent. You will first compare some water samples.

15.12 Comparing water samples

Materials: filtering and heating equipment, filter paper, samples of muddy water, rainwater, seawater, storage tank water, tap water; evaporating dishes, measuring cylinder

Method

Work in groups:

1 Prepare a table to compare the water samples; include appearance (colour and suspended material) and smell (but do NOT taste them. Why not?)

2 Each group tests one sample and shares results:
   (a) filter a set amount of the sample: observe and display the residue on the filter paper, and describe the filtrate.
   (b) heat a set amount to drive off the water: observe and display what is left behind in the evaporating dish.

3 List the samples from dirtiest to cleanest based on (a) first appearance and (b) the results of your tests.

4 Explain two ways you made sure it was a fair test.

Explanation: When you heat the samples, you will observe substances that had been dissolved and therefore were not seen in the original samples. There are many impurities and disease-causing organisms we cannot see in water.

15.13 Making clean water

Materials: dirty pond or river water, pile of books, cloth, two shallow dishes

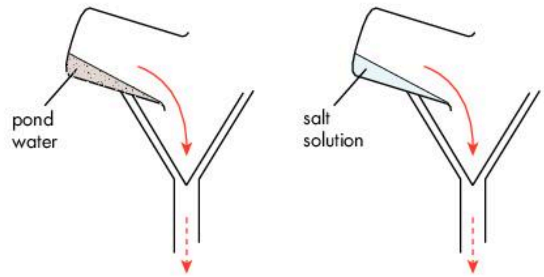
Method

Work in groups:

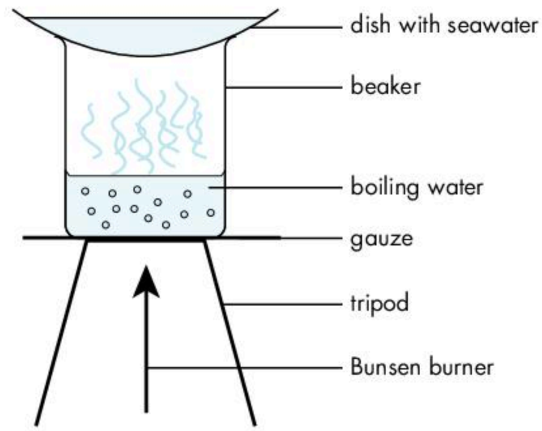
1 Students set up the apparatus below. Explain how you think it works. Prepare your own set-up to make clean water.

2 Compare the appearance of water in the two dishes.

3 Filter and heat equal amounts of water from each dish. What do you notice? Write a report on your findings.



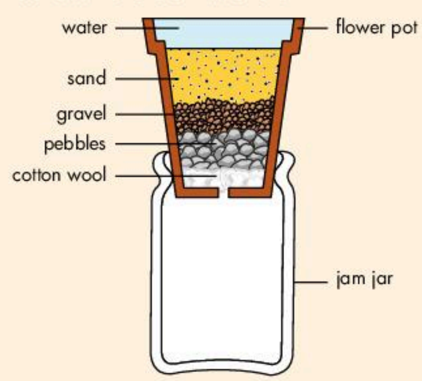
Examine the residue (left behind on the filter paper) and filtrate (what comes through) for each sample of water



Heating will remove the water and leave only solutes and suspended matter

15.14 Sand filter

1 Some students set up the apparatus below to clean water.



2 Other students said it would be better to have the gravel on top of the sand and another said that the distance should be much longer.

3 Use the Engineering design process to make a clean sample of water. Who can make the cleanest sample?

4 Carry out research to find out how similar arrangements are used in filter beds during water purification. ICT

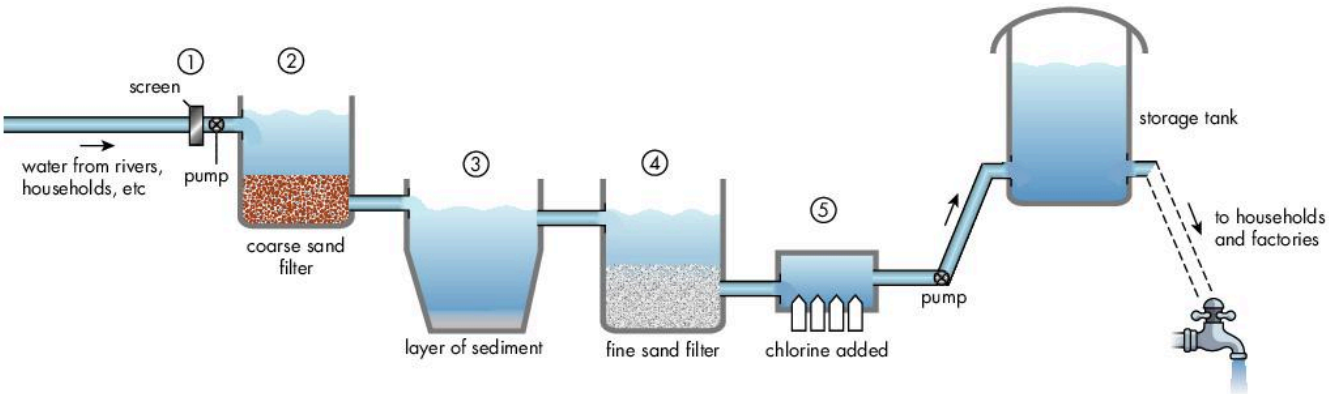
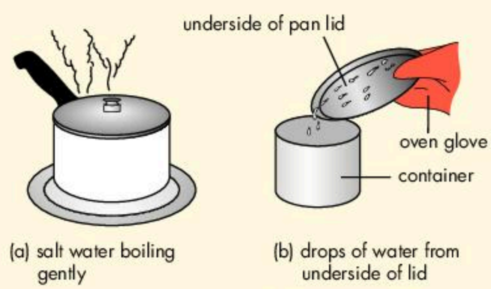


Diagram of a waterworks

Water is purified for drinking in five stages:
1 Sieving: a screen keeps back larger pieces of garbage.
2 Coarse filtering: through gravel or large sand particles.
3 Sedimentation: chemicals, such as alum are added to make small particles stick together, become heavier and sink.
4 Fine filtering: through fine sand that removes the smallest solid particles.
5 Chlorination: chlorine is added to kill micro-organisms.

15.15 Making pure water

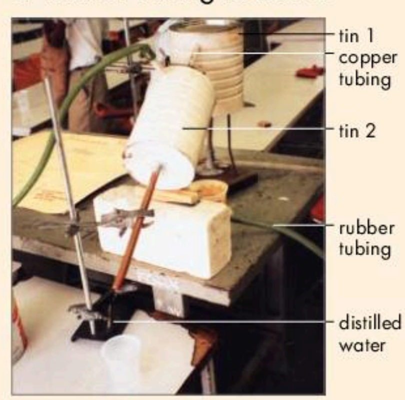
One way in which to get all the suspended material, solutes and micro-organisms out of the water is to distil it. Pure water vapour is produced when water is heated to 100 °C and this can then be condensed to give pure distilled water.
Materials: tap water, saucepan with a fitted lid, salt, plastic spoon, container, padded glove, stove
Method
Do this activity at home with your guardian's permission:
1 Half fill the saucepan with tap water and add five teaspoonfuls of salt.
2 Heat the saucepan on the stove, until the liquid boils. Put on the lid and turn down the heat, so it boils gently.



3 Use the padded glove to carefully take off the lid. What do you see on the under-surface? Collect them in a container.
4 Put the lid back on the pan and collect more liquid. Let it cool.
5 Compare the original water to your pure distilled water.

15.16 Make a model

Examine the model below, then use the Engineering design process to make an improvement for producing distilled water from seawater.
Material: two tin cans with lids, copper pipe, soldering equipment, rubber tubing, clamps, heating apparatus, retort stand, salt solution, plastic cup (You will need an adult's help with the soldering.)
1 Connect tin 1 to tin 2 using the copper tubing that goes right through tin 2.
2 Attach two small metal tubes to the top and bottom of tin 2, and lengths of rubber tubing to these.



3 Put salt solution in tin 1. Put on the lid and heat the water.
4 Connect the lower rubber tube to a tap so that cold water passes in at the bottom and out at the top of tin 2 and into a sink.
5 As the solution boils, pure water vapour goes down the copper tube and is cooled to make distilled water that can be collected.

Summary on purification methods

These are methods used to purify water.

- **Filtering**: this is the first step to remove insoluble and suspended materials, e.g. soil or sand. Use filter paper, coffee filter or cotton cloth. Then other methods can be used on the filtrate.
- **Boiling:** this will kill parasites and micro-organisms. Boil the water and keep it boiling for a full minute, then cover and let it cool for 30 minutes.
- **Activated charcoal:** this is used as a filter to remove insoluble substances. The charcoal has a large surface area to which impurities are **adsorbed** (stick to the surface). It is used for example during the purification of sugarcane.
- **Aeration:** very small bubbles of air are passed through the water which take away any dissolved gases and also interact with other substances to oxidise them so they can be removed by filtering from the water.
- **Chlorination:** this is used to disinfect water and kill micro-organisms. Household bleach that does not contain perfume or dye can be used. Five drops of bleach are used for two litres of water, and then left to stand for 30 minutes before using. Water sterilisation tablets can be used in a similar way.
- **Desalination:** this is the same process as distillation. The salty or unclean water is boiled, and produces pure water vapour, leaving impurities and salt behind. The vapour is condensed and changes into pure, fresh distilled water.

Water conservation

Water is a resource that is replenished by the water cycle and stored in underground aquifers. But it does not always rain where and when we need the water. We rely on stores of water in rivers and reservoirs. We should not waste water, because it costs a lot in money, energy and chemicals to treat and purify water so that we can use it.

At least 75% of the Earth's fresh water is frozen at the poles and in glaciers. Although 70% of the Earth's surface is covered in water, this is mainly seawater. It takes money and energy to convert this into drinking water.

In the Caribbean, the main wet season corresponds with the hurricane season (June to November/December) and a minor one in April/ May. In the drier months rainfall does not match the need for water. This can cause droughts that affect people, livestock and crops. So it is important that we know how water is used, and how we can help to **conserve** it.

Questions

1 What does 'conservation' mean? Does it mean we shouldn't use something?
2 Why is water conservation important?

TS 15.17 Water purification

Work in groups:

1 Research issues affecting water globally, e.g. scarcity, drought, contamination. **ICT**
2 If possible visit a water treatment plant to investigate the stages. Use the EDP to make a model to represent each stage and explain how it works.
3 A small Caribbean island with low rainfall wants to produce freshwater from dirty seawater. Design and plan two different systems that could be used to prepare freshwater. Use the EDP to make working models of your suggestions, improve your models and then explain them to the class.
4 Brainstorm different methods of water purification, their advantages and disadvantages and the possible costs and constraints. For example, methods involving the heating of water will involve an energy supply.

▶ **See Workbook Water: cleaning.**

UK 15.18 Use of water

1 Estimate how much water your family uses each day in litres. Include, for example, water used for:
   - washing people (showers, baths).
   - washing clothes
   - washing dishes
   - flushing toilets
   - cooking
   - drinking
   - watering the garden
2 Compare your estimates with those of a friend. How do they differ?
3 Work together to prepare a chart on how water is used each day

Fun facts

- An average bath holds 100 L of water.
- A shower uses 15 L of water a minute.
- A toilet uses 12 L for every flush.
- A washbasin holds 5 L of water.

15.19 Water use and conservation

Use in the home

1 Look at Activity 15.18 and combine the class results so you can list the activities in order for the amount of water that they use. Did you include things that are done on your behalf, such as cleaning? Check the water bill for your household and collect information from it to compare your total results to the readings over a set period of time.

Use at school

2 Produce a survey sheet to collect information about water use at school from other students, teachers, other staff such as kitchen staff and maintenance people. Make an overall list, with the uses in order from most to least. Include water used to water the grounds.

Water wastage

3 At home and at school identify any places where water is being wasted, e.g. dripping taps or broken water pipes. Estimate how much water is being lost: per hour, per week and per month. Then carry out a fair test to find out how good your estimates were.

Water conservation

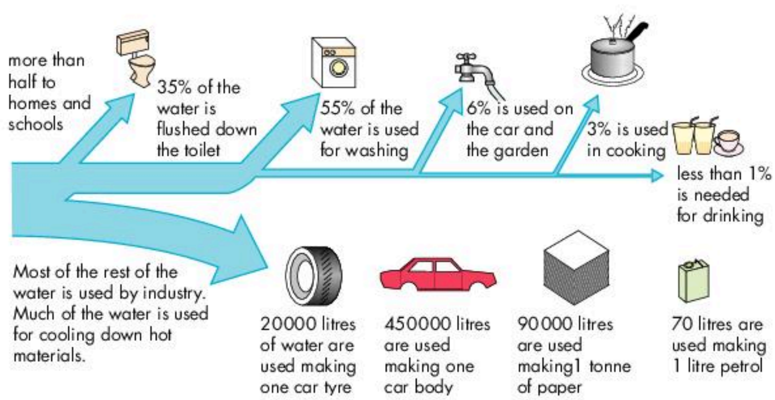
4 Create a strategy to reduce water wastage and usage at home and at school. Conservation relates to 'wise use' of resources. Brainstorm plans to reduce, re-use and recycle water at home and school. Will you need some posters or instructiions? Design and make what you need.

5 Plan and design a public education campaign to increase awareness on water conservation options. Use slogans, jingles, leaflets and charts. Present your materials to the school body in a variety of ways.

Uses of water

You may be surprised to learn that:

- More than half of the treated water is used in homes and schools.
- Most of the rest of the water is used by the rubber, petroleum, paper and steel industries.



Water use in homes, schools and industries

Fun facts

- Rivers and streams contain only 0.14% of the Earth's fresh water.
- Most washing machines use up to 180 litres of water in every wash.
- You probably flush 40 litres of water down the toilet every day.
- Many ships carry distillation apparatus to get distilled water from seawater.

A drought causes the soil to dry and crack

During a flood, soil that is not covered in plants can be washed away

Questions

1 What is most water used for (a) at home (b) by industries?

2 Draw (a) a bar chart and (b) a pie chart to show how water is used in homes and schools. You may draw them yourself, or create them with Excel®.

3 What factories and industries are there in your (a) neighbourhood, (b) town or city? Think about the processes involved and how they might use water.

4 Research major industries, e.g. bauxite to find out what they need water for. ICT

15.20 How can we conserve water?

1 Bring together the ideas of the groups on conserving water. (a) Which amounts could you reduce? For example, mending leaking taps, taking a shower instead of a bath.
(b) Where could you reuse or recycle water? For example, using washing-up water or bath water to water the garden.

2 Consider how water is used in agriculture and in the environment. Make suggestions on how water use could be reduced or recycled. For example, plants placed under polythene 'umbrellas' called cloches, or in polythene tunnels.

15.21 Discussing conservation

Work in a group to discuss how these ideas save water.

1 Water conservation at home
- Use water for only what is necessary.
- Wash your hands or clean your teeth from water in a container, instead of using running water.
- Use water from the washing machine to go onto the garden.
- Mend any leaking taps.
- Cut down on time in the shower.
- Re-use water when possible.

2 Water conservation in the garden and in agriculture
- Collect and use rain water when possible.
- Water plants in the early morning or late evening.
- Use various methods of irrigation.
- Grow plants in water with mineral salts (hydroponics).
- Cover plants with cloches or tunnels.
- Put stones around the base of plants. At night water condenses on the cold stones to water the plants.
- Put a mulch of cut grass around the base of plants.

3 Water conservation in the environment
- The Water Board could replace or mend leaking pipes.
- Keep forests and large trees where possible. They bring up water from underground and recycle it as they transpire.
- Find out from NRCA what steps are being taken nationally to conserve water in Jamaica.

Fun facts

- One drop of water per second from a tap wastes over 200 L water in a week.
- On average, about a quarter of the treated water is lost through leaking pipes before it reaches the user.
- An area of 100 m^2 of roof can collect 100 L of rain from 1 cm depth of rainfall.

How can the polythene tunnel help to save water? Set up a fair test with two sets of plants, using the same amount of water, to try out your ideas.

How can hydroponics help to save water?

▶ **See Workbook Water: conservation.**

Quick check ☑

Activities of humans often ________ our water, e.g. with ________ , ________ and ________ . Insoluble substances can be ________ from the water. Boiling and ________ kill micro-organisms. It is important that we also ________ and ________ water. Agriculture can also use irrigation, ________ and ________ .

Use these words to fill in the spaces as you write the sentences in your Exercise book.

pollute hydroponics reduce recycle pesticides chlorination fertilisers oil cloches filtered

Air: gases and uses

Objectives

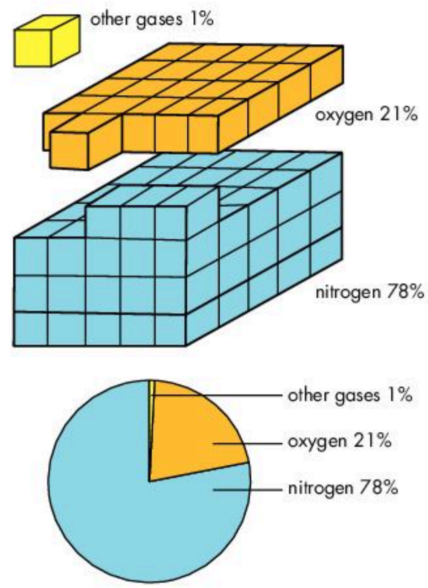
- List the main gases in the air and show air composition in a variety of ways.
- Investigate some properties of oxygen, carbon dioxide and nitrogen.
- List ways in which the different gases are used.

Air is not a compound, it is a mixture of gases. Its exact composition will change from time to time, but it mainly consists of nitrogen and oxygen. On average, air contains 78% nitrogen, 21% oxygen and 1% of other gases. We can illustrate this by cutting up a shape with 100 cubes (see top diagram), or by drawing a pie chart (lower diagram). We show the percentages (parts out of a 100) for each gas.

What gases make up the 1%?

- Argon, an unreactive gas makes up the biggest part: 0.9%.
- Carbon dioxide is a very small part: 0.03%
- Water vapour: amounts vary, for example there will be very little on a dry day but large amounts during wet weather.
- Small amounts of other noble gases, such as helium, neon, krypton and xenon.
- There will be small amounts of other gases in polluted air.

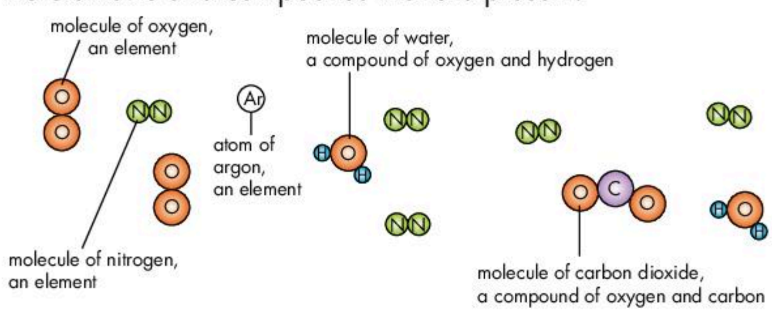
▶ **See Workbook Air: gases and uses.**



The composition of the air

Air is a mixture

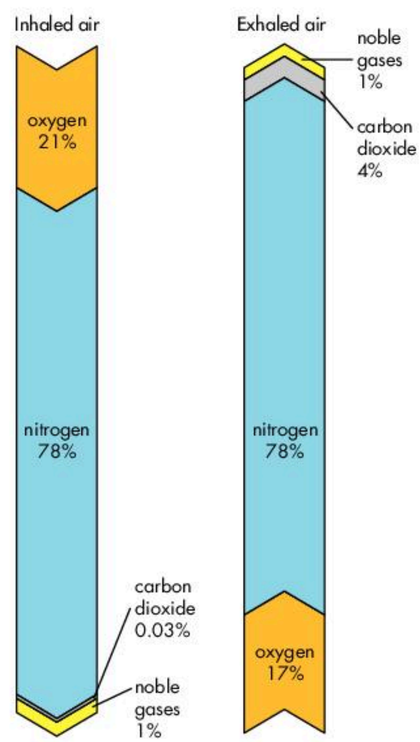
We can illustrate the composition of air by showing some of the elements and compounds that are present.



A mixture varies in its composition. This is true for air, for example inhaled and exhaled air have different compositions. Clean and polluted air, or dry and damp air, will also differ. The gases of the air are continually recycled (pages 185–6).

The parts of a mixture can also be separated by physical means. This is true for air. The air is first cooled to make it into a liquid. It is then allowed to warm up in a special chamber. The different parts change from liquid to gas at different temperatures, and so they can be collected separately (Unit 9, page 61).

We can also carry out tests to identify the different gases in the air. For example, the test for carbon dioxide is that it turns limewater milky. We can draw air through a solution of limewater and it will turn milky, showing the presence of carbon dioxide. We know that oxygen is present in the air because it can allow candles and wood to burn. It also allows us to breathe. The test for oxygen gas is that it relights a glowing splint. The amount of oxygen in the air is not large enough for ordinary air to do this; we need to test pure oxygen gas.



Comparison of inhaled and exhaled air

Burning needs air

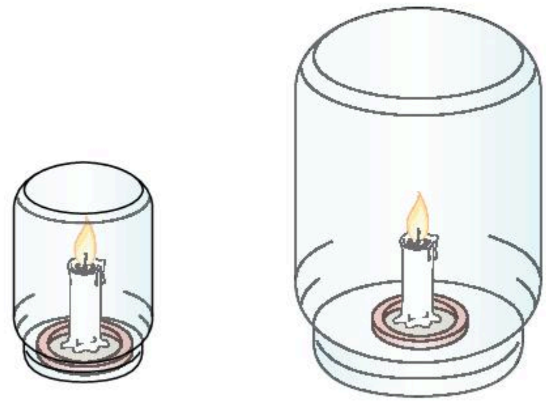
How is air important for burning?

15.22 Watching candles burn

Materials: two candles (the same size), two tin lids, small jar, large jar, matches

Method

1 Light a candle and let a little wax fall into a tin lid. Blow out the candle and push its base into the wax. Repeat for the other candle.
2 Light the candles at the same time. Put the jars on at the same time.
3 Watch the candles burn. Which one goes out first? Why?
4 Does your activity show that air is necessary for burning?



15.23 Which part of the air?

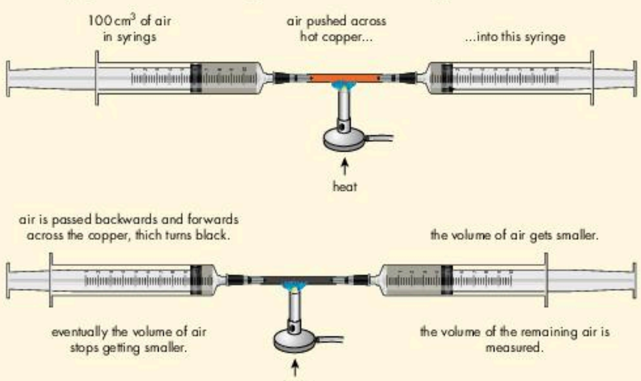
Materials: large candle, tin lid, large jar, deep dish, water, marker, ruler, matches

Method

1 Set the candle in the dish as in the last activity.
2 Fill the dish with water and put in the candle and lid.
3 Light the candle and quickly put the jar over it. Mark the starting level of the water on the side of the jar **(a)**.
4 Let the candle burn until it goes out.
5 What has happened to the level of the water in the jar? Has it filled the jar? Has all the air been used up? If all the air hasn't been used, then why does the candle go out?
5 Make a mark for the final level of water **(b)**. By about what amount has the water risen? Use your ruler to find out.
6 You will find about 20% of the air has been used up. So which gas do you think has been used for burning?

15.24 Combining oxygen with copper

Your teacher may do this activity or you view it online. An amount of 100 cm^3 of air is passed over heated copper, first from left to right, and then back again, continuously. The golden copper will change to black copper oxide.



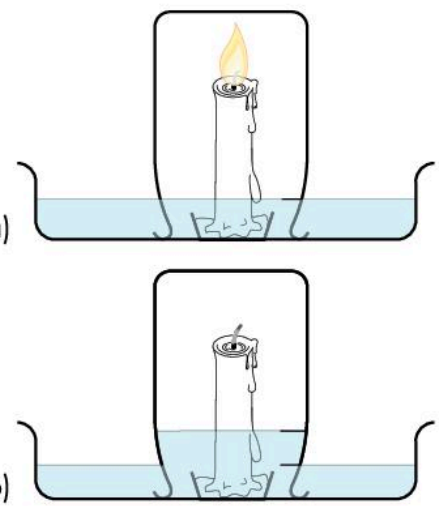
Questions

You can use the pictures on page 179 to help you answer these questions.

1 (a) What amounts of which gases are not changed as air is taken into the body and then breathed out?
(b) Which gases do change their percentages?

2 What is the main cause for the differences between inhaled and exhaled air? Explain your answer.

(a)



(b)

Copper and oxygen

Copper is a golden colour. A syringe with 100 cm^3 of air is passed continually over heated copper (backwards and forwards) between the syringes. The copper combines with oxygen to make copper oxide (black). When there is no more change, you will find about 20 cm^3 of the air (the oxygen) has been used up to combine with the copper.

Properties and uses of oxygen

Properties Oxygen is colourless and has no smell. Its density is similar to that of air. It is very active and combines with many substances. It is needed for the combustion of carbon-containing fuels (burning and respiration). Oxygen is produced by green plants during photosynthesis and is essential for life for all organisms. It is partly soluble in water where it provides a source of oxygen for aquatic animals and plants.

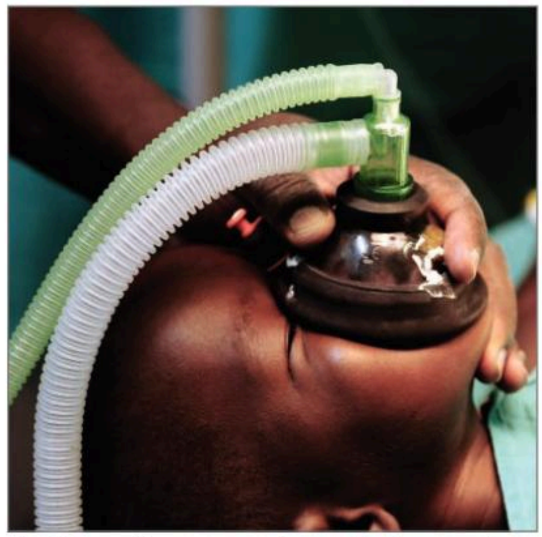
Uses Most of its uses depend upon the fact that it is needed for combustion and combining with metals to make oxides.

- Burning of fossil fuels, such as gasoline, kerosene and coal.
- Respiration of food in the cells of all living things.
- In extreme environments, such as underwater, when climbing high mountains and when exploring in space. In these cases, tanks and breathing masks are required to supply air with a greater proportion of oxygen for breathing.
- In hospitals. During operations a mixture of oxygen and anaesthetic gases is given to the patient. Some patients also receive pure oxygen inside special chambers to help speed the healing process if they have had gas poisoning or burns. Patients with respiratory diseases are cared for in 'oxygen tents' where the air contains an additional amount of oxygen.
- Pure oxygen is used in rockets to burn the fuel. This is because there is no air in outer space for them to use.
- For welding. Pure oxygen is used to burn gases such as acetylene in a special blowtorch. The mixture produces a very high flame temperature that can melt steel.

There is another use of oxygen: **rusting**. This is not useful for humans. It is an example of **corrosion**: chemical damage to the surface of a metal. It costs humans a lot of money to protect iron against rusting. Revise the work you did on carrying out fair tests to find the conditions necessary for rusting, and how to prevent it (page 51). Any iron object that is exposed to water and oxygen in the air, will rust.

Objects containing iron will rust with water and oxygen, unless the iron is specially treated or the surface is protected.

An underwater diver with an oxygen tank



A mixture of oxygen and anaesthetic gases is given during an operation

An oxy-acetylene torch being used

Questions

1 What is combustion?

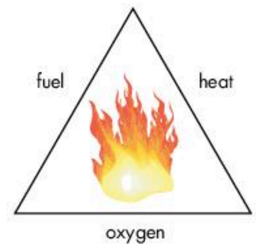
2 Choose one use of oxygen and prepare an illustrated account to share in class.

Properties and uses of carbon dioxide

Properties It is colourless, has no smell and is denser than air. It turns limewater milky by producing calcium carbonate. Carbon dioxide does not support burning. It is produced when living things respire and when fossil fuels are burned. Carbon dioxide is used by plants during photosynthesis.

Uses In fire extinguishers. We can take away:

- fuel: removed by turning off a source of gas.
- heat: removed by spraying the flames with cold water
- oxygen: removed by excluding air with a fire blanket or with carbon dioxide foam from a fire extinguisher.



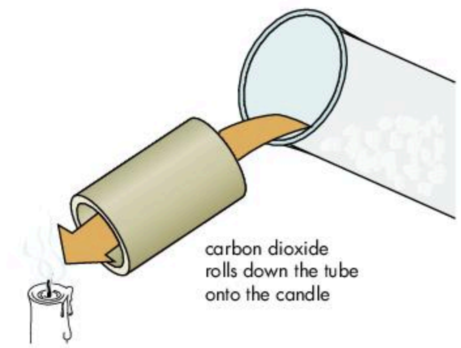
The fire triangle. Remove any of the three: fuel, heat or oxygen, to control a fire.

15.25 Making carbon dioxide

Materials: vinegar, jar, candle on a lid, matches, roll of cardboard, sodium hydrogencarbonate (baking soda)

Method

1 Light the candle.
2 Put a teaspoonful of baking soda in the jar. Pour in some vinegar. What happens?
3 Quickly tip the jar onto the flame. What happens?
4 Is carbon dioxide heavier than air? How do you know? Does carbon dioxide support combustion? How do you know?



Using carbon dioxide to put out a candle

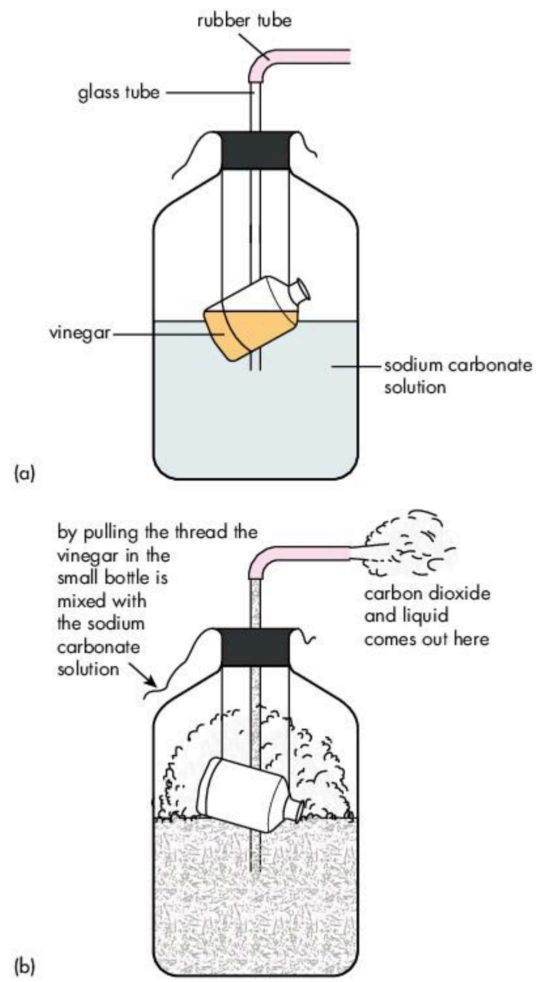
15.26 Make your own fire extinguisher

Materials: large bottle with a one-hole bung, small bottle to fit inside the large one, cotton thread, glass tube, rubber tube, water, vinegar, sodium carbonate (washing soda)

Method

Use the EDP to improve the following model fire extinguisher. Test your models and find the best one.

1 Three quarters fill the large jar with sodium carbonate dissolved in water.
2 Tie threads to the top and bottom of the small bottle.
3 Fill the small bottle with vinegar and slowly lower it into the large one. The mouth should be just above the liquid level.
4 Add the bung with the nozzle.
5 Go outside. Pull the thread attached to the bottom of the small jar. Explain what happens.



Making a fire extinguisher. How can you improve this model to make a better one?

Other uses of carbon dioxide are:

- To keep things cool. Solid carbon dioxide is very cold and it can be packed around things to keep them cool. It is called 'dry ice' because it changes directly from solid to gas (it sublimes) without making a wet liquid.
- To put the 'fizz' in sodas. Carbon dioxide is forced into drinks to make them fizzy. As the gas escapes the drinks go 'flat'.

Properties and uses of nitrogen

Properties It is colourless and has no smell. Its density is similar to that of air. It is the most abundant gas in the air. It is not very reactive: it does not combine easily with other substances. It does not support burning and does not turn limewater milky.

Uses Nitrogen is used on its own, and to make compounds.

- Nitrogen gas becomes a liquid at a very low temperature (–196°C). Liquid nitrogen is used to fast-freeze food to preserve it.
- Liquid nitrogen is applied at a clinic to precancerous growths, warts etc., and can freeze and remove them.
- Nitrogen is needed for plant growth, to make proteins. But plants cannot take in nitrogen gas; it first has to be made into compounds such as nitrates. This mostly happens in the soil. The plants then take in the nitrate salts dissolved in water in through their roots.
- Nitrates are also made commercially. Nitrogen is combined with hydrogen gas to make ammonia. This is then made into ammonium nitrate to be put into the soil as a fertiliser.
- Nitrogen is also used to make explosives and nitric acid.

Properties and uses of the noble gases

Properties They are colourless and have no smell. Helium is much less dense than air, but the others are denser. They are very inactive. They were called 'inert' gases, as it was thought they did not form any compounds. However, chemists have now made them combine with some other elements. This is why they are now called 'noble' gases.

Uses Their uses depend upon their properties.

- Argon, the commonest noble gas in the air, is used to fill incandescent light bulbs. As it is so unreactive, it can allow the filament wire to get very hot without burning.
- Helium is the lightest gas (after hydrogen). It is therefore used to fill toy balloons, weather balloons and airships. It is safer than hydrogen as it does not combine with oxygen, which would be a fire risk. Helium is also used by deep-sea divers as a mixture of 20% oxygen to 80% helium.
- Neon and krypton are used to fill tubes in advertising signs. When an electrical charge is passed through them, neon glows with an orange-red light, and krypton with a bluish-white light.

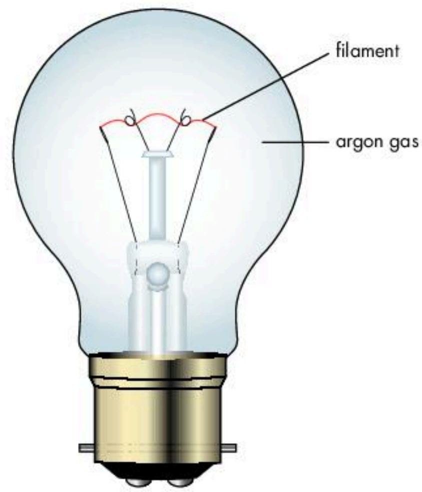
Questions

Refer to the structure of their atoms on page 95.

1. Why do you think the noble gases are so unreactive?
2. List the gases in the air that do not support combustion. Prepare a table to show how to distinguish them. Include physical properties, such as boiling point, and their chemical activity.

Questions

1. Why is it important that nitrogen does not support burning?
2. Research and write a report on how nitrogen can be used to produce fertilisers. Why is this important (a) for plants, (b) for animals? **ICT**



Argon is used to fill incandescent bulbs

Helium is used to fill balloons. Notice the streamlined shape

Neon is used in advertising signs

▶ **See Workbook Air: gases and uses.**

15.27 Gases in the air

Work in groups:

1 Research the chemical tests for oxygen, carbon dioxide and water vapour. ICT

2 For each of the three gases, what reactions could you carry out to produce pure samples? Here are some hints, but you have to draw the equipment needed, explain how it is set up and how you will show the positive tests for each gas.
   (a) Oxygen. This is produced by plants during photosynthesis in the light.
   (b) Carbon dioxide. You produced some in the fire extinguisher. How could you set up the equipment to produce carbon dioxide and find a way to test it?
   (c) Plants (in transpiration) and animals (when sweating) produce water vapour into the air. How could you test either of these with the correct chemicals?

3 Talk through your ideas and make rough plans. Do your research and also check back through this book to give you ideas. Then make clear, well-labelled drawings of the equipment you would use and how you could test each of the gases with the correct chemicals.

4 Research how the gases of the air are separated from each other. Find out why the air is first made into a liquid. How are changes of state important in the separation process? Why is it possible for nitrogen and oxygen be separated from each other? ICT

5 (a) Which of the gases of the air can be a pollutant if its concentration increases?
   (b) What processes carried out by humans might cause this gas to increase? Research and report on the pollution problem and what might be done about it. ICT

6 Research and list as many places as you can where humans have to take oxygen supplies with them. Consider (a) how is the oxygen transported and how is it delivered to the person? (b) the difficulties of humans staying for long periods in these surroundings. ICT

7 Prepare a podcast or wiki to sensitize the school community about the gases in the air.

Carbon dioxide is produced from fire extinguishers to exclude oxygen and therefore to stop burning. This demonstration shows how it is used. For a larger fire, water at high pressure is used to cool the gases and put out the fire.

15.28 Air pollution

Research gases and other materials in the air that would be considered pollutants. ICT

1 Make your list. You can include dust and pollen and other allergens.

2 For each one, find out where it was produced, e.g. sulphur dioxide from the burning of fossil fuels.

3 Find out its bad affect on plants, and humans and other animals.

4 Brainstorm ways in which it might be reduced or its production avoided.

5 Research how polluted air can help to cause respiratory diseases in humans. How are polluted air and smoking cigarettes related? ICT

▶ **See Workbook Air: gases and uses.**

Quick check ☑

The most common gas in the air is ________ . The gas that supports combustion is ________ , and the gas that we use in fire extinguishers to put out fires is ________ , which can also be a ________ . The noble gases are used, for example in balloons (________), incandescent bulbs (________) and advertising signs (________).

Use these words to fill in the spaces as you write the sentences in your Exercise book.

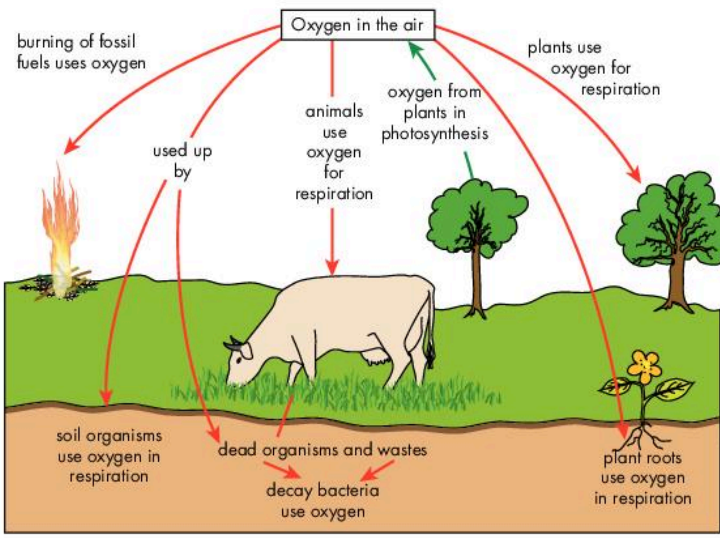
argon **carbon dioxide** **neon** **nitrogen** **oxygen** **pollutant** **helium**

Air: recycling of gases

You saw on page 166 that water vapour in the air is replenished through the water cycle. There are similar cycles for oxygen, carbon dioxide and nitrogen. These gases are used and returned to the atmosphere by living things.

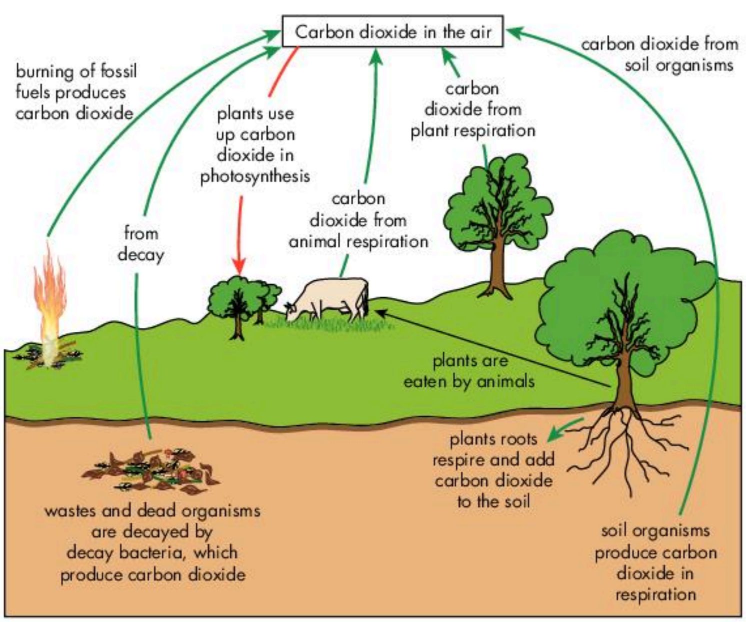
The oxygen cycle

List the processes that (a) use up and (b) produce oxygen. Write your own account of the oxygen cycle.



The carbon cycle

List the processes that (a) use up and (b) produce carbon dioxide. Write your own account of the carbon cycle.



Objectives

- Describe and illustrate the processes involved in the oxygen, carbon and nitrogen cycles.
- Realise how humans affect the natural cycles.
- Set up a terrarium and describe how the gases are recycled.

Fun facts

- Over half of the world's oxygen is produced by plant plankton that live in the oceans.
- Bamboo can grow 120 cm in 24 hours. An area of bamboo releases 35% more oxygen than the same area of trees.
- Carbon dioxide is produced from burning fossil fuels such as coal and oil.

TS 15.29 Cycles

Work in groups and choose either the oxygen or carbon cycle.

1 Use information from discussion, the internet, textbooks, multimedia and/ or graphic software to collect information on the oxygen or carbon cycle. ICT
2 Brainstorm, plan and create a model of the oxygen or carbon cycle.
3 Write a report on the importance of the two cycles and display your models.
4 How can humans upset these cycles? Why is this a problem?

Questions

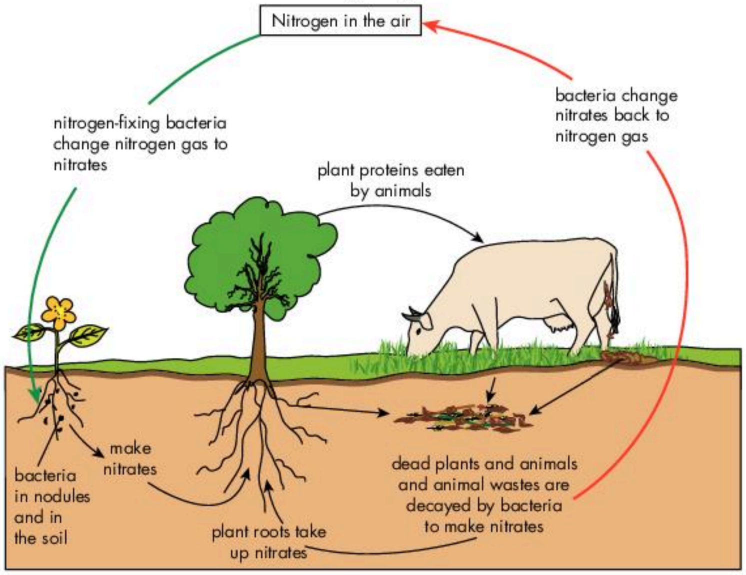
1 What is the only process that (a) produces oxygen and (b) uses up carbon dioxide?
2 Why is it so important to replant trees (reforestation) after some have been harvested for use?
3 Why would it be good to grow more bamboo in Jamaica? Research the 'Bamboo project and list some uses.

The nitrogen cycle

Plants, animals and soil organisms use oxygen for respiration, and plants use carbon dioxide for photosynthesis. But very few organisms can use the nitrogen gas in the air. It has to be in the form of compounds, such as **nitrates** and **proteins**.

There are different bacteria in the soil that change nitrogen to nitrates during **nitrogen fixation**. The plants then take in and use the nitrates to make proteins. The animals then eat the plants, or animals that have eaten other animals, and they get their nitrogen compounds as proteins.

Wastes and dead organisms are decayed and return nitrates to the soil. Some nitrates are changed by different bacteria back into the nitrogen gas in the air.



Questions

1 Nearly 80% of the air is nitrogen so how do (a) plants and (b) animals use it?
2 How do these bacteria affect the recycling of nitrogen?
(a) Decay bacteria, (b) Nitrogen-fixing bacteria.
3 How do humans affect the nitrogen cycle by (a) adding fertilisers and (b) removing crop plants when they have grown?

PS 15.30 Root nodules

Materials: seedlings or plants of red pea, cowpea or any bean, hand lens, water

Method

1 Carefully wash the soil from the roots in the jar of water.
2 Use your hand lens to look at the roots. Find small bumps called nodules.

Bacteria live in the soil and in the nodules of beans and peas (legumes). They can change nitrogen gas into nitrates. This is nitrogen fixation.

TS 15.31 A terrarium

A **terrarium** is a sealed container with soil, plants and small animals. The natural cycles of oxygen, carbon, water and nitrogen should make it self sufficient.

1 Research the idea of a terrarium and which plants and animals it would be good to use. ICT
2 Make sure there is enough food for the animals and enough moisture to be recycled.
3 Make your plans and check with your teacher. Design your system and set it up. (Note remove the stopper if the anaimls seem distressed by lack of oxygen.)

▶ **See Workbook Air: recycling of gases**

Quick check ☑

The only process producing ________ is photosynthesis during the daytime. Decay, ________ and ________ all use up ________ and release carbon dioxide. Only a few organisms can use ________ from the air. Most organisms need to take in ________ (plants) or proteins (animals).

Use these words to fill in the spaces as you write the sentences in your Exercise book.

combustion **nitrates** **respiration** **nitrogen** **oxygen**

Questions

Answer these questions in your notebook

For questions **1–37** answer A, B, C or D.

1 An artesian well is sunk down to
A the water table
B an aquifer
C impermeable rock
D all of the above

2 A geyser is most like a
A hot spring **B** lake
C well **D** river

3 The process of humans adding water to the aquifers in the wet season is called artificial
A cycling **B** recycling
C water cycle **D** recharging

4 The **main** process by which water enters the atmosphere is
A evaporation **B** transpiration
C respiration **D** sweating

5 The **main** process that occurs in the clouds is
A evaporation **B** condensation
C freezing **D** all of the above

6 A tomato is about 92% water. How much water would I get from eating two tomatoes?
A Exactly 92 g water
B About 90 g of water
C About 180 g water
D There is insufficient information

7 Yam is 23% carbohydrate and 2% protein. The rest is water. What is the % of water in yam?
A 25% B 75% C 25 g
D There is insufficient information

8 Which process in plants is most similar to sweating in animals?
A germination **B** respiration
C transpiration **D** photosynthesis

9 Which of these things would NOT be caused by transpiration of leaves taken from a plant?
A decrease in size
B increase in size
C decrease in mass
D becoming shrivelled up

10 Why can a spider walk on water. Because of
A cohesion
B adhesion
C surface tension
D its large feet

11 What happens when water freezes?
A the water molecules take up more space
B the water molecules take up less space
C the ice becomes heavier than water
D the ice sinks because it is very cold

12 Which of these objects is most likely to float?
A block of modelling clay
B sheet of modelling clay
C hollow metal bowl
D metal coin

13 390 g of a sample of water had a volume of 300 cm^3. The sample is MOST likely to be
A rain water **B** distilled water
C seawater **D** fresh water

14 How do we find out the chemical formula of water? By using a
A Hofmann voltameter to pass electricity through water containing a little acid
B Hofmann voltameter by passing electricity through strong salt solution
C Liebig condenser to produce distilled water
D powerful microscope to look at the particles

15 Why do water molecules attract each other? Because they
A are positively charged
B are negatively charged
C do not have charges on them
D each have positive and negative charges

16 The attraction between water molecules is called
A cohesion **B** transpiration
C adhesion **D** respiration

17 Which of these forces is NOT involved in transport in plants?
A cohesion **B** respiration
C adhesion **D** transpiration

18 What substances do plants take from water?
A oxygen only
B carbon dioxide only
C oxygen, carbon dioxide and water
D oxygen, carbon dioxide, salts and water

19 Which of theses processes depends on a property of water?
A density
B surface tension
C sea and land breezes
D all of the above

20 If a solution of salt in distilled water is filtered, what will the residue be?
A Salt **B** Water **C** Salt and water
D There will be no residue

21 If a mixture of sand in distilled water is filtered, what will the residue be?
A Sand **B** Water **C** Sand and water
D There will be no residue

22 How do we kill micro-organisms? With
A carbon **B** oxygen
C chlorine **D** hydrogen

23 Which of these is a pollutant of water?
A fertilisers **B** acid rain
C pesticides **D** all of the above

24 Which of these processes would NOT remove solid substances from water?
A sieving **B** boiling
C adsorption **D** filtering

25 Which of these processes would produce the purest water?
A boiling **B** sieving
C distilling **D** filtering

26 Which household activity uses the most water?
A washing **B** drinking
C cooking **D** flushing toilets

27 What is a major use of water for industry?
A cooling hot materials
B washing
C in fruit juices
D making paper

28 Which of theses is a way of conserving water? Using
A a cloche **B** mulch around trees
C hydroponics **D** all of the above

29 Which is the commonest gas in the air?
A carbon dioxide **B** oxygen
C nitrogen **D** neon

30 What percentage of the air is oxygen?
A 0.03% **B** 1% **C** 21% **D** 80%

31 What is the main cause of air pollution? Burning
A wood **B** fossil fuels
C charcoal **D** rubbish

32 Which part of the air does heated copper combine with?
A carbon dioxide **B** nitrogen
C oxygen **D** all of the air

33 Which gas is used in fire extinguishers?
A carbon dioxide **B** oxygen
C nitrogen **D** helium

34 Which gas supports combustion?
A carbon dioxide **B** nitrogen
C oxygen **D** all of the air

35 Which gas is used in advertising signs?
A argon **B** neon
C nitrogen **D** helium

36 Which is the only process that produces oxygen?
A combustion **B** photosynthesis
C decay **D** respiration

37 What do nitrogen-fixing bacteria do?
A make nitrogen gas into proteins
B make nitrogen gas into nitrates
C make nitrates into nitrogen gas
D make nitrates into nodules

For questions **38-61** write the answers in your notebook.

38 (a) Describe what is meant by aquifers.
(b) Describe one way they could be recharged.

39 (a) What happens during evaporation?
(b) List four places where evaporation occurs.

40 (a) What happens during condensation?
(b) List two places where condensation occurs.

41 Write down a property of water. Explain how this property is important to (a) plants and (b) animals that live in water.

42 How can a mosquito walk on water?

43 Why do objects (a) float in water and (b) sink in water?

44 An ice cube floats in tap water. If it is put into seawater will it float higher or lower? Why?

45 (a) Give three examples of solutes.
(b) Explain how one of them is important for plants or animals.

46 How do fish get (a) oxygen and (b) food from the water in which they live?

47 How are (a) adhesion, and (b) cohesion important in raising water and salts in plants?

48 Describe how soil can be separated from water. Would it then be safe to drink? Explain your answer.

49 How can pure fresh water be obtained from sea-water?

50 Write five sentences to say what you have learnt about the importance of water in this unit.

51 (a) What is the atmosphere?
(b) Give two reasons why it is important.

52 Would a candle burn for a longer time in inhaled than exhaled air? Explain your answer.

53 (a) Describe three uses of oxygen.
(b) Describe three uses of three different named noble gases.

54 How and why does a simple fire extinguisher work?

55 How do (a) fertilisers (b) sewage and (c) crude oil affect water? How could each be dealt with?

56 Describe the stages from the use of fossil fuels in a power station to dead fish in a nearby pond. Illustrate your answer.

57 Write ten hints for water conservation.

58 In the oxygen cycle list the processes that (a) produce oxygen and (b) use up oxygen.

59 How are the oxygen and carbon cycles related to each other?

60 Why do farmers include a crop of beans or peas in their rotation of crops?

61 Write five sentences to say what you have learnt about the importance of air in this unit.

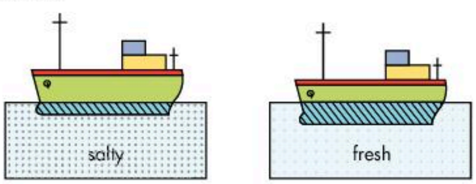
Key ideas

- Aquifers are an important underground source of water. They can be artificially recharged.
- Fresh water above ground is replenished by the water cycle.
- Plants need water: for transport of mineral salts and food, for germination, photosynthesis, support and for cooling the plant by transpiration.
- Humans need water: for transport in the blood, for digestion, for gas exchange and for cooling the body by sweating.
- Pure water has no smell, taste or colour. It boils at 100 °C and freezes at 0 °C.
- Many of the uses of water depend upon it being a good solvent.
- Solutes raise the boiling point and lower the freezing point of water, so it remains liquid over a wider range of temperatures.
- Water is a good solvent of many important solutes, such as oxygen, carbon dioxide and simple food molecules.
- Density is mass divided by volume (g/cm^3)
- A block with a density of more than 1 g/cm^3 will sink in fresh water. If the density is equal to or less than 1 g/cm^3 it will float in fresh water.
- Salt water has more buoyancy than fresh water.
- Ice is less dense that water, and floats.
- Liquid water remains under a covering of ice.
- Air is a mixture of gases: 78% nitrogen, 21% oxygen, 0.9% argon and 0.03% carbon dioxide.
- Exhaled air contains less oxygen (17%) and more carbon dioxide (4%) than inhaled air.
- Oxygen is important for combustion (the respiration of living things and the burning of fossil fuels). It has medical and industrial uses.
- Carbon dioxide does not support combustion and is used in fire extinguishers to put out fires.
- Nitrogen is used for freezing food, and to make ammonia, nitric acid and nitrate fertilisers.
- Noble gases are used for lighting and balloons.
- Oxygen, carbon dioxide and nitrogen from the air are recycled by various processes.
- Water needs to be conserved in the home and by industry and agriculture.
- We need to reduce, reuse and recycle.
- Various pollutants are produced, mainly by the activities of humans, which can damage water supplies and the atmosphere.

▶ **See Workbook Water and the Earth's atmosphere.**

Problems

1 Your group will design a chart on the properties of water. They decided to include illustrations. Here are the statements they chose, but you should add some more and prepare your own chart.
Explain each of the following observations.
(a) Water molecules attract each other.
(b) A mosquito can walk on water.
(c) Boiling water can be used to make tea.
(d) Crude oil spills float on water surfaces.
(e) Animals can live underwater.
(f) A metal coin sinks, but a metal ship floats.
(g) Ice floats on water.
(h) If a boat gets a hole in it, it will slowly sink.
(i) A ship floats higher in seawater than in fresh water.



2 The class was having a discussion on, 'What is pure water?' Here are some of the students' ideas. Do you agree with any of them? Make up your own definition.
'Pure water' is:
- water that has been filtered
- water that has been boiled
- water that looks and smells clean
- water with melting point 0 °C and boiling point 100 °C
- water vapour produced from boiling water that is then condensed.

3 Another group decided to find out about the micro-organisms that might be in unclean pond or stream water. They researched the Internet and other resources and made a list of six important water-borne diseases. They then chose one each to do further research on causes, symptoms, precautions and treatment. Then they each produced a one-page sheet to go into a class book: 'Water-borne diseases'. Your group can do the same. **ICT**

Answers to Quick check

Working like a scientist (2)
Page 10
We study science as part of **STEAM**. Scientists use the scientific **method** to set up fair **tests** so they can trust their results. Scientists manipulate the **independent** variable. **Technologists**, e.g. **engineers** use **EDP** to make new things to solve problems.

Page 14
We need **safety** rules to protect people, **equipment** and surroundings. Measuring **equipment** has **scales** with different values. The main heating **equipment** is the **Bunsen** burner. For filtering we use special **filter** paper that acts like a **sieve** to separate substances.

Page 23
Data in words is **qualitative**; numerical **data** is **quantitative**. A bar chart has only one **quantitative** variable. A line **graph** shows the relation between two **quantitative** variables. A **pie** chart shows the parts of a whole. We can use **Excel®** to make displays of **data**.

Unit 8 Photosynthesis and energy relationships
Page 31
Chlorophyll in the chloroplasts absorbs light energy, and makes it available for **photosynthesis**. **Carbon dioxide** gas is taken into the leaves, and **water** and mineral salts enter by the roots. Sugars are made that quickly change to **starch**. **Oxygen** gas is released that passes out of the leaf.

Page 39
Living things need **energy** to stay alive. Food **chains** and webs are how organisms **feed** on others. **Producers** are at the beginning of all food **chains**. Various levels of **consumers** depend on them. Raw materials are **recycled** in a food web. **Energy** is not recycled.

Page 41
A food web in nature stays in **balance**. If a certain **organism** increases in numbers it will be **eaten** by another one. Humans and natural **disasters** can upset the **balance**. It may take many **years** or it may be impossible to **revers**e the damage, e.g. to coral reefs.

Unit 9 Physical and chemical changes
Page 48
Only pure substances have **fixed** melting and boiling points. Pure substances have one kind of particle and are **elements** and compounds. They are made of **atoms** or **molecules**. Impure substances are **mixtures**; they have **two** or more kinds of particle.

Page 53
A physical change does not produce **new** substances; it only affects **physical** properties. A **chemical** change produces **new** substances with **different** properties. A change in **state** is a **physical** change. The formation of **rust** is a **chemical** change.

Page 63
Substances are **elements**, mixtures and **compounds**. Mixtures are of different kinds depending on the **state** and **sizes** of their parts. Mixtures can be separated by **filtering**, evaporation, chromatography, a magnet and **distillation** depending on the properties of their components.

Unit 10 Human nutrition
Page 73
The main food nutrients are **proteins**, carbohydrates and **fats**. Vitamins and **minerals** are important, and also water and **fibre**. **Fats** give a translucent stain on paper. Starch turns blue-black with **Iodine** solution. Proteins turn purple with the **Biuret** test. Simple sugars, such as glucose, turn red with the **Benedict's** test.

Page 81
Physical digestion occurs because of the **teeth**, **stomach** muscles and **bile**. Chemical digestion occurs because of **enzymes** and occurs mainly in the small **intestine**. Soluble food molecules then pass through the walls of the **villi** and into the **blood** to the **liver**. Waste food material is egested as **faeces**.

Unit 11 More about matter
Page 91
Particles are close together in **solids**; particles in gases and **liquids** can **diffuse**. **Particles** in elements can be **atoms** or molecules. The proton is **+ve** and the electron is **–ve**. The number of protons equals the **atomic** number. **Atoms** are neutral. An ion is **–ve** or **+ve**.

Page 96
The atomic number is the number of **protons** in the atom. The mass number equals the number of **protons** plus the number of **neutrons**. The **electrons** are arranged in **shells** around the nucleus. Elements are arranged in **groups** in the **periodic** table.

Page 104
Metals are good conductors of heat and electricity; non-metals are **poor** conductors, except for **graphite**. **Alloys** are a mixture of metals. Metals **lose** electrons to become **+ve** ions; non-metals **gain** electrons to become **–ve** ions.

Unit 12 Forces and motion
Page 120
If the forces are balanced then the object stays at **rest** or continues at a steady speed unless acted on by another **force**. The downward force due to gravity is **weight**; on land an object is supported by an **equal** and opposite **upward** force. The force between touching surfaces is **friction**. In water and air the upward force is **upthrust**. Air and water resistance to movement are called **drag**.

Page 124
A **force** can be used to move another **force**. The **force** doing the work is called the **effort** and the **force** moved is the **load**. Movement occurs around the **fulcrum**. There are three classes of **lever** and these are also found in the human **body**.

Page 129
An object at rest or moving has **inertia**: it continues as it is unless acted on by an **unbalanced** force. Distance is a **scalar** quantity and displacement is a **vector** quantity. Speed is measured in **m/s** and **velocity** is speed in a certain direction. The rate of change of velocity is **acceleration**, a **vector** quantity measured in **m/s/s**.

Unit 13 Gas exchange and respiration
Page 139
Breathing is the movements of the ribs and diaphragm. Gas exchange takes place in the **alveoli**. Air rich in **oxygen** is taken in, and air with more **carbon dioxide** is passed out. Inflammation and infections can cause **lung** diseases; **smoking** is a major cause.

Page 141
Respiration occurs all the time to release energy from food. **Anaerobic** respiration occurs without oxygen, and in muscles produces **lactic acid** and in **yeast** produces carbon dioxide and **alcohol**. Aerobic respiration is completed in the **mitochondria** and releases additional energy

Page 142
Photosynthesis occurs only in the **day** time in green plants. It uses the Sun's **energy**. **Respiration** occurs all the time. **Carbon dioxide** and water are used in **photosynthesis** and produced in **respiration**. **Oxygen** and food are produced in **photosynthesis** and used in **respiration**.

Unit 14 Space science
Page 149
The Universe contains billions of **galaxies** each one containing billions of **stars**. Only the **stars** produce light. The **stars** can be seen in groups called **constellations**. Distances in space are measured in **light-years**. **Planets** can **orbit** a star, and many of these may have **natural satellites** that **orbit** them.

Page 155
The largest planet in our Solar System is **Jupiter** and the smallest is **Mercury**. **Motion** and **gravity** keep the Solar System together. In a **solar** eclipse the Moon is between the Sun and the Earth; when the **Moon** is in shadow it is a **lunar** eclipse

Page 159
Rockets are needed to launch satellites, space probes and **spacecraft**. Satellites are used for communication, **observation** and **navigation**. Astronauts train with **simulations** to prepare them for space. When returning from the Moon, the **escape** velocity is less than on Earth.

Unit 15 Water and the Earth's atmosphere

Page 172

Water circulates in the water **cycle**. **Aquifers** are porous rocks containing water. Water molecules are **H_2O** and their charges are attracted to surfaces (**adhesion**) or each other (**cohesion**). Water habitats are called **aquatic**. Water has many uses because it is a good **solvent** for **solids** and **gases**. Water is used in living things and in agriculture and **industry**.

Page 178

Activities of humans often **pollute** our water, e.g. with **oil**, **pesticides** and **fertilisers**. Insoluble substances can be **filtered** from the water. Boiling and **chlorination** kill micro-organisms. It is important that we also **reduce** and **recycle** water. Agriculture can also use irrigation, **cloches** and **hydroponics**.

Page 184

The most common gas in the air is **nitrogen**. The gas that supports combustion is **oxygen**, and the gas that we use in fire extinguishers to put out fires is **carbon dioxide**, which can also be a **pollutant**. The noble gases are used, for example in balloons (**helium**), incandescent bulbs (**argon**) and advertising signs (**neon**).

Page 186

The only process producing **oxygen** is photosynthesis during the daytime. Decay, **combustion** and **respiration** all use up **oxygen** and release carbon dioxide. Only a few organisms can use **nitrogen** from the air. Most organisms need to take in **nitrates** (plants) or proteins (animals).

Glossary and Index

Here is a description of important terms and the main places to find them in the book.

Atmosphere Protective layer of air around the Earth. Contains gases important for life, 179
Atom A single neutral particle; smallest particle that can take part in a chemical reaction, 48, 88; structure of, 89–95, 102, 106
Atomic number This is the same as the number of protons in the nucleus of an atom, 90, 92, 95, 102
Attitudes How we approach our work, e.g. curiosity, perseverance, 2, 5

Bacteria Single-celled micro-organisms that can cause disease, 139, 176; in the soil, 35, 185–6
Balance Lever-arm balance that is used to measure mass, 12
Balanced and unbalanced diet Need a healthy mix of food nutrients in the right amounts, 67, 70–1; and deficiency diseases, 71
Balanced and unbalanced forces Balanced forces do not change motion; forces that are unbalanced can cause motion, 108–10, 113–18
Bar chart A way of representing results by drawing bars to show the numbers of things, 15, 16, 17, 19
Base ten Counting system using ten digits: 0 and 1–9, 9
Base two or binary Counting system using two digits: 0 and 1, 9
Base units The units identified in the SI systems from which other units are derived, 12
Bile Produced in the liver it emulsifies fats into small droplets, 77, 79
Binary code Counting in base two using 0 and 1; used in computer systems, 9
Biomass The amount of living material, e.g. at one trophic level in a food chain, 38
Boiling point Temperature at which a pure substance rapidly changes from a liquid to a gas: 100°C for pure water, 47, 88; kills micro-organisms, 176
Bonds Formed between elements in a chemical change, 53
Breathing Movement of the rib cage and diaphragm to take air in and out of the lungs, 134–5
Bronchi Main branch from the trachea into the lungs, 134
Bronchioles Small branches from bronchi; they end in alveoli, 134
Brownian movement The movement, e.g. of dust particles as they are pushed around by invisible air particles, 85, 86
Bunsen burner Source of heat; gas burns with a blue or yellow flame, 13
Buoyancy The supporting force of water; the upward push of a liquid on an object, 112, 113, 116, 171

Cancer Uncontrolled growth of cells, e.g. in lungs, 139
Canines Teeth used for tearing food, 74; structure of, 74
Capillary action Process by which water and dissolved substances rise up narrow xylem vessels due to adhesion and cohesion, 168, 169, 170
Carbohydrates Nutrients supplying energy, e.g. starch and sugar, 68–9; made by plants, 29; elements in, 55; tests for, 72–3; digestion of, 75–80
Carbon cycle Processes by which carbon dioxide in the air is recycled, 37, 142, 185
Carbon dioxide Used in photosynthesis: 29; produced in respiration, 140–2; in air, 135–6, 179; produced in burning, 182, 185; exchanged in alveoli, 135; properties and uses, 182; test for, 136, 140, 184
Carnivores Animals that eat other animals, 34–5, 38–9, 75
Cell respiration Respiration occurring in all living cells, 81, 140 *see* Aerobic and Anaerobic
Cells Building blocks of living things, 81, 141
Centrifuging Using the spinning action in a centrifuge to separate components of different density, 63
Change of state The process by which one state changes into another; a physical change, 49, 88
Chemical change Makes a compound; cannot be easily reversed, e.g. lighting a match, and new substances are formed, 49–53
Chemical digestion Breakdown of food into soluble particles using enzymes, 76–80
Chlorination Process used to kill disease-causing micro-organisms in water, 175, 176
Chlorine A non-metal gas; a halogen, 85, 93, 95, 96, 97, 101, 175
Chlorophyll Green pigment in chloroplasts in plant cells; needed for photosynthesis, 30
Chloroplasts In green plants contain chlorophyll, 28, 30
Chromatography A method used to separate substances with different solubility, 59, 63
Chronic respiratory diseases Long-standing diseases of the respiratory system, e.g. bronchitis, emphysema, 133, 138–9
Cigarette smoking Can cause respiratory diseases, 138–9, 144

Ions Charged particles, formed when an atom loses (+ion) or gains (-ion) one or more electrons, 91
Irrigation Artificial application of water to plants, 178
Isotopes Atoms of a particular element that have different numbers of neutrons, 93

Kinetic theory Matter is made of particles that are in constant motion, 87–8
Knowledge and Comprehension (KC) Recalling and understanding of science content, 2–4

Lamina The flat blade part of a leaf, 23, 28
Land and sea breezes Convection currents set up near the shore, 171
Leaves The green parts of plants where photosynthesis and transpiration occur, 28–31
Legumes Peas and beans. With nuts, they form an important food group for plant proteins, 67, 69; used to provide nitrates in the soil, 186
Length How long something is; base unit is the metre (m), 11, 12, 126, 127
Lever Solid bar with a turning point (fulcrum) around which a load is moved by an effort, 121–4, 124
Lever-arm balance Used in the laboratory to measure mass, e.g. in g and kg, 35
Lift Upward force of air that travels quickly over an aerofoil in planes and birds, 117, 119
Light energy Waves of radiation that we can see; important for photosynthesis, 30
Light-year The distance that light can travel in a year: 9.5 million, million km (9.5 x 10^{12} km), 147
Limewater Calcium hydroxide solution. Used as a test for carbon dioxide; it goes milky, 136
Line graph A display that shows how one variable changes in relation to another, 17, 21, 22
Liquids Particles are close together, but can move amongst each other, 86, 87, 88
Liver Makes bile and keeps blood composition constant, 77, 80–1; disease of, 79
Living things Have certain characteristics, 32
Load Weight to be moved by a lever, 121–4
Luminous objects Ones that produce light, e.g. stars including the Sun, 146, 154
Lunar eclipse The Moon is in shadow; the Earth blocks the Sun's light from shining on the Moon, 154
Lungs Used for gas exchange in animals, 133, 134; and disease, e.g. bronchitis, lung cancer, 133, 138–9

Magnet Usually made of iron or steel that can attract other pieces of iron or steel; used in separation method, 52, 59, 63
Magnetic force The effect of magnets on each other and on iron and steel objects, 52, 110
Magnification Length of drawing divided by length of specimen, 23
Manipulated variable *see* **Independent variable**
Mass Amount of substance in an object the; base unit is the kilogram (kg), 11, 12, 111, 151
Mass number Number of protons and neutrons combined, equals relative mass of atom, 90, 92–3
Mastication Cutting and chewing of food, 75
Mathematics Manipulating numbers, reading scales and displaying and interpreting data, 2, 9, 11–12, 15–22, 26
Matter The material of which everything is made; can be living or non-living, 46–8, 86–8; in different states, 87–88
Measuring equipment Used to measure quantities using scales to record the size or amount of something, 11, 12
Mechanical digestion Breakdown into smaller pieces of the same kind (physical digestion), 67, 75
Melting point Temperature at which a pure substance changes from solid to liquid, 46, 88, 168
Metals Elements with only a few electrons in the outer shell; form positive ions, 85, 96–100, 102
Meteoroid A piece of rock from space being burned up in our atmosphere, 148, 150
Micro-organisms Bacteria and viruses, 176, 139, 189
Mid rib Central large vein in a leaf, 23, 28
Minerals Needed by plants to make proteins, 29; needed in small amounts by animals for health, 68–9
Miscible Liquids that mix, e.g. water and alcohol, and fractions of crude oil, 61, 62
Mitochondria Small structures in the cytoplasm where the final stages of aerobic respiration occur to release large amounts of energy, 141
Mixtures Two or more substances together; parts keep their own characteristics and can be separated easily, 46, 47, 52, 54; properties of, 56; classification of, 56–7; in body, 55; separation of, 58–63
Molars and premolars Teeth used for chewing food, 74
Molecules Made of two or more atoms joined together. Can be elements or compounds, 48, 88

Moon A natural satellite, e.g. the Moon orbits the Earth, 148, 154, 159; phases, 154; and eclipses, 154
Motion Movement brought about by unbalanced forces, 107, 108–10, 117, 125–8
Mouth Contains the teeth and saliva for digestion, 74–5, 79–80

NASA National Aeronautics Space Administration, for space exploration, 157
Natural satellite A natural body, such as our Moon, which orbits a planet, 149, 152, 153
Neon A noble gas used for coloured lighting, 95, 101, 183
Neutrons Particles in the nucleus of an atom. They have the same mass as protons, but are neutral, 89, 93
Newton (N) Unit used to measure force, 111
Newtonmeter *see* **Spring balance**
Nitrates Salts containing the nitrate radical; the form in which most plants take in nitrogen, 186
Nitrogen Gas which is 78% of the air, 135, 179; separation from air, 61; uses, 93, 101, 183
Nitrogen cycle Recycling of nitrogen in the air, 186; fixation of nitrogen to nitrates in the soil, 186
Noble gases Group 0: unreactive gases, e.g. helium, neon and argon, 95, 101, 102, 163, 179, 183
Nodules On the roots of beans and peas (legumes). They contain nitrogen-fixing bacteria, 186
Non-living things They do not feed, respire, have body wastes, move or respond to changes on their own, nor grow, develop or reproduce, 32
Non-luminous objects Do not make light and are only seen as they reflect light, e.g. the Moon, 146, 154
Non-metals Elements usually with a lot of electrons in the outer shell; form negative ions or share electrons, 85, 96–8, 101, 102
Nucleus Central part: of atoms, contains protons and neutrons, 89, 90, 94
Nutrition The process of feeding, 32; plants in photosynthesis, 29–30; humans, 67–81

Observation Using the senses, safely, to describe characteristics of living and non-living things, 7
Omnivores Animals that eat both plants and animals, 34–5, 75
Orbit Path taken by electrons around the nucleus of an atom: arranged in shells, 89; path that a planet takes around the Sun, or a satellite around a planet or moon, 149, 150–1, 156
Osmosis The movement of water through a membrane such as a cell membrane, 87
Oxygen Produced in photosynthesis, 30, 142; used in respiration, 142; and combustion, 180, 185; in air, 135–6, 179, 180; properties and uses, 93, 101, 180–1; test for, 30; separation from air, 61; and rusting, 51, 66
Oxygen cycle Processes by which oxygen in the air is recycled, 142, 185
Oxygenated blood Taken from the alveoli in the lungs in the pulmonary vein, 135

Pancreas Gland producing a digestive juice and insulin for glucose control, 77, 79, 80
Particles Small piece of matter, 47, 48, 86–88; *see* **Atoms**, **Molecules**
Pattern Regular results in data that can help us to interpret them, 15, 22
Percentage Parts out of a hundred, 16, 20
Periodic table Arrangement of elements according to their structure and properties, 94–6, 97, 102
Periods Rows in the periodic table with the same number of shells where atomic numbers increase one at a time from left to right, 94, 96, 102
Peristalsis Muscular contractions of the alimentary canal, which push food along, 76
Pesticides Chemicals that kill pests, 173
Petiole Leaf stalk, 23, 28
Photosynthesis Carried out by green plants in the day-time, 137, 142. Uses carbon dioxide, water, and energy from the Sun; produces food and oxygen, 27–31, 33, 34, 38, 39, 185; and respiration, 142
Physical change Makes a mixture; can be easily reversed, e.g. change of state, and no new substance is formed, 45, 48–50, 52–3
Physical digestion Breakdown into smaller pieces of the same kind (mechanical digestion), 67, 75
Pie chart A circle where the sectors correspond to the percentages of the parts, 1, 16, 20, 138, 179
Planets Bodies that orbit the Sun. They do not make light: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, 148, 149, 150–5
Plants Living things that can make their own food, 32, 34–5, 137; and importance of water, 167, 170–1
Plastics Made of repeated small molecules joined together, e.g. polythene, 101
Pollutants Mostly chemicals, such as pesticides and oil that cause harm to living things, 138,173, 184
Pollution Excess chemicals or heat that can harm living things or buildings; of water, 173; of air, 184

Sink To drop to the bottom of a fluid: weight is greater than upthrust, 112–3, 116
Skills Thinking and practical skills needed for science and technology, 2–3, 4–5
Smoking Using cigarettes or cannabis etc., 138–9
Sodium An alkali metal, 85, 95, 96, 99, 102
Solar eclipse The Sun's light is blocked by the Moon from reaching Earth, 154
Solar energy Energy from the Sun, 29, 146
Solar System The Sun and the eight planets and asteroids that orbit it, 145, 150–5
Solids Particles close together so that they wobble but do not move from place to place, 86, 87, 88
Solubility How easily a substance dissolves in another, e.g. oxygen and carbon dioxide in water, 137
Solute A substance that dissolves in another, 56, 168, 171
Solution A homogeneous mixture of substances, with one dissolved in the other; parts cannot be separated by filtering, 56–7, 168
Solvent A substance, e.g. water that dissolves another, 56, 168, 169, 170, 171; in industry, 172; in cleaning, 172
Space Beyond our atmosphere, 156–9
Spacecraft Usually with humans inside, to explore space, 156, 157–9
Space exploration Launching of artificial satellites, space probes and spacecraft to find out about conditions in space, 151, 156, 159, 162
Space shuttle Was a reusable vehicle that took satellites and modules into Earth orbit, 157
Space station Living accommodation and research laboratories in orbit around the Earth, 157
Speed A scalar quantity: distance travelled divided by time, e.g. m/s, 127
Spring balance Used to measure weight and other forces in newton (N), 111, 114
Staples Food groups containing root crops, rice, bread and pasta, 67, 68–9
Starch Carbohydrate made of glucose molecules; test for, 29, 72
Stars Bodies in space that make light from nuclear reactions, 146–7; in constellations, 148; may have planets orbiting them, 150, 155
States of matter The state of a substance at room temperature; solid, liquid or gas, 88
STEAM Studying Science as part of Science, Technology, Engineering, Art and Mathematics, 2–5
Stomach Wide part of the alimentary canal, 77, 79, 80
Stomata Small holes in a leaf's epidermis for gas diffusion, 27, 28
Streamlined A shape that helps a living or non-living thing move more quickly through air or water, 119, 120
Stretching Pulling on a rubber band, 111, 118
Sublimation Change of state direct from a solid to a gas, e.g. heating iodine crystals, 50
Sugars Simple carbohydrates, e.g. glucose; in photosynthesis, 29; test for, 73
Sulphur dioxide A pollutant that is the main cause of acid rain, 173
Sun The star at the centre of our Solar System. It produces light and heat, 150, 154
Surface tension Very thin supporting layer, e.g. on water surface, 168, 169, 170
Surface water Water, e.g. in streams, rivers, lakes, icebergs and the sea, 165, 166
Suspension Mixture with particles large enough to see with the naked eye, 56–7
Sweating Evaporation of excess water from the blood, which also cools the body, 165, 166, 167
Symbol A shorthand way of writing a chemical name, e.g. Cl for chlorine, 92

Table A record of words and numbers in rows and columns, 15, 16, 17, 18
Teacher-led Classrooms where the teacher decides the topics and activities, 3
Technological skills Designing and making skills that are part of EDP, 2–3, 5
Technology The use of raw materials to design and make new things for a certain purpose, 2–3, 5
Teeth Hard structures in the mouth that break food into pieces, 74–5; structure and care of, 74, 84
Telescope Instrument for magnifying, 146, 156
Temperature How hot or cold something is: base unit is kelvin (K), and degrees Celsius (°C) also used, 11, 12
Terrarium An enclosed space where oxygen, carbon dioxide and nitrogen are recycled, 186
Terrestrial habitat Found on land and in the soil, 32, 34–5, 38
Tertiary consumers They are carnivores, animals that eat secondary consumers, 34–5, 38–9
Thrust Forward force of motion, e.g. due to an plane's engine or bird's muscles, 117, 119
Time How long it takes to do something; base unit is the second (s), 11, 12, 127, 128
Trachea Tube (windpipe) from throat to the bronchi of the lungs, 134
Transition metals Common metals placed between Groups 2 and 3 in the periodic table, 97–9, 102

Transpiration Evaporation of water from the leaves, 28, 165, 166
Trend A pattern in results that can help identify anomalous results and predict other values, 15, 22
Trophic level Position of an organism in a food chain, 38–9
Twist A turning force, e.g. opening a tap, *see* **Forces**

Universe This contains all the matter and energy that exist, 146–7, 155
Upthrust Upward force of water (buoyancy) or air (air resistance and lift) that acts against the force of gravity, 116–7, 119
Use of Knowledge (UK) Thinking skills of science, e.g. analysis and interpreting, 2, 4

Variable A condition in an experiment, such as the amount of moisture, 7
Vector quantities Described by size and direction, e.g. displacement, velocity, 108, 125, 126, 127–8
Vegetables Provide vitamins, minerals and fibre, 68–9, 71
Vein Transporting tubes in plants, made of xylem and phloem, 28, 31
Velocity A vector quantity: distance covered in a certain direction (displacement) divided by time, 127–8; of planets, 127, 150; escape velocity, 156
Villi Finger-like outgrowths in the small intestine where digested food is absorbed, 78
Viruses Micro-organisms that can cause diseases, 139
Vitamins Chemicals in the food needed in small amounts for health, 68–9; Vitamin C test, 72
Volume Amount of space something takes up; measured, e.g. cm^3, 12
Vomiting Food pushed out through the mouth, 79

Water Compound of hydrogen and oxygen, 169; it is essential for life, 55, 68–9, 167, 170–1; uses, 29, 170–2, 176, 177; tests for, 167; states of, 88; properties, 112–3, 168–9; sources, 164–7; conservation, 176–8
Water cycle Circulation of water in nature, 165, 166
Water pollution Chemicals and heat that enter the water supplies and cause harm, 173
Water purification Removing pollutants from water, 163, 166, 174–6, 189
Water resistance Force of water that acts against forward motion, 117; reduced by streamlining, 120
Water table The level below which the soil and rocks are saturated with water, 164, 165
Weight The downward force with which an object is attracted by the force of gravity; measured in newton (N), 111, 119, 151
Weightlessness Conditions in space where an object is not attracted by the force of gravity, 158
Word equations Shows the reactants and products during a chemical reaction, 31, 141

Xylem Narrow tubes that carry water and mineral salts from the roots to the leaves, 169, 170

Year The time it takes Earth to orbit the Sun. It is 365 days and a quarter, 150, 152, 153
Yeast A unicellular fungus; and anaerobic respiration to produce carbon dioxide and alcohol, 141

Oxford excellence for the Caribbean

Investigating **Science** for Jamaica
Integrated Science

Investigating Science for Jamaica comprehensively covers the **National Standards Curriculum (NSC) for Grade 8 in Integrated Science**. As well as acquiring scientific knowledge, students will develop the process skills necessary to engage in scientific enquiry. With activities and questions that provide a methodical approach to investigation and problem solving, this course gives students an excellent foundation for the study of science at CSEC® level.

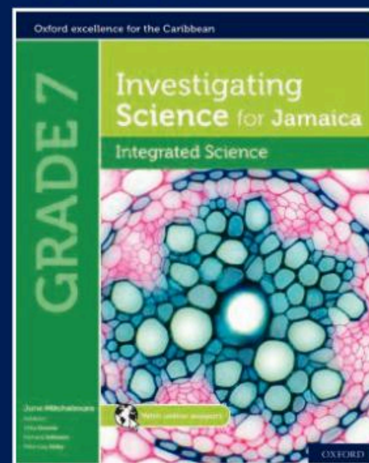
Key features:

- Science topics presented as part of STEAM (Science, Technology, Engineering, Art, and Mathematics)
- Integration of ICT, with activities strongly based on investigations and inquiry-based learning, utilising the scientific method and the engineering design process
- Objectives set out the learning outcomes for each unit and topic
- Quick check exercises at the end of each topic with key ideas to consolidate learning
- Fun facts about Science that bring the topics to life
- Accompanied by a specially designed Workbook and Teacher's Guide

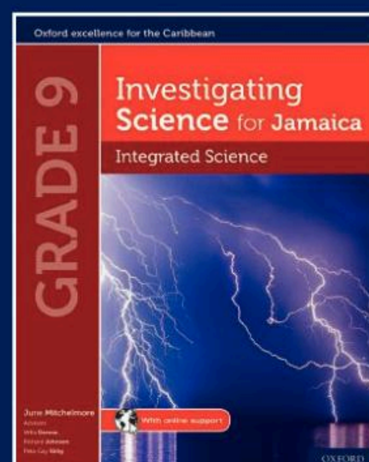
Resources for Grades 7–9 Integrated Science also available. View the full series at:
www.oup.com/caribbean/isj

eBook Available

Books in this series:



Grade 7 Student's Book
9780198426745



Grade 9 Student's Book
9780198426820

OXFORD
UNIVERSITY PRESS

How to get in touch:
web www.oup.com/caribbean
email schools.enquiries.uk@oup.com
tel +44 (0)1536 452620
fax +44 (0)1865 313472

ISBN 978-0-19-842678-3
9 780198 426783