INVESTIGATING SCIENCE

FOR JUNIOR CYCLE

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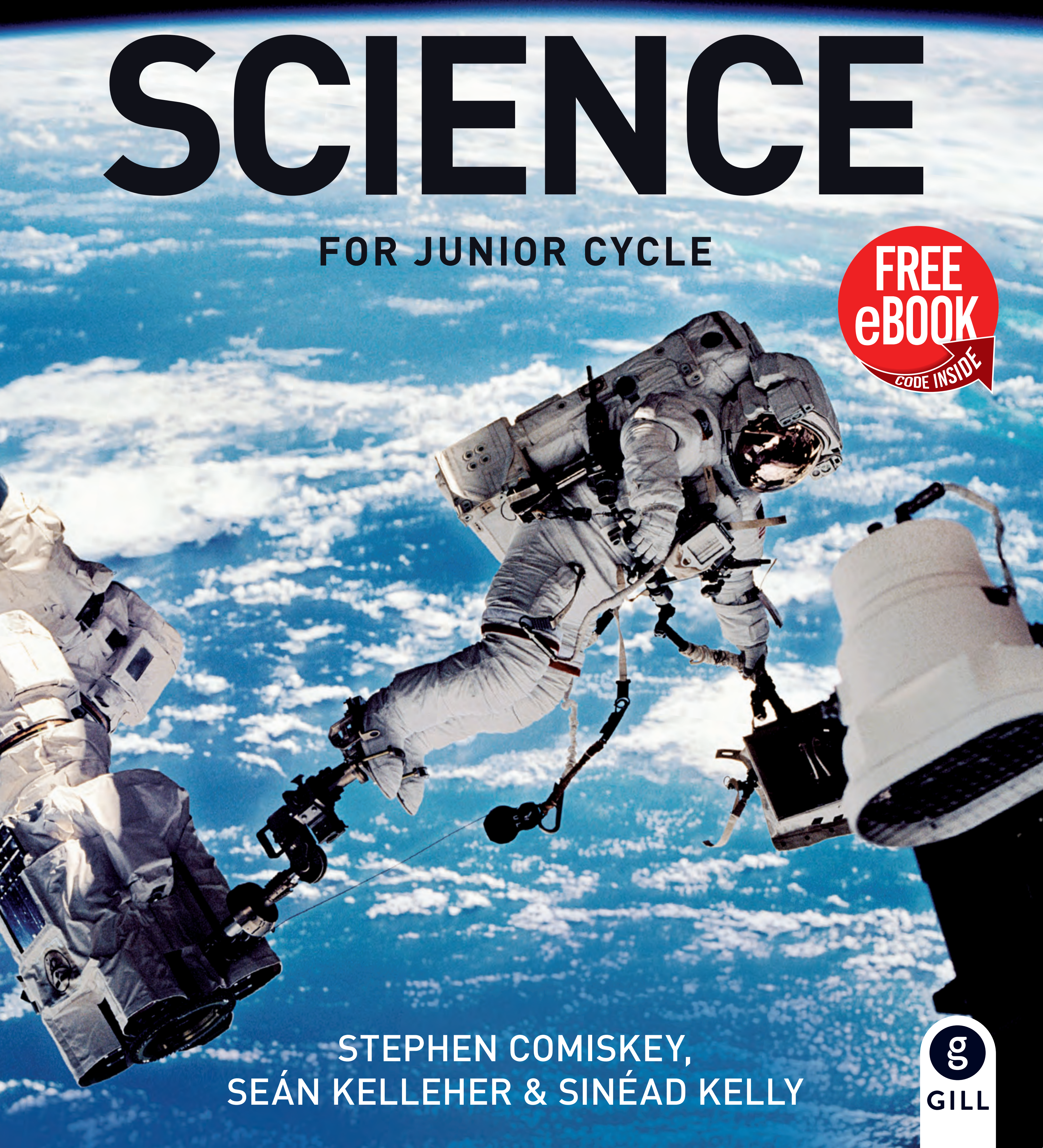

STEPHEN COMISKEY,
SEÁN KELLEHER & SINÉAD KELLY

GILL

INVESTIGATING SCIENCE

FOR JUNIOR CYCLE

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GILL EDUCATION

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Contents

Introduction

Investigating Science is a three-year textbook designed to meet all the requirements of the new **Junior Cycle Science Specification**.

There are forty-six learning outcomes in the Specification across the unifying strand, **Nature of Science (NOS)**, and the four contextual strands: **Earth and Space (ES), Chemical World (CW), Physical World (PW)** and **Biological World (BW)**. All learning outcomes are rigorously covered in ***Investigating Science***, with Nature of Science outcomes embedded throughout the other strands.

The **inquiry-based approach** in ***Investigating Science*** emphasises the practical experience of science for each student. It supports the use of a wide range of teaching, learning and assessment approaches that provide opportunities for students to develop a range of inquiry skills.

Investigating Science provides opportunities for students to engage with contemporary issues in science that affect everyday life. They will **learn**, **interpret** and **analyse data** – a skill that has a value far beyond science wherever data is used as evidence to support argument. In **presenting evidence and findings**, they will engage in objectively discussing and justifying conclusions.

Investigating Science affords a reasonable degree of **flexibility for teachers and students** to make their own choices and pursue their interests, and offers many possible routes for an integrated science approach, including class-based extension work and outside school discussions/projects.

Question Time

Copy and Complete

In this unit I learned that a _______ can be made by ________ a _________ into a _________. A strong solution can be called a _________ solution and a weak solution is called a ________ solution. _________ solutions have the maximum amount of _________ that is possible at a _______ ______. The solubility of a solid _________ as _________ increases. The solubility of a _________ decreases with the increase of temperature. Crystals are formed when _________ solutions are _________.

Questions

1. Can you list four substances that are insoluble in water?
2. *Fig. 06.02.09* shows three solutions of copper sulfate. Decide which diagram, A, B or C, is the **dilute** solution. Also decide which diagram is the **saturated** solution.

Question Time at the end of each unit provides a variety of question types.

The **Copy and Complete** task is ideal for revision and as an exercise for those at different learning levels.

General contextual questions bring topics together.

Inquiry

A **Research** the answers to the following questions:
- (i) Why would a muscle need many mitochondrion?
- (ii) Which part of a plant cell absorbs energy from the sun?
- (iii) The heart muscle is called cardiac muscle and it never tires. How is cardiac muscle different from all the other muscles in the body?
- (iv) Which of the following animals are vertebrates? Why? Which is an invertebrate? Why?
  dog • snake • butterfly • frog • turtle • whale

Inquiry questions allow for further investigation while preparing students for their classroom-based assessment, the EEI and SSI. Key action words linked to Bloom's taxonomy are highlighted.

Other features to help the student in *Investigating Science*:

KEYWORDS

concentrated
concentration
crystallisation
dilute
dissolve
insoluble
saturated
solubility
solubility curve
soluble

Keywords are given at the start of units to assist with literacy strategies.

Saturated: A solution that has the maximum amount of solute dissolved into the solvent at a given temperature.

Concise and student-friendly **definitions** of key concepts present appropriate and suitable information.

Did you know?
Across the world, many people eat insects as they are a great source of protein. In some countries you can even buy chocolate-covered ants!

Did you know? boxes include fun and interesting additional information to engage students as they work through topics.

For the teacher:

The symbol (R) appears in this book where there are additional resources available to support teaching, such as background information, tips and photocopiable worksheets, which offer differentiated learning opportunities.

What About Electrons?

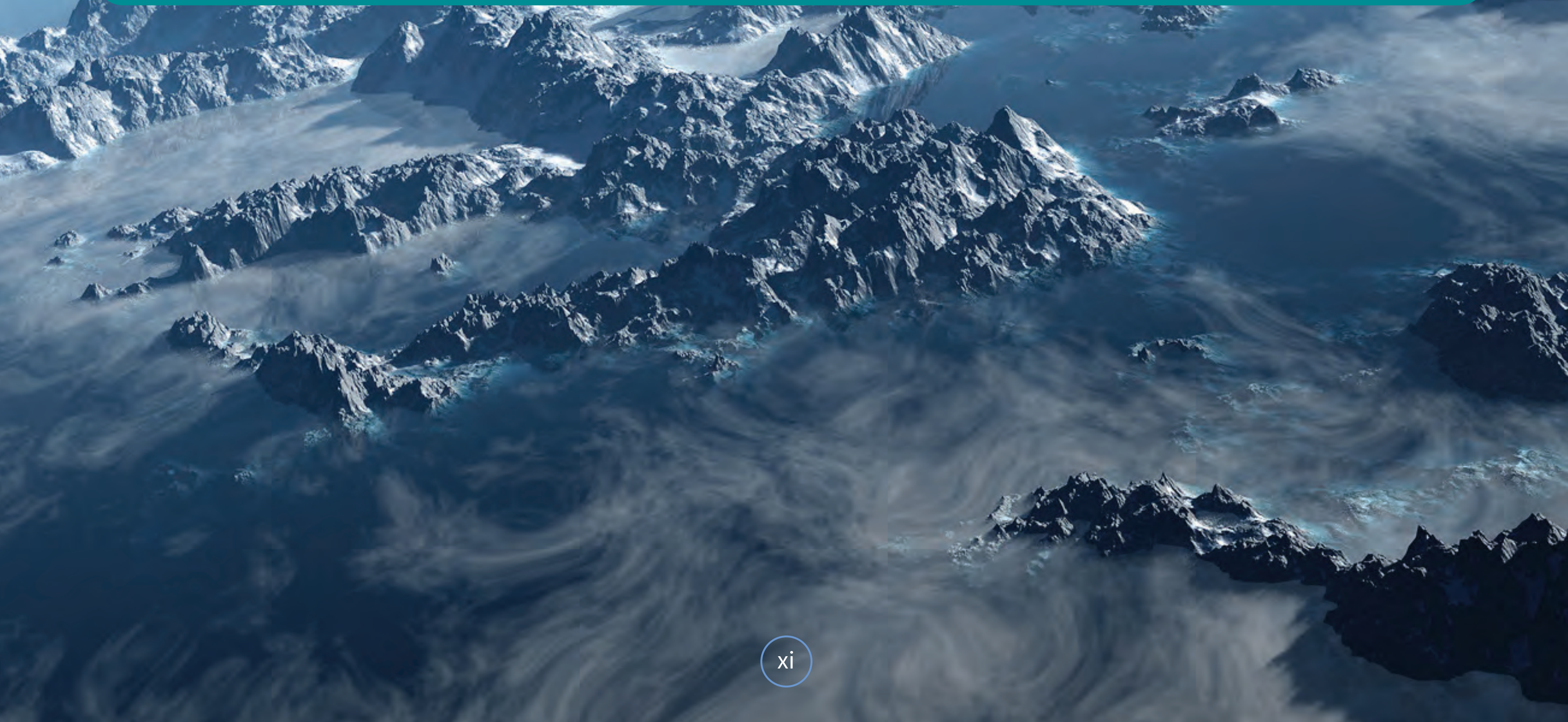
(R) Scientists were certain that the protons and neutrons sat as a solid mass in the centre of the atom (the nucleus), but where did the negative sub-atomic particles – the electrons – fit?

The **Teacher's Resource Book** provides support material to enable active, yet focused, lessons and investigations.

- A detailed planning section includes practical guidelines and advice.
- Detailed information and conclusions are given for each demonstration and investigation.
- Additional context and clarification notes assist with new topics/activities.
- Differentiated worksheets facilitate mixed-ability teaching.

On GillExplore.ie:

- Curriculum-focused videos
- Selected PhET interactive simulations
- Unit PowerPoints, which provide support in the laboratory when undertaking demonstrations and investigations. Including click-by-click solutions to all Lightbulb, Checkpoint and end-of-chapter questions, they are a great classroom aid.
- Additional resources to support teaching and learning.



Assessment Focus

Science Assessment for the Junior Cycle Profile of Achievement (JCPA) will have the following components:

- Two Classroom-Based Assessments (CBAs), one to be carried out in second year and the other in third year, to be evaluated by the class teacher.
- A written Assessment Task (AT), based on the second CBA. This will be submitted to the State Examinations Commission (SEC) for marking.
- A final written exam, of not more than two hours, to be taken in June of third year.

Remember:

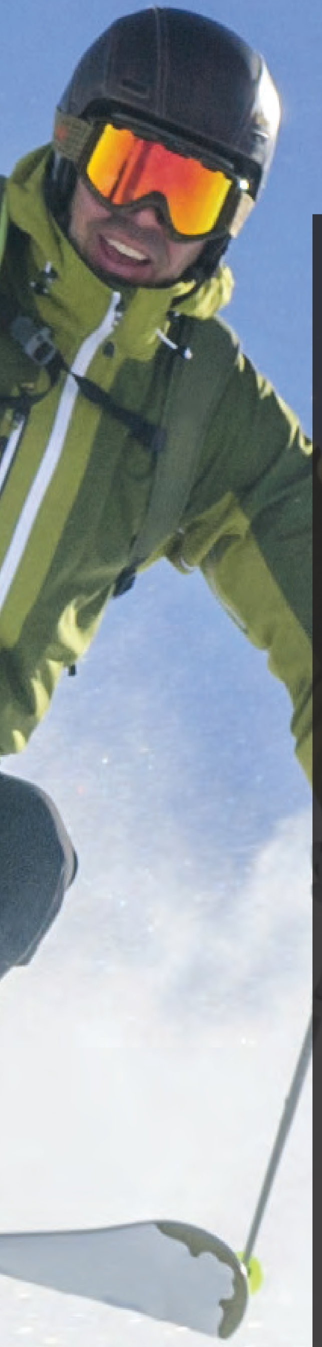
- All assessment components are at common level.
- All assessment and exam formats may change from year to year.

Classroom-Based Assessments

The following table gives some detail on the current requirements for the CBAs.

CBA	Format	Student preparation	Completion of assessment
Extended Experimental Investigation (EEI)	Reports which may be presented in a wide range of formats	Students will, over a three-week period, formulate scientific hypotheses, plan and conduct an experimental investigation to test their hypotheses, generate and analyse primary data, and reflect on the process, with support/guidance by the teacher.	End of second year
Science in Society Investigation (SSI)	Reports which may be presented in a wide range of formats	Students will, over a three-week period, research a socio-scientific issue, analyse the information/ secondary data collected, and evaluate the claims and opinions studied and draw evidence-based conclusions about the issues involved, with support/guidance by the teacher.	End of term 1 or early term 2 of third year

Presentation formats can vary and may include handwritten/typed reports, model building, multimodal presentations, webpages, podcasts, etc.



Assessment Task (AT)

The formal written Assessment Task will be based on the topic or task undertaken in the second Classroom-Based Assessment. This Assessment Task will be submitted to the SEC to be marked along with the state-certified examination in the subject.

State Exam

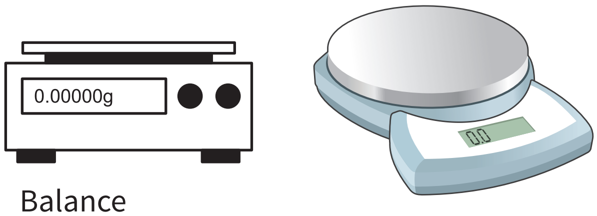
There will be a written examination completed at the end of third year. Examinations will be set, administered, marked and resulted by the SEC. The written examinations will be of no longer than two hours.

All elements of assessment will be recorded in the Junior Cycle Profile of Achievement (JCPA).

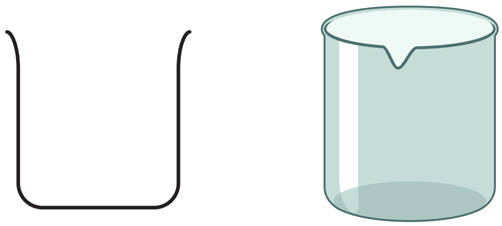
Investigating Science and Assessment

- The inquiry questions at the end of each unit in ***Investigating Science*** are designed to prepare students for their CBAs and to give ideas for **topics/ approaches**.
- Students will experience a variety of **presentational formats** through completion of checkpoint questions and through the inquiry section.
- Throughout ***Investigating Science***, extensions to investigations encourage and spark ideas for the **Extended Experimental Investigation**.
- Throughout the inquiry sections, students are offered opportunities to develop skills for both the **Extended Experimental** and **Science in Society** investigations. The inquiry tasks are diverse as they can require research and/or further experimental activities to be carried out.

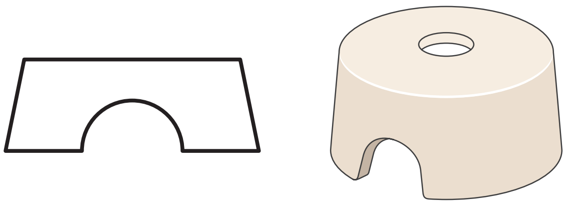
Laboratory Equipment and Student Diagrams



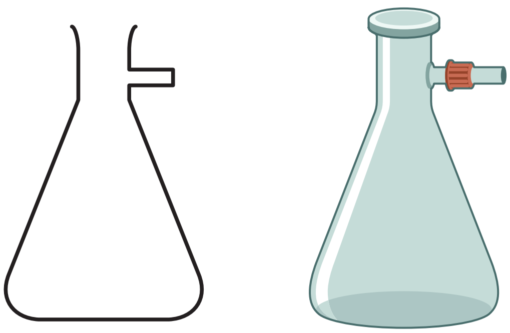
Balance



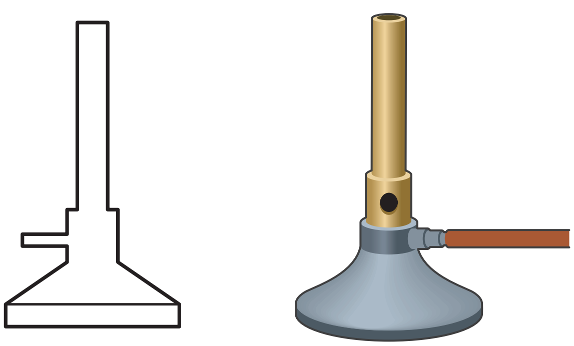
Beaker



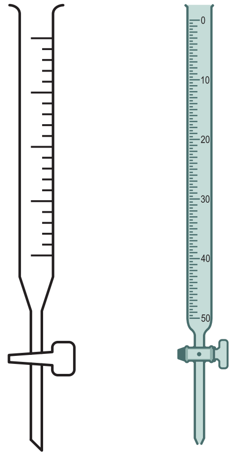
Beehive stand



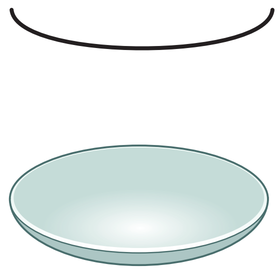
Büchner flask



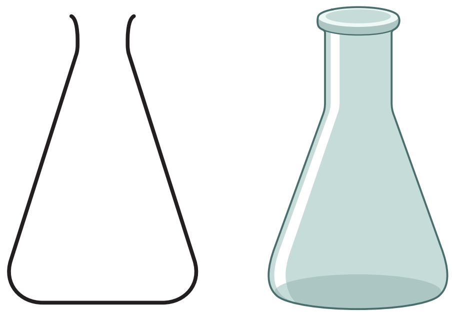
Bunsen burner



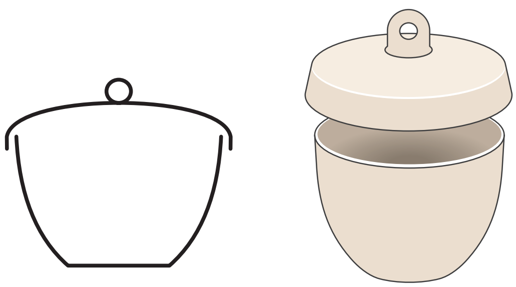
Burette



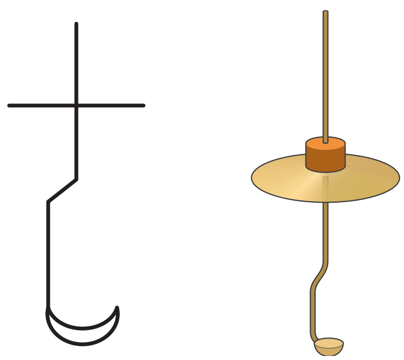
Clock glass



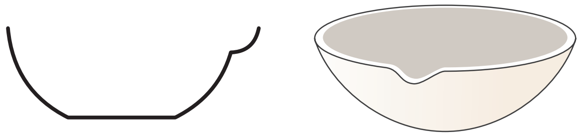
Conical flask



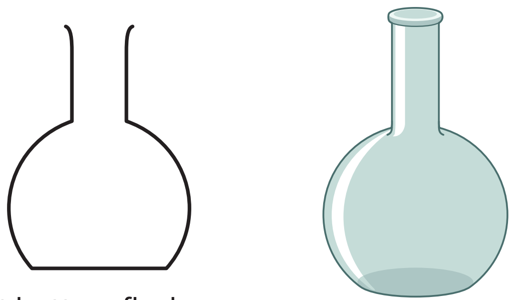
Crucible



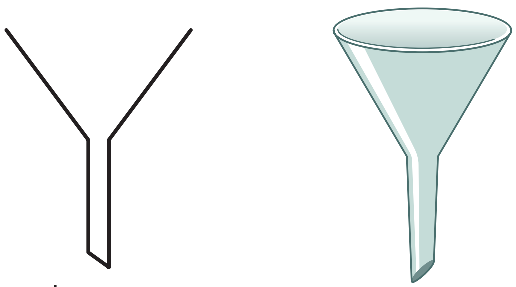
Deflagration spoon



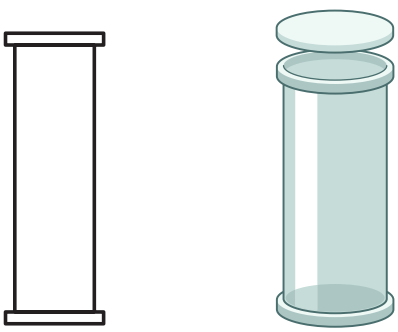
Evaporating dish



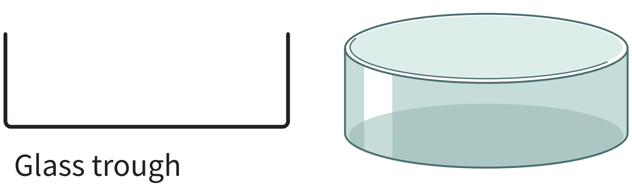
Flat bottom flask



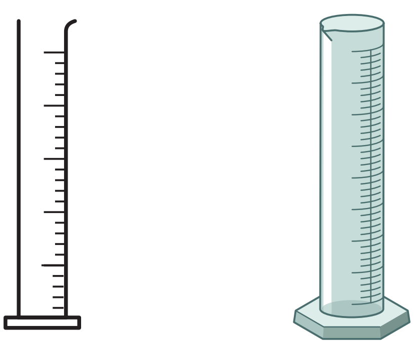
Funnel



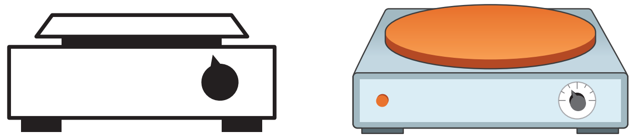
Gas jar



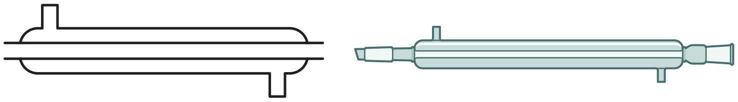
Glass trough



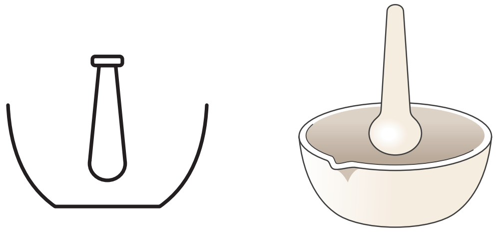
Graduated cylinder



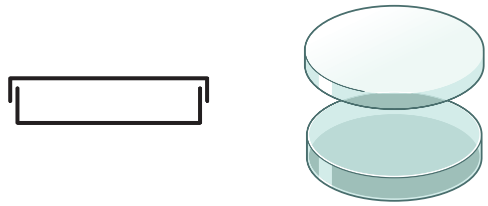
Hot plate



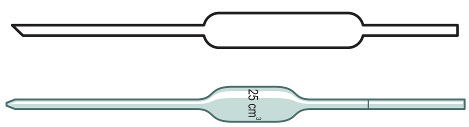
Liebig condenser



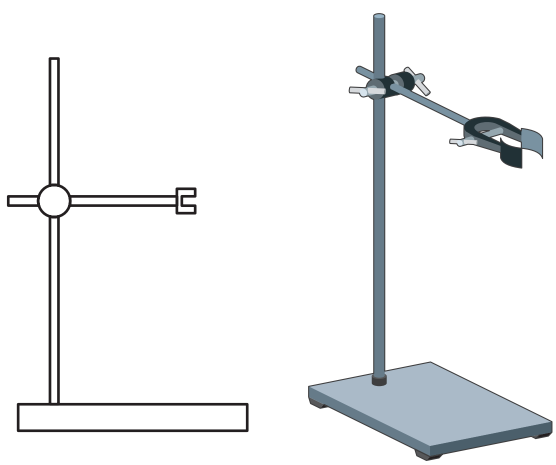
Pestle & mortar



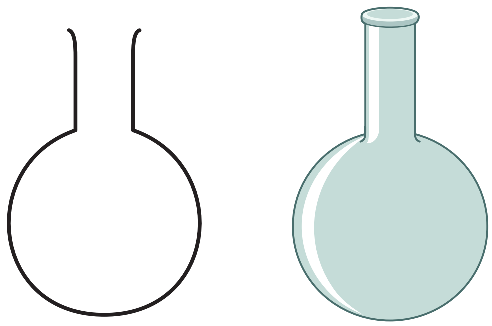
Petri dish



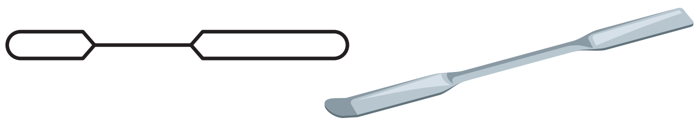
Pipette



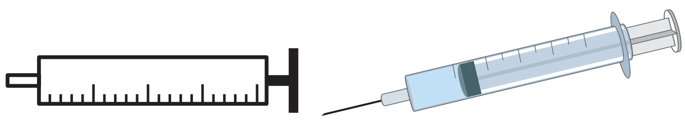
Retort stand



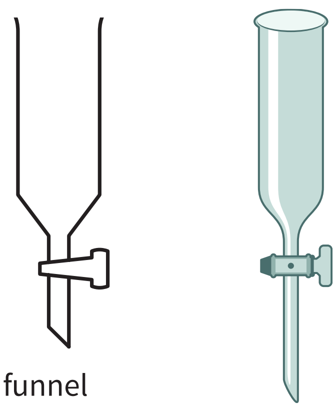
Round bottom flask



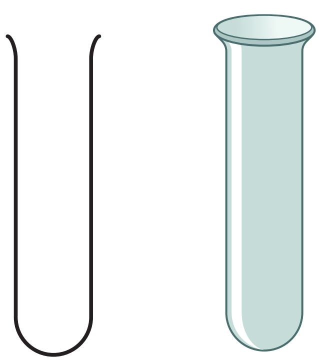
Spatula



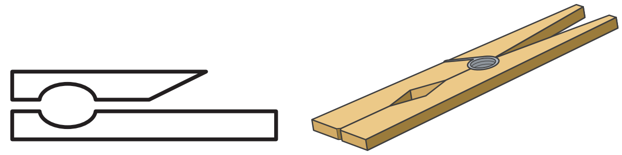
Syringe



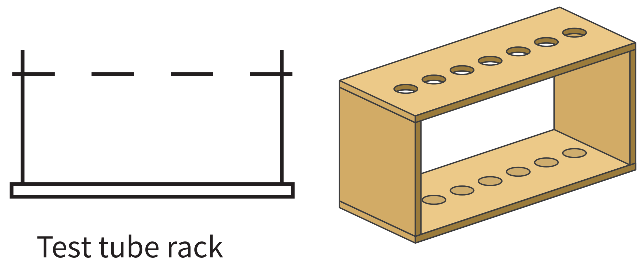
Tap funnel



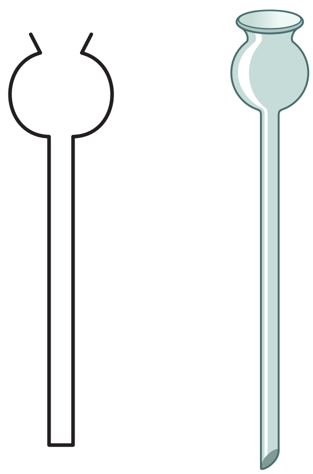
Test tube



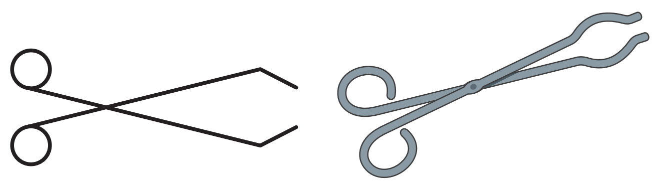
Test tube holder



Test tube rack

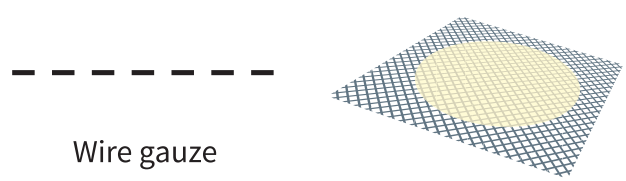


Thistle



Tongs

Tripod



Wire gauze

UNIT

3.2

The Digestive System

Learning Outcomes

BWLO 4. Describe the structure, function and interactions of the organs of the human digestive, circulatory and respiratory **systems.**

NSLO 3. Design, plan and conduct investigations; explain how reliability, accuracy, precision, fairness, **safety, ethics and a selection of suitable equipment have been considered.**

NSLO 4. Produce and select data (qualitatively/quantitatively), critically analyse data to identify patterns and relationships, identify anomalous observations, **draw and justify conclusions.**

NSLO 6. Conduct research relevant to a scientific issue, evaluate different sources of information including secondary data, understanding that a source may lack detail or show bias.

R Teacher's reference

KEYWORDS

absorption
amylase
appendix
bile
catalyst
chemical digestion
enzymes
faeces
gall bladder
gut flora
large intestine
liver
maltose
mechanical digestion
nutrients
oesophagus
pancreas
rectum
salivary glands
small intestine
soluble
stomach

LEARNING INTENTIONS

At the end of this unit you should:

1. Be able to describe what the word 'digestion' means.
2. Be able to distinguish between the two types of digestion.
3. Be able to discuss the role of the teeth, tongue and stomach in digestion.
4. Be able to describe mechanical and chemical digestion and the difference between them.
5. Know that digestion involves breaking down large molecules into smaller soluble ones.
6. Be able to describe what happens to food when it is broken down.
7. Be able to describe the role and the importance of enzymes in digestion.

The Digestive, Circulatory and Respiratory Systems

The digestive, circulatory and respiratory systems are very closely linked and they all depend on each other. If one system fails, so will the others. This knock-on effect can even permanently damage or cause another system to fail completely. For example, if the **liver** fails it can cause the kidneys to fail, soon followed by other body systems. The body's goal is to use the **nutrients** from food, and oxygen to make energy. Some nutrients are used for the growth and repair of cells. In this unit we shall focus on how the digestive system works, but first, examine *Fig. 03.02.01* to see the importance of the digestive, circulatory and respiratory systems to each other.

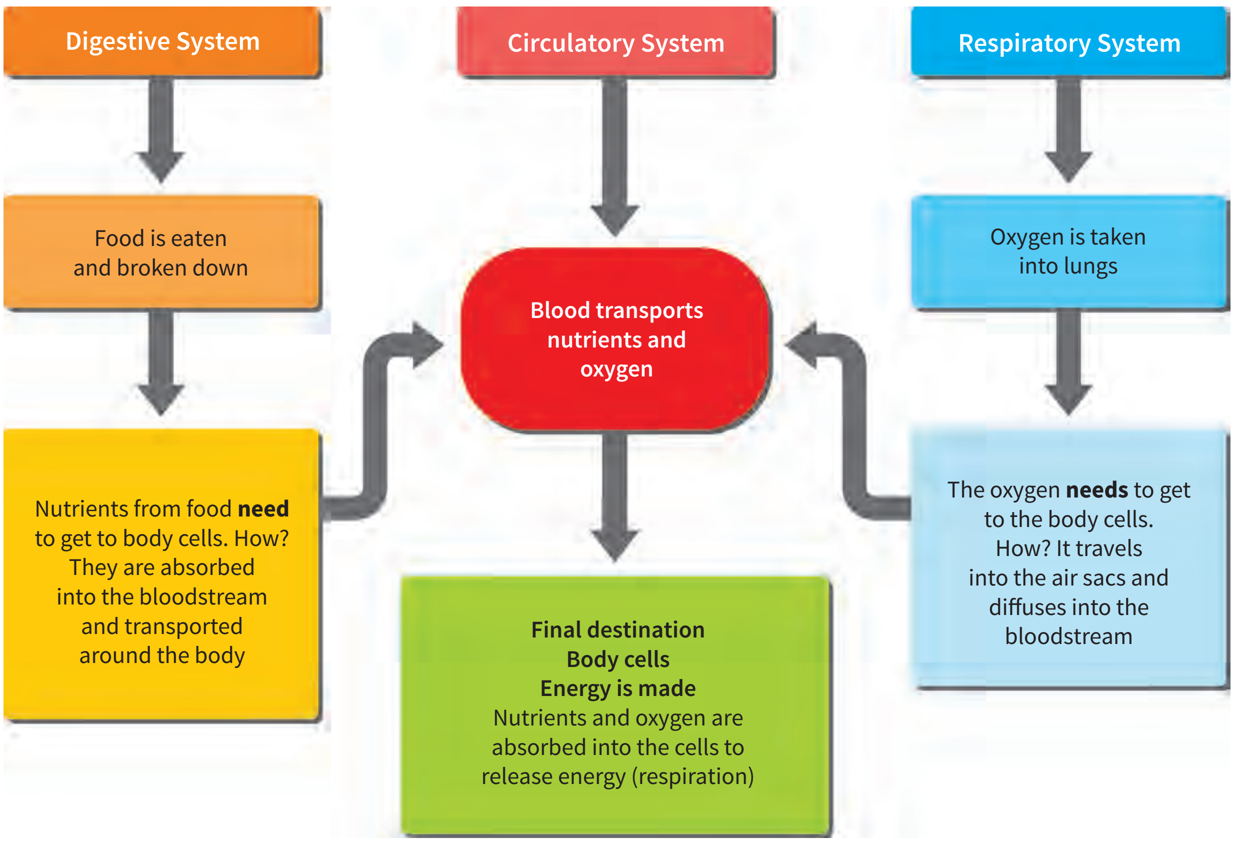


Fig. 03.02.01 How the digestive, respiratory and circulatory systems interact.

The Digestive System

Our digestive system is all about getting food into our body, breaking the food down, releasing the nutrients and absorbing them into our bloodstream to bring to our body cells. Once we put food into our mouth, the digestive process starts.

We need energy to break down our food. We also need food to give us energy. So why does digestion take so long? What happens to digested food after it has been absorbed into the blood?

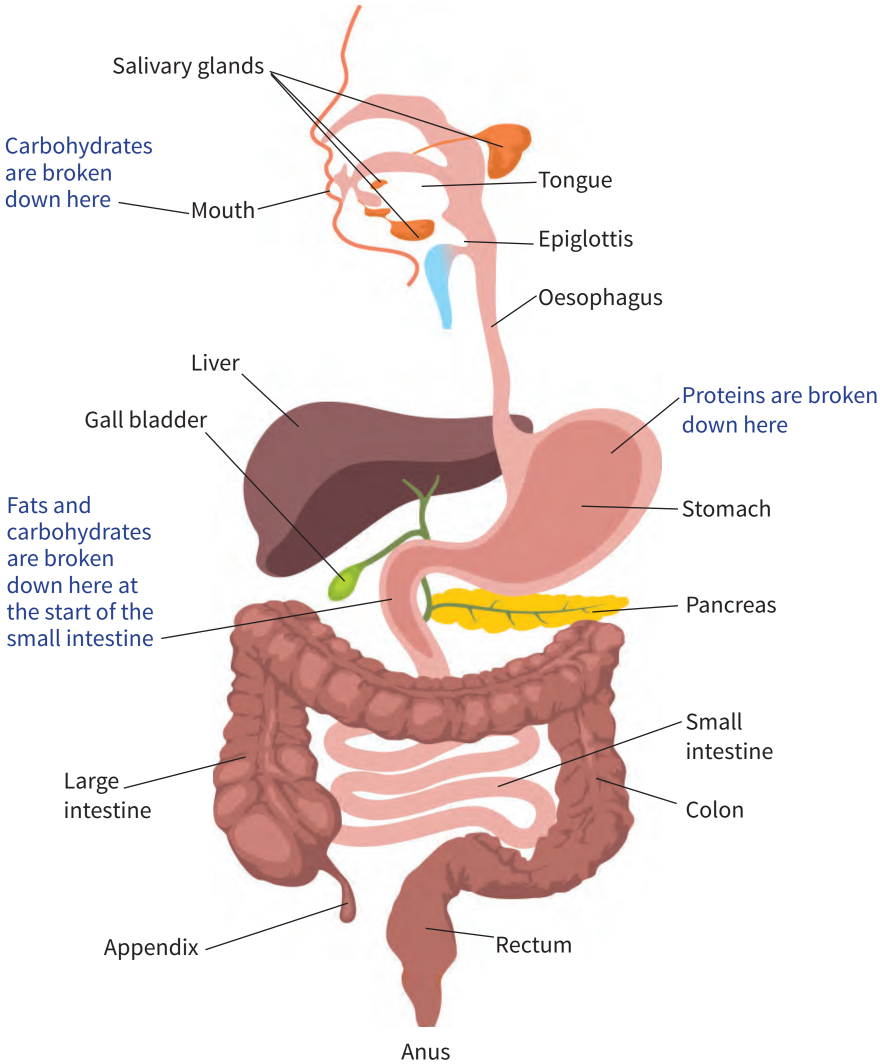


Fig. 03.02.02 The structure of the digestive system. Different food groups are broken down in different parts of the system.

How is Food Broken Down?

The food we take in is broken down in two ways:

- Mechanical digestion
- Chemical digestion.

Mechanical digestion is the physical breaking down of food by the tongue, the teeth (by chewing) and the **stomach** (by churning).

In **chemical digestion**, **enzymes** or digestive juices are added to the food in the digestive system to help break it down. Enzymes speed up the breakdown of the food and are therefore known as biological **catalysts**.

Checkpoint 1

You are about to eat a meal that consists of a homemade beef burger with a bread bun and a slice of cheese on top, served with a small side salad and no dressing. Give a detailed explanation of what happens to the food as it passes through the digestive system. For example, what happens in the mouth? Where does the food go then? Use *Fig. 03.02.02* to help you.

Part of Digestive System	Function	Food group broken down	Type of Digestion
Mouth	• Takes food in • Breaks food down, chemically and mechanically	Carbohydrates	• Mechanical – teeth grind, tear, bite and chew • Chemical – enzyme salivary amylase is released
Oesophagus	• A muscular tube that allows food to be passed to the stomach		
Stomach	• Churns food • Contains hydrochloric acid (HCl), which kills bacteria and allows enzymes to work • Enzymes are present to break down food	Proteins	• Mechanical – churning • Chemical – adding of enzyme pepsin
Liver	• **Bile** is made • Toxins are broken down	Bile breaks fat into smaller parts	
Pancreas	• Releases hormones such as insulin, which keeps our blood sugars at the right levels • Releases juices that contain enzymes into small intestine	The juices released contain enzymes to break down protein, fats and carbohydrates	• Chemical – releases digestive juices
Small intestine	• **Soluble** food is absorbed into the blood (**absorption**)	Fats and carbohydrates	
Large intestine	• Water is absorbed from the food (leaving **faeces**)		
Rectum	• Undigested food is stored here as faeces • It then gets moved out of the body through the anus		

R *Table 03.02.01 Functions of the digestive system.*

What is the Appendix?

The **appendix** is found at the **large intestine**. Recent research shows that the appendix could be a source of natural or good gut bacteria that live in our body. It was originally needed as our ancestors would have eaten a lot of plants and it helped with the digestion of tough fibre.

Digestion: The breaking down of food.

Catalyst: Speeds up a chemical reaction without being used itself in the reaction.

Checkpoint 2

R Test your knowledge of the functions of the parts of the digestive system. See how many you can remember, then check *Table 03.02.01* to see how many you got right.

Enzymes and Absorption

The food molecules taken into our mouths are too big to be absorbed. The teeth, tongue and stomach make these molecules smaller, but the body needs more help to break them down. It gets this help from chemicals called **enzymes**.

Enzymes speed up the breakdown of the food molecules without being used up in the reaction, and are referred to as **catalysts**.

Each enzyme only breaks down one particular food group, in the way that a key only fits one lock. For example, the enzyme **amylase** breaks down starch into **maltose**. Amylase is found in saliva, which is produced by the **salivary glands**.

Absorption: The process in which the nutrients in the food are passed into the bloodstream at the small intestine.

Enzyme: A protein that speeds up a chemical reaction in an organism.

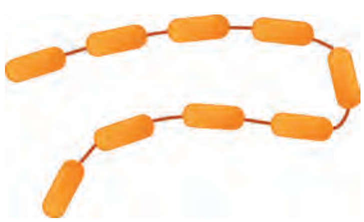
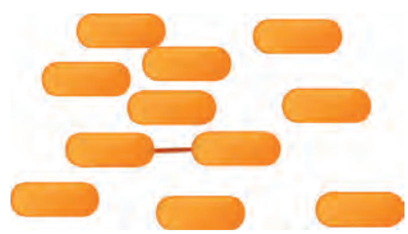
Food broken down	Enzyme involved	Product from the reaction
Starch	Amylase	Maltose
	Amylase breaks down starch into smaller molecules	

Table 03.02.02 Enzyme action on starch.

Checkpoint 3

R *Table 03.02.03* shows the results of an investigation into how temperature can affect the speed at which the enzyme amylase works.

(i) Study the results and suggest at which temperature the enzyme works best.

(ii) Give an explanation for your choice of temperature.

(iii) Present the results as a graph. (*Hint:* x axis = temperature; y axis = rate of amylase activity [how quickly it happens].)

(iv) Suggest a reason why you think enzymes may need a specific temperature to work at. Refer to your graph in your answer.

Amylase activity (rate of activity)	Temperature (°C)
0	0
1	10
2.5	20
5	30
7	40
4.5	50
0	60

Table 03.02.03 Results of an investigation into amylase.

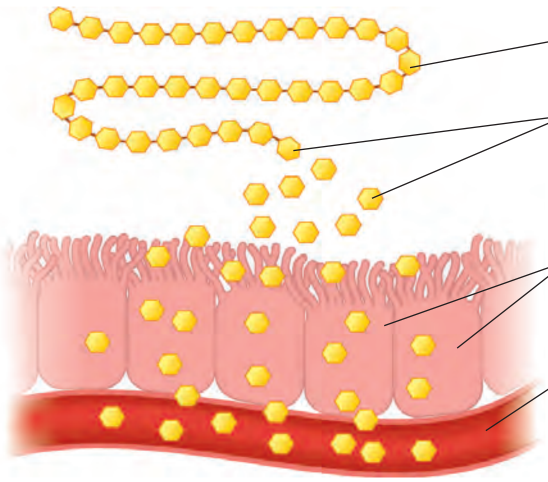


Fig. 03.02.03 Absorption of glucose into the walls of the small intestine and into the bloodstream.

Investigation 03.02.01: **Investigating what happens when food is taken into your body**

Equipment: A pop-sock, pestle and mortar, bin, clear plastic bag, funnel, hydrochloric acid, amylase solution, pepsin, water, a scissors, a sandwich (imagine a sandwich, halved, then halved again, then halved again: this is the size of your sample).

Instructions:

1. Working with a partner, match up each body part in the digestion list below with an everyday object in the equipment list that could represent it. (More than one body part can be matched with the equipment list.)
   Digestion list: Intestines • teeth • tongue • mouth • toilet • stomach • oesophagus
   Equipment list: Pop-sock • pestle and mortar • bin • clear plastic bag • funnel
2. Now that you have the equipment list linked to the digestive system and understand the need for the chemicals, plan an investigation to show what happens when food (your sandwich sample) enters your body.
3. Where would you find hydrochloric acid in your body?
4. What does the amylase solution represent?

What did you learn?

1. Explain what involvement the chemicals had in the breakdown of your food.
2. You needed to add water at different stages during the investigation. Can you link this to real-life experiences? Make a note of at least two links.
3. Explain how the pestle and mortar relates to your mouth, including references to the chemicals and the water.

Fig. 03.02.04 Pestle and mortar.

We Need Bacteria!

When we think of bacteria we think of diseases, but bacteria are essential to our health. Bacteria are found all over our body, for example on our skin and eyes, in our mouth and small intestine, but most of them are in the large intestine. The bacteria cells that live on us and in us are harmless most of the time. They help our bodies function, and in turn we give them a safe place to live. The bacteria in our digestive system are also called **gut flora**.

Did you know?
We have approximately ten times more bacteria cells than human cells in our body: 100 trillion bacteria cells as compared to 10 trillion human cells!

How do Bacteria Help Us?

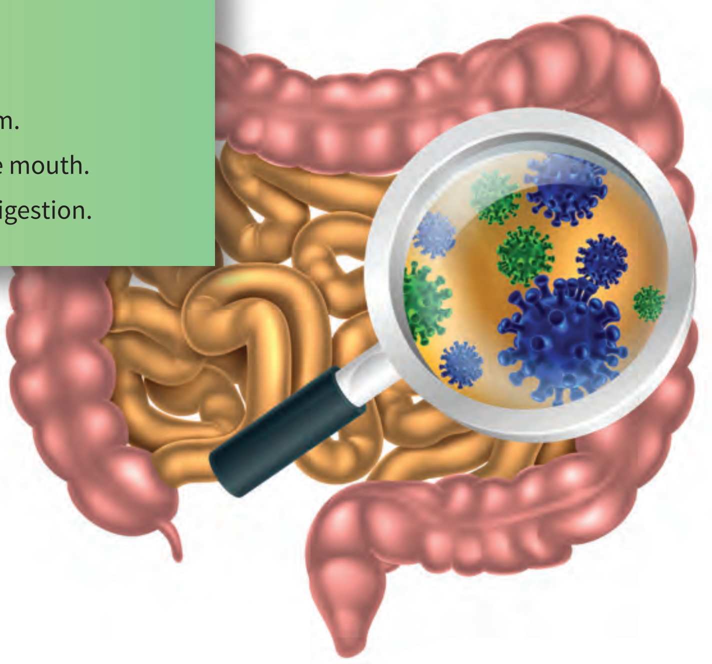
- On our skin, some bacteria help keep other harmful bacteria out.
- Some bacteria produce enzymes that help break down fibre.
- Our gut bacteria can produce vitamin K and some B vitamins. One job of vitamin K is to help clot blood. One job of the vitamin B group is to promote healthy hair and nails.
- Bacteria help our immune or defence system prepare for when it needs to respond to harmful bacteria that may cause disease.
- Some break down hormones in the body when they are no longer needed.

The digestive system relies on the combination of bacteria, enzymes, blood and its own organs, all working together, to be an efficient system.

Have you ever been prescribed a course of antibiotics? An antibiotic is used to treat infections or a disease caused by bacteria, but it is actually made from micro-organisms such as bacteria and fungi that work to kill other micro-organisms or prevent them growing. We need bacteria!

WHAT I HAVE LEARNED...

- The digestive system breaks down food so that it can be used by the body.
- The order of the parts of the digestive system.
- The functions of the parts of the digestive system.
- The two different types of digestion: physical and chemical.
- Where each food group is broken down in the digestive system.
- Amylase is used in chemical digestion and is released into the mouth.
- Large molecules are broken down into smaller parts during digestion.



Question Time

Copy and Complete

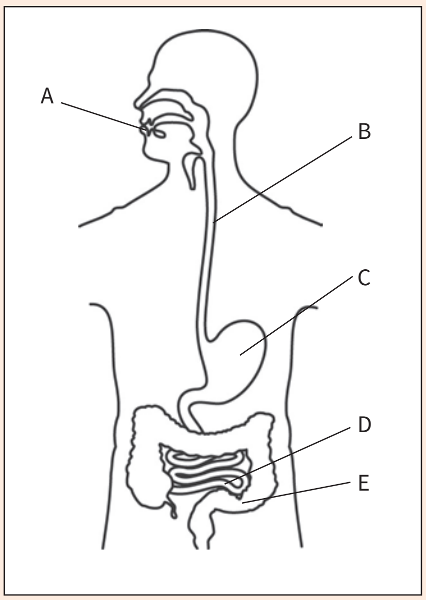
In this unit I learned that the digestive system ________ ________ food. We take food into our mouths and this is where ________ starts. Your ________ and tongue break food down into smaller parts, but it is also broken down by an enzyme called ________, which is found in saliva. Enzymes help to ________ up the breakdown of food. After the mouth the ____ moves through the________. It then moves into the stomach, which ________ and mixes the food with an ________. This kills any ________ that might be present in the food, and there are also enzymes in the stomach. After the stomach the food moves through the ________ ________. It is here that the nutrients from the food move across into the ________. This is called ________. The rest of the food parts move through the ________ intestine, where ________ is taken out of the food. The remaining substances leave the body through the ________.

Questions

1. Use the following keywords to describe what digestion is:

   • food breaks down • mechanical • chemically • nutrients

2. In your copy, name the parts labelled A–E in the diagram of the digestive system (*Fig. 03.02.05*).



R *Fig. 03.02.05 Name the labelled parts.*

3. Copy and complete *Table 03.02.04,* filling in the functions of the parts of the digestive system.

Parts of the Digestive System	Functions
Mouth	
Oesophagus	
Stomach	
Small intestine	
Large intestine	

Table 03.02.04.

4. Make a list of the main food groups and state where each group is broken down in the digestive system.
5. Explain what absorption is and why it is so important to the body.
6. Suggest a reason why the digestive system relies on the circulatory system.
7. How are the nutrients from the foods we digest used by the body?
8. Large food molecules cannot pass through the walls of the small intestine into the bloodstream. What chemicals help with the breakdown of these foods in the body? Give an example of this chemical action.

Inquiry

A The national science museum has asked you to **produce** a 'travel guide' to the digestive system and how it breaks down food. Your guide must be colourful, feature pictures/diagrams, and include the following information:
- What places you will visit after the mouth
- What happens at the places you visit
- If you will meet any other attractions on the way that might help food break down.

B **Research** whether genetically modified foods have an effect on the bacteria that we need in our bodies.

C **Design** a poster or IT information sheet on a disorder of the digestive system. You could choose one of the following: Crohn's disease; gastritis; coeliac disease. Include:
- Name of disease or disorder
- Symptoms
- Causes
- Treatment (if any)
- How a person adapts to having the disorder.

UNIT

7.1 The Atom

Learning Outcomes

CWLO 3. Describe and model the structure of the atom in terms of the nucleus, protons, neutrons and electrons; compare mass and charge of protons, neutrons and electrons.

NSLO 1. Appreciate how scientists work and **how scientific ideas are modified over time.**

NSLO 10. Appreciate the role of science in society **and its** personal, social and **global importance.**

PWLO 3. Investigate patterns and relationships between physical observables.

R Teacher's reference

KEYWORDS

atom
atomic number
Billiard Ball Model
Bohr Orbital Model
charge
dalton
electron
electronic configuration
element
energy level
isotopes
mass number
matter
negative charge
neutral
neutron
nucleus
orbit
Planetary Model
Plum Pudding Model
proton
shell
sub-atomic particles

LEARNING INTENTIONS

At the end of this unit you should:

1. Be able to describe the parts that make up an atom and where they are inside an atom.
2. Know the charges for the different parts of the atom.
3. Know the scientific definition of an atom.
4. Know the difference between atomic mass and atomic number.
5. Read the information for any element from the periodic table and describe it.
6. Draw the Bohr models showing the structure of the first twenty elements from the periodic table.

Are the atoms of each element different?

Why an Atom?

In Ancient Greece, science was conducted by men called philosophers who carried out 'thought experiments'. Some believed that all **matter** was made up of particles which could not be divided. They called these particles **atoms**, from the Greek word *atomos*, meaning indivisible. Others, however, believed that everything was made up of different combinations of five **elements** (which we came across in the previous unit): earth (solid), water (liquid), air (gas), fire (heat) and aether (an invisible substance that filled empty space).

This idea of the five elements was to last for 2000 years. In 1803, English school teacher John Dalton came up with a theory that changed the scientific meaning of the word 'element'. He suggested that not only were atoms the smallest possible particles, but that each element contained only one type of atom. Dalton's explanation become known as the **Billiard Ball Model**.

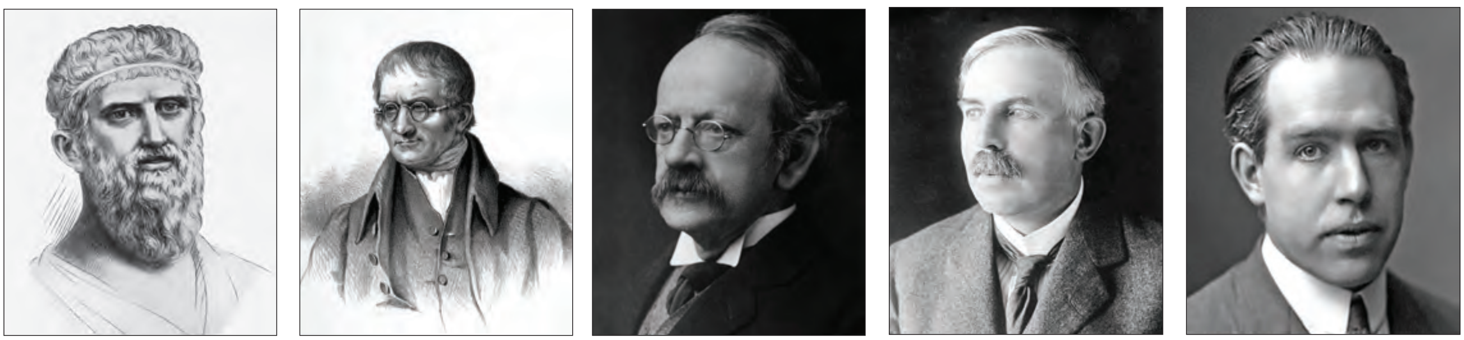
This was an incredible suggestion. If true, it meant that every atom in a particular element was identical but different from the atoms in other elements; and the way the elements reacted to each other and the environment was special to that element.

It took another 130 years of experiments to figure it out completely, but at least now scientists had a good definition of what an atom was, one that was supported by experimental results.

Matter: Anything that takes up space and has mass.

Atom: The smallest particle of an element that has the properties of that element.

Element: A substance made up of only one type of atom.



Aristotle 384BCE–322BCE | John Dalton 1766–1844 | J.J. Thomson 1856–1940 | Ernest Rutherford 1871–1937 | Niels Bohr 1885–1962

Fig. 07.01.01 Scientists involved in the changing ideas of what an atom was.

Sub-Atomic Particles

The next discovery was that atoms *did* contain smaller parts, called **sub-atomic particles**. Three types of sub-atomic particles were discovered: **protons**, **neutrons** and **electrons**. Sub-atomic particles don't have the properties of atoms, but the amount of each type does decide which element an atom belongs to.

In 1897, English physicist J.J. Thomson was able to show that there were particles that had **negative charge**. He suggested that large positive mass (which was a solid sphere) was studded on the outside with these negative charge particles. He also suggested that how these negative charge sub-atomic particles were arranged was important. This became known as the **Plum Pudding Model**, and these negative charge particles were named electrons.

Sub-Atomic Particles: Particles that are smaller than an atom; different amounts of each type make up an atom.

Charge: The number showing how positive or negative a particle is.

Electrons: A sub-atomic particle that has a negative charge of -1 and a mass of $\frac{1}{1840}$ dalton.

In 1911, Thomson's friend and former student Ernest Rutherford was to prove him partly wrong. Rutherford fired positive particles at very thin gold foil. Most passed straight through, but some bounced almost straight back, while others deflected at angles. If J.J. Thomson's Plum Pudding Model had been correct, all the particles should have passed straight through.

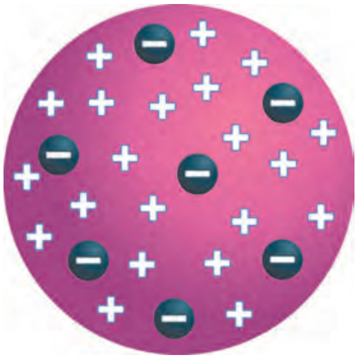


Fig. 07.01.02 The Plum Pudding Model.

Rutherford came up with several conclusions:

- Atoms were mostly empty space.
- There was a large mass in the centre which caused some positive particles to bounce almost straight back.
- Some particles passed through but at an angle because positive particles in the atom repelled them and pushed them slightly off course.

Rutherford's conclusions became known as the **Planetary Model** as it showed that electrons orbited the **nucleus** (made up of the protons and neutrons) like the planets move around the Sun.

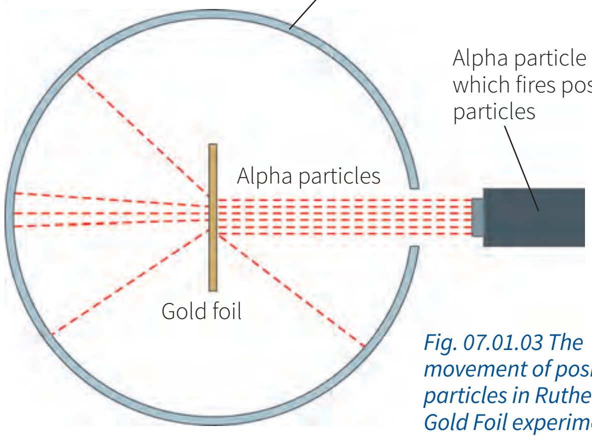


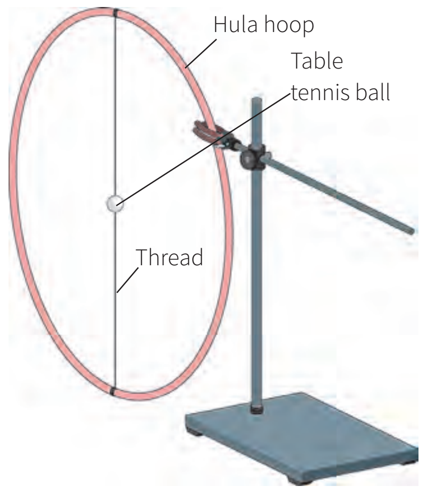
Fig. 07.01.03 The movement of positive particles in Rutherford's Gold Foil experiment.

CHEMISTRY

Investigation 07.01.01: **Checking Rutherford's conclusions**

Equipment: Hula hoop, string, table tennis ball, retort stand, brown rice, drinking straw.

Instructions:
1. Set up the equipment as shown so the table tennis ball is in the centre of the hula hoop.
2. Using the drinking straw, fire at least thirty single rice grains through the hula hoop.
3. Count the number of grains that pass through, are deflected, or bounce right back.



What did you learn?
Can you explain why your results agree/disagree with Rutherford's conclusions from the Gold Foil Experiment?

Rutherford named these new sub-atomic particles protons as they had positive charge. Because an atom has equal numbers of electrons (negative charge) and protons (positive charge), they are **neutral** overall.

To make sense of measurements from a number of experiments, Rutherford also suggested the existence of a type of sub-atomic particle that had no charge, but had the same mass as a proton. These were called neutrons. Experiments also showed that the protons and neutrons were in the centre of the atom, called the nucleus.

R The mass of a proton is 1/12th the mass of ^{12}C (carbon-12) which is 0.0000000000 0000000166053892 kg! For convenience it is easier to call this unit one '**dalton**' (Da), named after John Dalton.

Protons: A sub-atomic particle that has a positive charge of +1 and a mass of one dalton.

Neutrons: A sub-atomic particle that has no charge, and a mass of one dalton.

For atoms to be atoms, and not to be changing constantly, they need to be stable. This means that the total amount of positive charges must be equal to the total amount of negative charges – they must balance. So if you know how many protons an atom has, you also know how many electrons it has. This is called the **atomic number**. It was proven in an experiment by English physicist Henry Moseley in 1913.

In 1932, another English physicist, James Chadwick, used polonium, beryllium and paraffin wax to carry out a number of delicate radiation experiments. These experiments were the final proof on top of Rutherford's work that neutrons existed, that they had no charge, and that along with protons they made up the rest of the nucleus.

Nucleus: The central part of an atom that contains the protons and neutrons.

Atomic Number: The number of protons in an atom of an element.

Comparing the Sub-Atomic Particles

By this time scientists had calculated the mass of all three sub-atomic particles. Protons and neutrons had the same mass, but electrons were almost 2000 times less than protons or neutrons. Because of this, in most calculations the mass of the electrons was ignored.

The combined mass of the protons and neutrons is very important, because it is different for the atoms of each element. This is called the **mass number**. It is one of the ways to tell the difference between the atoms of each element.

Mass Number: The total number of protons and neutrons in one atom of that element.

Sub-Atomic Particle	Mass	Charge	Location
electron	$\frac{1}{1840}$ dalton	–1	orbiting the nucleus
proton	1 dalton	+1	nucleus
neutron	1 dalton	0	nucleus

Table 07.01.01 Properties of the sub-atomic particles.

Checkpoint 1

(a) What information about an atom does the mass number give?

(b) How is an atom different to a sub-atomic particle?

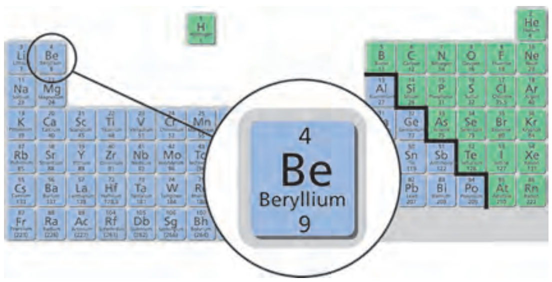
Note
Number of neutrons in an atom = Mass number – Atomic number

How Many Neutrons are there in an Atom?

Once scientists became sure about what the atomic number and mass number meant exactly, they could use these to find one other important piece of information – the number of neutrons in an atom. It turned out to be a simple calculation: subtract one from the other.

Number of neutrons in beryllium
= 9 – 4 = 5 **neutrons**

So Beryllium (Be) has 4 electrons, 4 protons and 5 neutrons.



Checkpoint 2

Use the periodic table on page 184 to help you find the element name for each of the elements in *Table 07.01.02*. Then complete the rest of the table, filling in the number of protons and electrons and calculating the number of neutrons each element has.

What difference do you notice between each type of atom? What do you notice about the number of protons and electrons in each atom?

Element	Element name	Atomic number	Number of protons	Number of electrons	Mass number	Number of neutrons
${}^{1}_{1}\text{H}$		1			1	
${}^{2}_{4}\text{He}$		2			4	
${}^{3}_{7}\text{Li}$		3			7	
${}^{4}_{9}\text{Be}$		4			9	
${}^{5}_{11}\text{B}$		5			11	
${}^{6}_{12}\text{C}$		6			12	
${}^{7}_{14}\text{N}$		7			14	
${}^{8}_{16}\text{O}$		8			16	
${}^{9}_{19}\text{F}$		9			19	
${}^{10}_{20}\text{Ne}$		10			20	
${}^{11}_{23}\text{Na}$		11			23	
${}^{12}_{24}\text{Mg}$		12			24	
${}^{13}_{27}\text{Al}$		13			27	
${}^{14}_{28}\text{Si}$		14			28	
${}^{15}_{31}\text{P}$		15			31	
${}^{16}_{32}\text{S}$		16			32	
${}^{17}_{35}\text{Cl}$		17			35	
${}^{18}_{40}\text{Ar}$		18			40	
${}^{19}_{39}\text{K}$		19			39	
${}^{20}_{40}\text{Ca}$		20			40	

Table 07.01.02.

R What About Electrons?

Scientists were certain that the protons and neutrons sat as a solid mass in the centre of the atom (the nucleus), but where did the negative sub-atomic particles – the electrons – fit?

Both J.J. Thomson and Ernest Rutherford had made suggestions about how electrons were arranged inside an atom, but it was Danish physicist Niels Bohr who came up with an explanation that made the best sense of what scientists knew. He suggested that electrons moved around the nucleus in **energy levels**, which he called **orbits** (or **shells**). This was called the **Bohr Orbital Model**.

The number of electrons each atom of each element had, and how they filled each shell, was very specific. This was called the **electronic configuration** and can be shown as a diagram (*Fig. 07.01.05*) or as a list, e.g. Al (Aluminium) is (2, 8, 3).

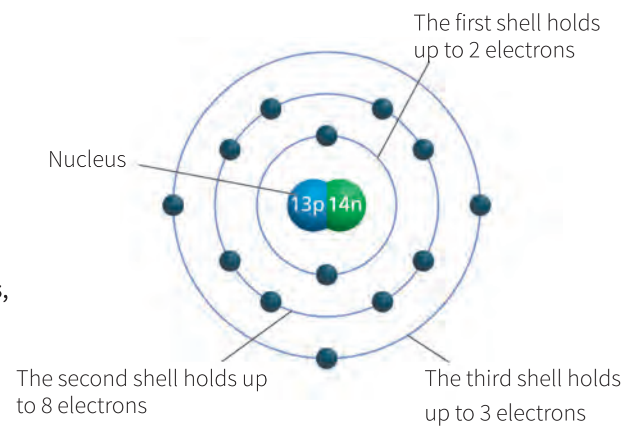


Fig. 07.01.04 The Bohr Orbital Model for aluminium.

Shell (Orbit): An energy level in which electrons move around the nucleus.

Electronic Configuration: The arrangement of electrons in the shells around an atom.

Fig. 07.01.05 The changing concepts of the basic particles of all matter.

The Octet Rule

The Octet Rule means that atoms arrange themselves so that they have eight electrons in their outer shell, and are therefore stable and unlikely to react. If an atom cannot get eight outer electrons, the next most stable number of electrons is two. Atoms react with other atoms so that they can have a stable number of electrons in their outer shell.

All this information allowed scientists to create rules for how atoms reacted. These rules eventually led to the point where new medicines could be successfully designed by computer without trying thousands of combinations of atoms in the laboratory to find the right one.

Did you know?

Robert Bunsen invented the Bunsen burner because he wanted to get a steady and hot gas flame so that he could experiment on elements. What he didn't know was that by heating the atoms of the element he was causing electrons to move between energy levels. They gave off energy as light when they did this – the colour was different for each element. This became known as the flame test.

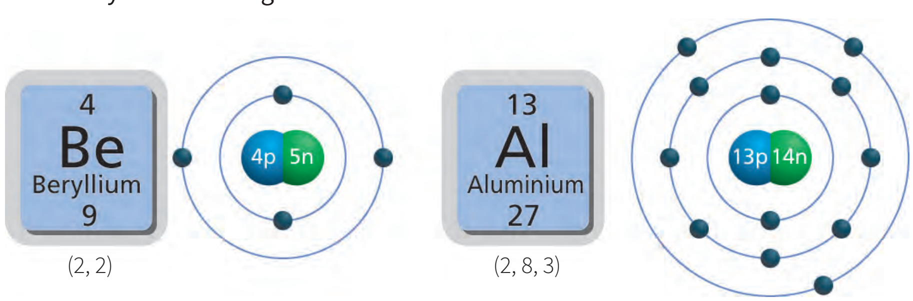


Fig. 07.01.06 Bohr diagrams for beryllium and aluminium. They show the electronic configuration for these atoms.

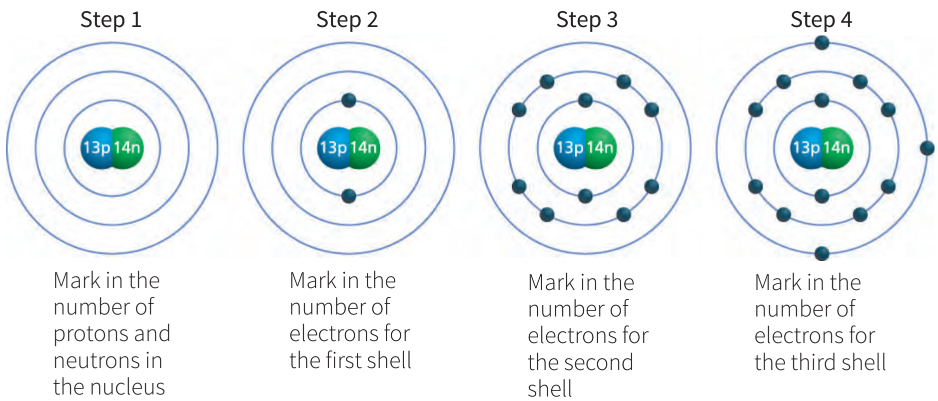
R How to Draw the Electronic Configuration of Aluminium (Al)

1: Check the atomic number of the element of aluminium to find out how many protons and electrons there are.

2: For aluminium there are 13 electrons: 2 in shell one, 8 in shell two. That leaves 3 for shell three, so that equals: 2, 8, 3 (the electronic configuration). There are also 13 protons in the nucleus.

3: Subtract the atomic number from the mass number to give you the number of neutrons in the atom. For aluminium: 27 – 13 = 14 neutrons in the nucleus.

4: Fill in the empty nucleus and shells by drawing four circles around each other. Fill each circle step by step.



Checkpoint 3

(a) **Draw and write out the electronic configuration for fluorine (F) and argon (Ar).**

(b) **Argon is a gas used to put out fires without causing further damage. It is also used to fill sealed packets of food to keep them fresh. Compare the outer shell of the two diagrams you have drawn. Why do you think argon can and fluorine cannot be used for both of these jobs?**

CHEMISTRY

Isotopes

When scientists calculated the mass of a carbon atom, it could be heavier or lighter depending on where in the world the carbon came from. But why? If all the atoms of an element are identical, then the calculation should always work out the same, no matter where the carbon was mined. The discovery of **isotopes** answered this question.

In 1913, Frederick Soddy, an English radiochemist, came up with the answer to explain why scientists were finding atoms from the same elements that had the same number of protons but different numbers of neutrons.

Isotopes: Atoms of the same element which have the same number of protons but different numbers of neutrons.

It turns out that carbon has two isotopes. Most carbon is ^{12}C ('carbon-12'), with a mixture of ^{13}C and ^{14}C. Carbon-12 has 6 electrons, 6 protons and 6 neutrons, but carbon-13 has 6 electrons, 6 protons and 7 neutrons. This means that carbon-13 has an extra neutron, and explains why its mass number is one greater than carbon-12. Carbon-14 has two extra neutrons compared to carbon-12. How much of each depends on where the carbon is mined, so the exact mixture of isotopes can give information about the specific mining location of an element.

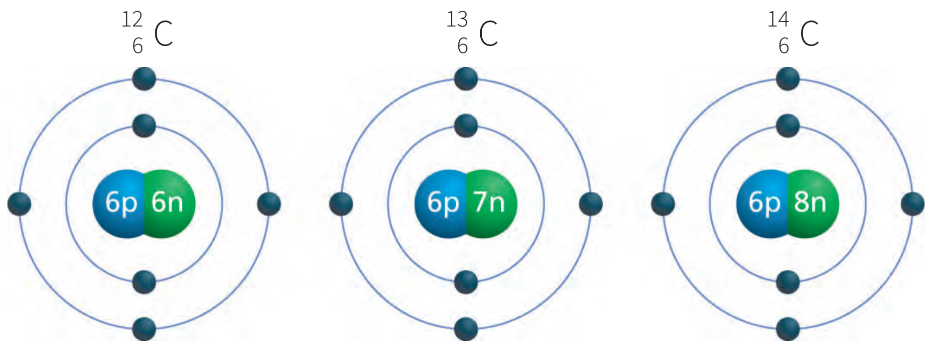


Fig. 07.01.07 Comparative Bohr diagrams of carbon-12, carbon-13 and carbon-14.

Carbon-14 is also useful in dating ancient objects containing carbon because it breaks down into carbon-13 and carbon-12 at a steady amount over time, which can be measured. So any object which contains carbon, such as cloth, wooden tools or pottery, can be dated to within ten years. This is called radiocarbon dating and is often used by archaeologists to date objects which don't have dates marked on them, as coins do.

The most famous item to be dated like this is the Shroud of Turin. This is a burial shroud that is believed to have been used to wrap the body of Jesus Christ for burial over 2000 years ago because the image of a crucified man can be seen on it. There is no reasonable scientific explanation for how this image was made, but radiocarbon dating has shown that the shroud was made in the early 1200s, suggesting that it may be a fake. (However, further to this, there has been controversy about how the testing of the cloth was done.)

Fig. 07.01.08 Front view of the Shroud of Turin. A fire in the French chapel holding the relic in 1532 caused the four scorch marks that can be seen around the imprint of the body.

WHAT I HAVE LEARNED...

- The smallest particle of an element is an atom.
- All the atoms in an element are identical.
- Atoms are made up of electrons, protons and neutrons.
- Electrons move around the nucleus of an atom in energy levels called orbits (or shells).
- Protons and neutrons make up the centre of the atom, called the nucleus.
- Protons and neutrons both have a mass of one dalton and electrons have a mass of $\frac{1}{1840}$ dalton.
- Electrons have a charge of -1, protons have a charge of +1, and neutrons are neutral so have a charge of 0.
- The atomic number is the number of protons in an atom.
- The number of electrons in an atom is equal to the number of protons.
- The number of neutrons in an atom can be found by subtracting the atomic number from the mass number.
- How to draw the arrangement of electrons in an atom (electronic configuration/the Bohr Model).
- Isotopes are atoms of the same element which have the same number of protons but different numbers of neutrons.

Bohr's Orbital Model

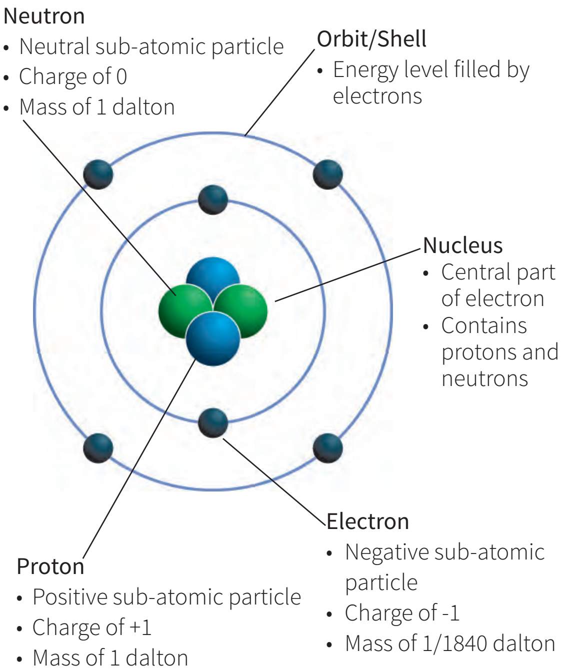


Fig. 07.01.09 A Bohr Orbital Model showing the parts of an atom.

Question Time

Copy and Complete

In this unit I learned that there are three types of __ - _____ particles. Different _________ of each type make up an atom. The ___________ has a charge of -1, a ___________ has a charge of +1 and the ___________ has no charge. Both the _________ and the _____________ are located in the centre of the atom, which is called the _____________. The atomic number of an atom tells you how many ________ are in that atom. The _________ number of an atom tells you how many protons and __________ are in that atom. Each atom is neutral because each _________ charge cancels each______charge. This is because there are equal numbers of________ and ________ in each stable atom. Isotopes are atoms of the ________ element that have the same number of protons but ________ number of ________.

Questions

1. Where in an atom would you find:
   (i) an electron?
   (ii) a proton?
   (iii) a neutron?
2. *Fig. 07.01.10* shows an element from the periodic table. Using the information in the diagram and the periodic table on page 184, find:
   (i) the name of this element
   (ii) how many electrons this element has
   (iii) how many protons this element has.

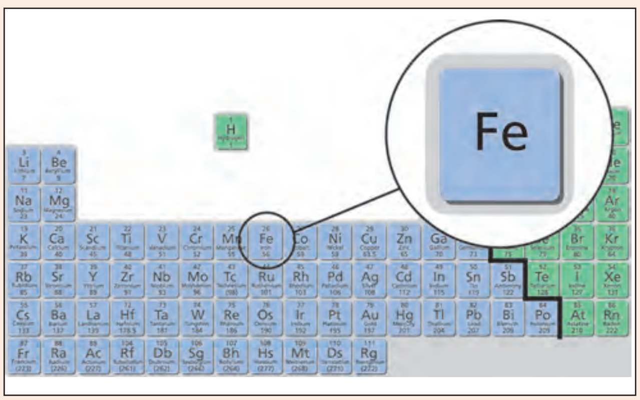


Fig. 07.01.10 An element from the periodic table.

3. Using the answer bank provided, copy and complete *Table 07.01.03*. Some answers may be used more than once.

Answer bank			
• 0	• Proton	• Positive	• Negative
• 1	• Electron	• Neutron	

Name of Sub-atomic Particle	Charge	Location	Mass (dalton)
		Nucleus	
		Orbit	
		Nucleus	

Table 07.01.03.

4. Niels Bohr received the Nobel Prize for Physics in 1922 for his model of the electronic structure of the atom. Potassium has an atomic number of 19. Give the arrangement of the electrons in an atom of potassium in the way that Bohr suggested.

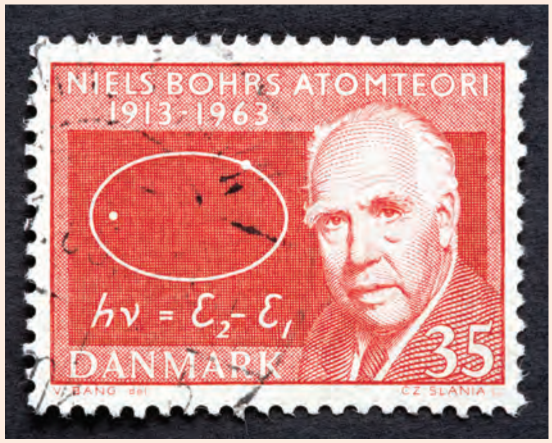


Fig. 07.01.11 Niels Bohr commemorative stamp.

5. Chlorine's atomic number is 17. Chlorine's atomic mass is 35.5. If all chlorine atoms had 17 neutrons, its atomic mass would be about 34.00. If all chlorine atoms had 18 neutrons, its atomic mass would be about 36.00. Explain why the atomic mass of chlorine is between 34 and 36.

Inquiry

A Americium-241 is a radioactive isotope of uranium used in smoke detectors, but in such small amounts as to be harmless. **Design** a poster that explains how americium-241 is used in a smoke alarm.

B **Create** a model that shows how the electrons in an atom are arranged. You may choose from element 11 to element 20.

C **Research** the work of one of the following scientists and **create** a poster or presentation on them: Aristotle, Dalton, Thomson, Rutherford or Bohr.

UNIT

14.1 Electricity

Learning Outcomes

PWLO 1. Select and use appropriate measuring tools.
PWLO 2. Identify and measure/ calculate length, mass, time, temperature, area, volume, density, speed, acceleration, force, **potential difference, current, resistance** and electrical power.
PWLO 5. Design and build simple electronic circuits.

R Teacher's reference

KEYWORDS

circuit
conductor
electric current
electrolysis
electrolyte
electromotive force
insulator
Ohm's Law
parallel
potential difference
resistance
schematic
series
static electricity
voltage

LEARNING INTENTIONS

At the end of this unit you should:

1. Be able to classify materials as conductors or insulators.
2. Be able to use appropriate instruments to measure current, potential difference (voltage) and resistance.
3. Be able to explain the relationship between current, potential difference and resistance.
4. Be able to perform simple calculations based on the relationship between current, potential difference (voltage) and resistance.
5. Be able to describe the heating effect, the chemical effect and the magnetic effect of an electric current, and identify everyday applications of these, including the action of a fuse.
6. Be able to set up simple series and parallel circuits containing a switch and two bulbs.

Electricity

Electricity is essential to our everyday lives. Without it we would not be able to charge our phones, turn on our kettles, power our schools or even produce this book. However, there was a time when electricity was not around. Electricity, as it currently is, was not discovered until 1800 by Italian physicist, Alessandro Volta. He stacked copper (Cu) and zinc (Zn) plates in acid and discovered that it produced a steady flow of electricity. It was this invention that sparked the generation of electricity as we know it today.

Fig. 14.01.01 Alessandro Volta (1745–1827).

Why do wires glow red hot when electricity passes through them?

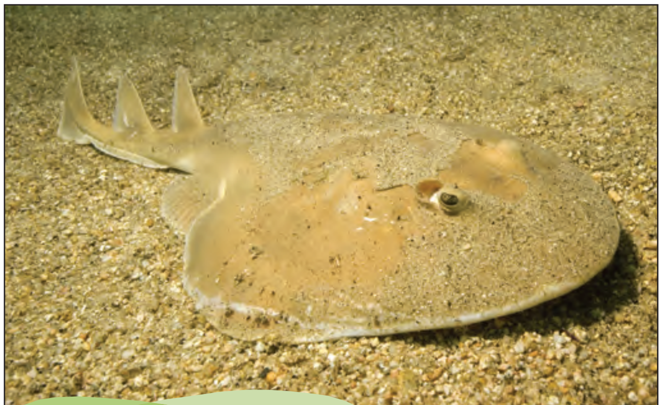


Fig. 14.01.02 The electrifying torpedo fish.

Did you know?
Volta got his idea for stacking the zinc and copper plates in acid by dissecting a torpedo fish (also known as an electric ray). Torpedo fish have two organs on either side of their brain which consist of millions of jelly-like plates stacked up.

Current electricity is one form of energy, but there is another form of electricity called **static electricity**. Unlike current electricity (which is what we will be looking at), static – as the name suggests – does not move.

R **Did you know?**
Static electricity can be easily created by rubbing a balloon against your head or rubbing a pen against your jumper and trying to pick up a small piece of paper.

Current Electricity

So what is current electricity? How does it work? We must look back to atoms again. Recall that an atom is made up of different sub-atomic particles, one of which, the electron, contains a negative electrical charge. Electricity works on the principle of the flow of these negative charges. This flow of charge is called a **current** and is given the symbol I. The unit of current is the ampere, also known as amp, and the symbol for amp is A.

R **Imagine this:** You have a small pipe and you place it flat on the ground (this is your wire). Grabbing some marbles (your 'charge carriers'), you roll one marble through the pipe. So when you roll one charge carrier (marble) through the wire (pipe), you now have a current. The more charge carriers (marbles) you have going through the wire (pipe), the higher the current.

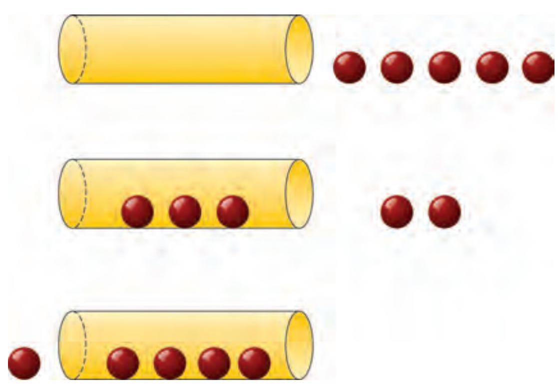
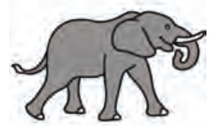


Fig. 14.01.03 Current: the flow of charged particles.

Current: The flow of charged particles. Symbol: I. Unit: amp (A).

Conductors and Insulators

Not all substances will allow electricity to flow through them. For example, if we try to pass an **electric current** through wood, nothing will happen, whereas electric current will pass through metal (*Fig. 14.01.04*). We classify any object which allows electric current to easily pass through as a **conductor**, whereas any object which does not allow electric current to easily pass through is called an **insulator**. It is important to remember that an insulator is just a poor conductor and not something completely different to a conductor.



REMEMBER

Current is the flow of charge carriers (for example, the electron) flowing through the wire. The unit of current is the ampere (or the amp) (A).

Conductor: An object or substance that electric current passes through easily.

Insulator: An object or substance that electric current cannot pass through easily.

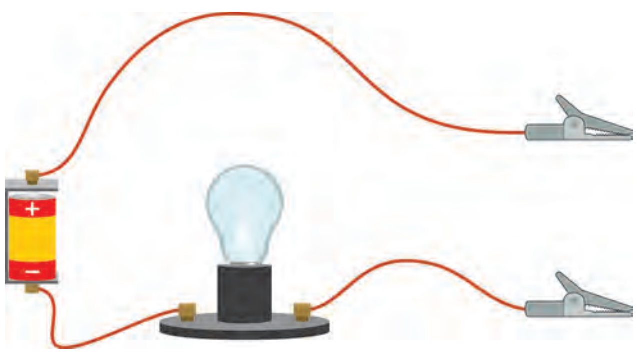
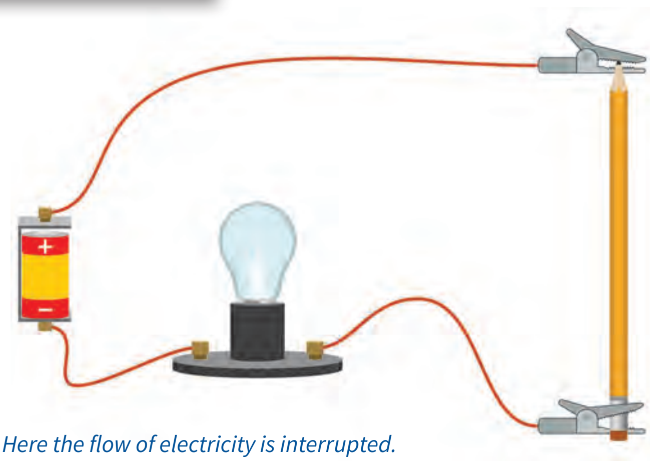


Fig. 14.01.04 Passing an electrical current through an object.



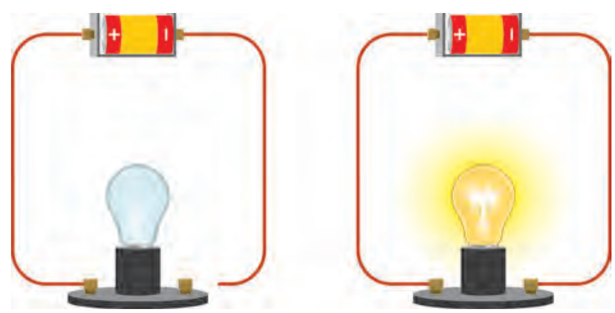
Here the flow of electricity is interrupted.

How Do the Charge Carriers Flow Through the Wires?

You might next wonder how the charge is carried along the wire/ circuit? This is a very good question, but first we must understand the following: *Fig. 14.01.05* shows two identical **circuits** – one where the light is not lighting, the other where it is. A circuit is a connection between electrical components (i.e. the wire, pencil and bulbs) and a source (the battery).

Circuit: A connection between electrical components and a power source.

In order for any electric current to flow we must have a complete circuit. This means that the wires must start at the source and end at the source. If the circuit is not complete, no current flows through the circuit and the bulb does not light.



Incomplete circuit Complete circuit

Fig. 14.01.05 On the right we have a complete circuit as all terminals are connected in a loop back to the battery. On the left we have an incomplete circuit as there isn't a complete loop back to the terminal.

Electromotive Force/Potential Difference/Voltage

Now that we know this, we can explain how an electric current goes through these circuits. If you look at the top of a 9V battery, you will notice two little bumps. These bumps are called terminals and are labelled positive (+) and negative (–). The negative terminal contains all of the negative charge carriers. The positive terminal contains positive charges. You've heard the phrase opposites attract? In *Unit 7.3* we noted that positive ions attract negative ions. The same goes for electricity. We have negative charge carriers in the – terminal and they want to find the positive ones in the + terminal. This force of attraction causes the negative charge carriers to move through the wires to find the positive ones (*Fig. 14.01.07*). This is called the **Electromotive Force** (**voltage**), or EMF. The unit is the volt (V). In batteries the negative charge carriers are in fact electrons.

Fig. 14.01.06 A 9V battery.

Be aware:
It is more common to call EMF potential difference or voltage. For the rest of this unit we will call it voltage or EMF.

Electromotive Force (Voltage): The work done to bring one charge carrier from the negative terminal to the positive one. Unit: volt (V).

R Did you know?
Scientist now know that charge carriers flow from – to +. But this wasn't actually discovered until much later on because we did not understand the nature of the electron. Therefore we still refer to the flow of 'conventional' current as from + to –.

So an electric current will go through a circuit under these conditions:

1. We have a complete circuit
2. When the EMF is enough to move the charge carriers in that circuit between the – and + terminals.

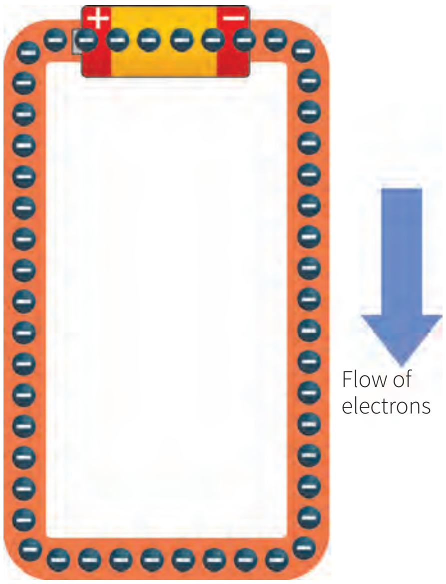


Fig. 14.01.07 The flow of electrons from the negative terminal of the battery to the positive terminal of the same battery.

Resistance

We have spoken about conductors and insulators, but do all conductors allow current to flow through them at the same rate?

Some conductors allow the electrons to flow through them with great ease (for example, copper). However, others such as brass and bronze do not allow the electrons to flow through them easily. This brings us to what is known as **resistance**. The unit of resistance is the Ohm (Ω).

To understand resistance, imagine yourself walking down your school corridor. When it is empty you can walk through it with ease. But what happens when students spill out of class and start walking against you? You begin to bump off them and slow down. This is the idea of resistance.

Resistance: The ability of a material to resist the flow of electric current. Unit: Ohm (Ω).

PHYSICS

Each material has a built-in level of resistance to electrical current, which slows down the flow of electrons. The higher the resistance, the harder it is for the electrons to flow though the material.

Some materials have such a high resistance that the electrons begin to give off heat energy. When these electrons are slowed down, the energy they have must go somewhere (according to the Law of Conservation of Energy). This is why the electrons start to give off heat energy.

This is how the heating coils in kettles and washing machines work. Indeed, in the old filament lightbulbs, a lot of the energy produced by the electrons was in fact turned into heat energy, because the metal used in the bulbs had a very high resistance. Nowadays we use what are called 'energy-saving' lightbulbs, where more light energy is produced as opposed to heat energy.

Checkpoint 1

(a) What is an electric current?
(b) What is a conductor?
(c) What is an insulator?
(d) What are the charged carriers in a battery?
(e) What is another name for potential difference?
(f) What is electromotive force?
(g) In which direction does actual current flow?

Effects of Current

R 1. Heating Effect

As we have mentioned, the old filament bulbs used to become hot when turned on This is because the wires used in the bulbs, typically Tungsten, had a very high resistance. As a result, most of the energy was converted into heat energy and very little was converted into light energy. This is an example of the **heating effect** of electric current.

Fig. 14.01.08 Old filament lightbulbs (left) used to convert most of their electricity into heat energy and very little into light. To combat this, 'energy-saving' lightbulbs were created. Compact Fluorescent Lamps (CFL) use one-fifth of the energy of old filament bulbs while giving out the same amount of light. They also last 8–15 times longer.

2. Magnetic Effect

If you just connect a battery with wires and place a compass near the wires, you will notice something strange. The compass will deflect when it comes near the wire. This means that the wire is producing a magnetic field.

An amazing application of this magnetic effect is the Magnetic Levitation (MagLev) train in Shanghai, China (*Fig. 14.01.09 (a)*). Using the magnetic effect, the MagLev train travels along guiding rails using magnets to create not only lift but also propulsion (forward movement). As well as this, because it is not in contact with the ground or guiding rails, there is a reduction in friction, allowing the train to reach a whopping 430 km/h (its safe operational speed). It covers its full journey, a distance of 30.5 km, in just eight minutes!

Fig. 14.01.09 (b) The magnetic effect is also seen in scrapyards where large amounts of metal can be moved about.

Fig. 14.01.09 (a) The amazing MagLev Train in operation.

Investigation 14.01.01: The magnetic effect of current

Equipment: Power supply, wires, resistor, crocodile clips, compass.

Instructions: Design an investigation to discover what effect a wire carrying electricity might have.

What did you learn?

What effect, if any, did you notice? What does this tell us?

R 3. Chemical Effect

When current is passed through acidified water, the water is chemically broken down into hydrogen and oxygen gas. This is called **electrolysis**. The electric current is able to break down the H_2O (water) and charge can then be conducted through the liquid. Conduction is possible in other liquids such as nitric acid, and hydrochloric acid, and these liquids allow current to flow through them. This is because when electricity is passed through these liquids, they decompose and create ions, which are able to conduct electricity.

These types of liquids are called **electrolytes**.

A **Hofmann Voltameter** is used to split water into hydrogen and oxygen.

You can see a Hofmann Voltameter in action by following this link: https://www.youtube.com/watch?v=EE58a5fN468

Electrolysis: The breaking down of water into hydrogen and oxygen by the application of a current.

Electrolyte: A liquid which conducts electricity through the movement of ions created by electrolysis.

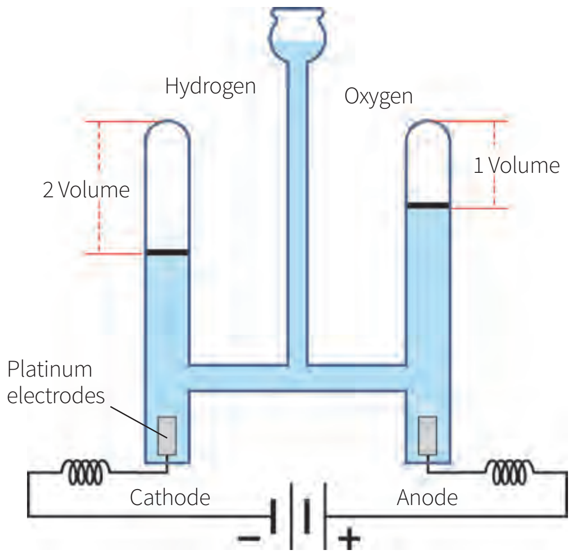


Fig. 14.01.10 Diagram of a Hofmann Voltameter.

Fig. 14.01.11 An electroplated iPhone.

There are many practical applications of electrolysis, but one you may all be familiar with is **electroplating**. Electroplating uses the movement of these electrolytes to coat a material a different colour. A famous example of this is Apple's gold iPhone.

Checkpoint 2

(a) Name the three effects of electric current.

(b) Pick two of these effects and describe how to demonstrate them.

(c) Give an everyday example of one of the effects.

PHYSICS

Building Circuits and Measuring Voltage, Resistance and Current

Drawing all the components in a circuit correctly can become very difficult, so scientists agreed on a set of symbols, known as **circuit symbols**. An agreed set of symbols means that fewer mistakes will be made and everyone using them understands each other.

Circuit symbols can be put together in a circuit diagram, called a **schematic**. Engineers and electricians use these diagrams when they are working; otherwise the drawings for real-life versions of complicated circuits would simply be too big to carry around.

Table 14.01.01 gives a complete table of the components of a circuit you will need to know.

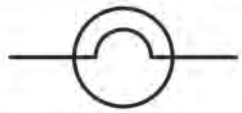
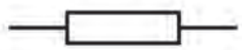
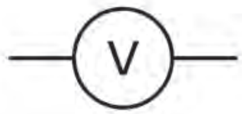
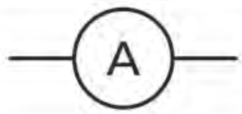
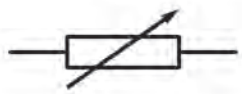
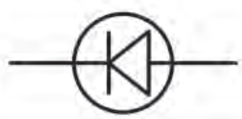
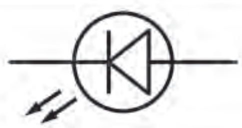
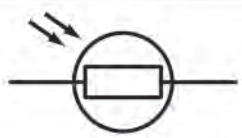
Component	Symbol	Measures	What it does
Battery			Produces an EMF for the circuit
Wire			Provides conduction for charge carries
Switch			Breaks/connects a circuit
Bulb			Produces light when connected in a closed circuit
Resistor			A fixed value resistance
Voltmeter		Voltage	Connected in parallel (across an object); measures the potential difference across that object
Ammeter		Current	Connected in series, it measures the current of a circuit
Variable resistor		Resistance	Increases/ decreases the resistance of the resistor
Diode			A device that allows current to flow in one direction only
Light emitting diode (LED)			A diode which gives off light when current is flowing through it
Light dependent resistor (LDR)			A resistor whose resistance depends on the amount of light shining on it

Table 14.01.01 Circuit components and their symbols.

Series Circuit

A circuit is said to be in **series** when the current has to flow through each component one after the other in order to complete the circuit (*Fig. 14.01.12*).

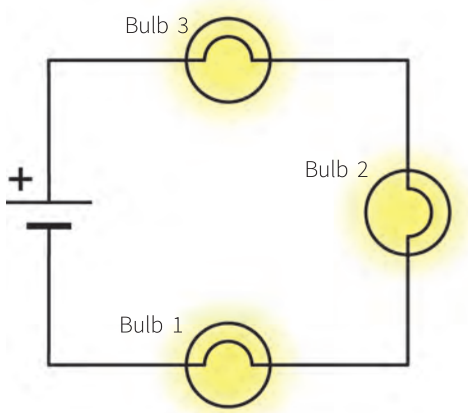


Fig. 14.01.12 A circuit in series.

Investigation 14.01.02: **The effect of adding bulbs to a series circuit**

Equipment: Suitable filament bulbs (at least three), wires, crocodile clips, 9V battery, switch.

Instructions: Using the equipment as listed, design and carry out an investigation to demonstrate the effect of adding several bulbs to a series circuit.

What did you learn?

1. What did you notice happened as you added bulbs to the circuit?
2. Compare the effect when there is one bulb, a second bulb and a third bulb added. What did you find?
3. What conclusion can you draw about the effect of adding bulbs in a series circuit?

Parallel Circuit

A circuit is said to be in **parallel** when the current does not have to flow through each component one after the other in order to complete the circuit (*Fig. 14.01.13*). This means that each component is connected independently of the others, which has a very interesting side-effect.

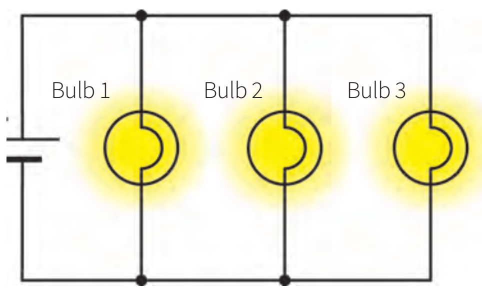


Fig. 14.01.13 A circuit in parallel.

Investigation 14.01.03: **The effect of adding bulbs in parallel**

Equipment: Suitable filament bulbs (at least three), wires, crocodile clips, 9V battery, switch.

Instructions: Using the materials above, design and carry out an investigation on the effect adding several bulbs to a parallel circuit has on the circuit. In your investigation, ensure you measure voltage, current and resistance.

What did you learn?

1. Did you notice any effect when bulbs were added in parallel?
2. Discuss what effects you observed on the current, voltage and resistance when bulbs were added in parallel.
3. What conclusion can you draw about the effect of adding bulbs in parallel circuits?
4. Compare and contrast the effects of adding bulbs between series and parallel circuits.

PHYSICS

The Relationship Between Current, Voltage and Resistance

Recall that:

- **Current** (I) is the flow of charged particles. Its unit is the amp (A).
- **Electromotive force** (voltage) is the force of attraction between the two terminals of a source. Its unit is the volt (V).
- **Resistance** is a material's ability to resist the flow of current in it. Its unit is the Ohm (Ω).

Investigation 14.01.04: **The relationship between voltage and current**

Equipment: Voltmeter (used to measure voltage), resistor, power supply, wires, crocodile clips, variable resistor (if not built into power supply) and ammeter (used to measure current).

Instructions: Design an investigation using the equipment as listed to find out if there is a relationship between voltage and current.

What did you learn?

1. Construct a table with your data.
2. Represent this information on a graph.
3. What does your graph tell you about the relationship between voltage and current?

In 1827, Georg Ohm was able to find a link between the current flowing through a battery and its **voltage**. To do this he used a constant which he called **resistance**. This is why the unit of resistance is called the Ohm. This discovery led to one of the most useful laws in electricity, called **Ohm's Law**. This law describes the relationship between voltage and current, and is written as: $R = \frac{V}{I}$

Alessandro Volta (1745–1827)

André-Marie Ampère (1775–1836)

Georg Ohm (1789–1854)

Fig. 14.01.14 The scientists whose names are given to the basic units of electricity because their experiments help to improve the understanding of electricity, how it worked and could be used. Volta gave his name to the volt, Ampere gave his name to the amp and Ohm to the ohm!

When Ohm carried out his own version of this experiment, he found that the voltage is directly proportional to the current in the wire. So when voltage is increased each time by a fixed amount, the current increases by a fixed amount (similar to *Table 14.01.02*).

When Ohm plotted his current and voltage measurements on a graph, he got a straight line. When this straight line passes through the origin we get a unique relationship which is referred to as being **directly proportional**. This means that the two properties maintain a constant ratio. After many years it was found that this ratio could be described by a constant. In the case of Ohm's Law, this constant is called **resistance**.

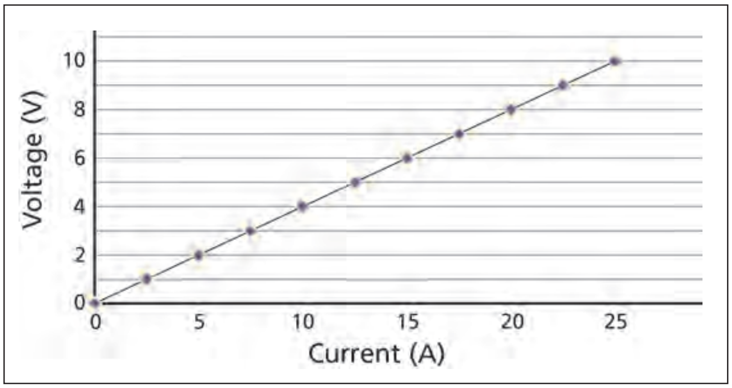


Table 14.01.02.

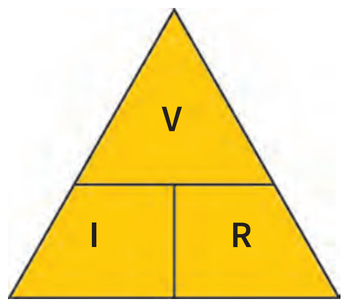
So using the readings as depicted in *Table 14.01.02*, Ohm would have divided the voltage by a matching current. For this graph the answer is 0.8 Ω. This means that every time Ohm increased the current by 2 A, the voltage increased by 1.6 V. This means that multiplying the current by the resistance allows you to calculate the voltage. Also, dividing the voltage by the resistance will give you the current.

Ohm's work showed that the relationship between resistance, current and voltage is the same even if each experiment gives a different set of voltages and currents.

Calculating Resistance	Calculating Voltage	Calculating Current
$V = 40$ V	$I = 2$ A	$V = 3.5$ V
$I = 8$ A	$R = 0.8\ \Omega$	$R = 2\ \Omega$
$R = \frac{V}{I}$	$V = IR$	$I = \frac{V}{R}$
$= \frac{40}{8}$	$= 2 \times 0.8$	$= \frac{3.5}{2}$
$= 5\ \Omega$	$= 1.6$ V	$= 1.75$ A

Fig. 14.01.15 Ohm's examples of how to calculate voltage, current and resistance using

Ohm's Triangle



Cover the variable you want to find and perform the resulting calculation (Multiplication/Division) as indicated.

Fig. 14.01.16 Ohm's Law Triangle.

WHAT I HAVE LEARNED...

- Current (I) is the flow of charged particles and its unit is the amp (A).
- Voltage is the force of attraction between the two terminals of a source. The unit is the volt (V).
- Resistance is a material's ability to resist the flow of current in it. The unit is the ohm (Ω).
- Conductors allow current to flow through them easily.
- Insulators do not allow current to flow through them easily.
- We must have a complete circuit for current to flow through it.
- A series circuit is when components are connected one after the other.
- A parallel circuit is when components are connected side by side.
- The relationship between voltage and current is also known as Ohm's Law.
- Ohm's Law states that the voltage and current are directly proportional.
- When resistors are added in series their resistance is added together.

Question Time

Copy and Complete

In this unit I learned that _______ is the flow of _______ particles. In order to make these _______ particles flow there needs to be a P_______ d_______. P_______ d_______ is also known as voltage. This voltage is the force of _____ between two _______ in a battery. It is this force which causes the _______ _______ to flow through a circuit. I also learned that in order for charged particles to flow in a circuit, we must have a _______ circuit. This means that all wires are connected to each component and connected to both terminals of the ______. I also learned that not all materials will allow _______ to flow through them. When current does not flow through a material easily it is called an ______; whereas if it does allow current to flow through it easily it is called a _______. This property of materials is called ______ and its unit is the ________. There are two types of complete circuits. ______ circuit is when the current has to _________ through the ________ one after another. _______ circuits are when the current _______ _______ have to flow through all the components one after another. I also learned another key relationship between _______ and _______. This is commonly known as _______ Law. This relationship states that _______ is directly _______ to the _______ and this gives us our physical constant of _______.

Questions

1. What are the three effects of electric current?
2. Which effect is the Hofmann Voltameter associated with?
3. How do you test if a current carrying wire produces a magnetic field?
4. What is the relationship between the voltage and current in a circuit?
5. What instrument would you use to measure current?
6. What instrument would you use to measure voltage?
7. Calculate the current of the circuit as shown in *Fig. 14.01.17*.

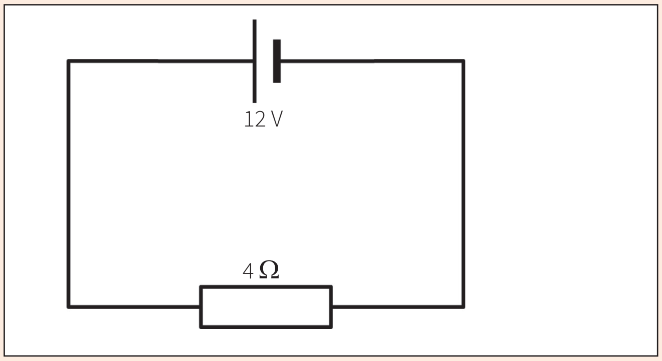


Fig. 14.01.17 Calculate the current of the circuit shown.

8. If we have a complete series circuit with a 2 Ω and 5 Ω resistor connected in series, what is the total resistance of this circuit?
9. A science student investigated the relationship between voltage and current for a resistor, as detailed in *Table 14.01.03.*

Voltage (V)	0	0.22	0.40	0.58	0.80
Current (I)	0	0.20	0.40	0.60	0.80

Table 14.01.03.

(i) Draw a graph of voltage versus current.

(ii) Describe clearly the relationship between voltage and current shown by the graph you have drawn.

(iii) Use the graph to calculate the resistance of the resistor used in this experiment.

10. *Fig. 14.01.18* shows the circuit used by the student to perform this experiment. Two meters were used, one to measure voltage and the second to measure current.

(i) R Copy and complete *Fig. 14.01.18* by entering the symbols for both meters in the circuit diagram, each one in the appropriate circle.

(ii) How was the voltage/current varied when doing this investigation? (*JC HL 2013*)

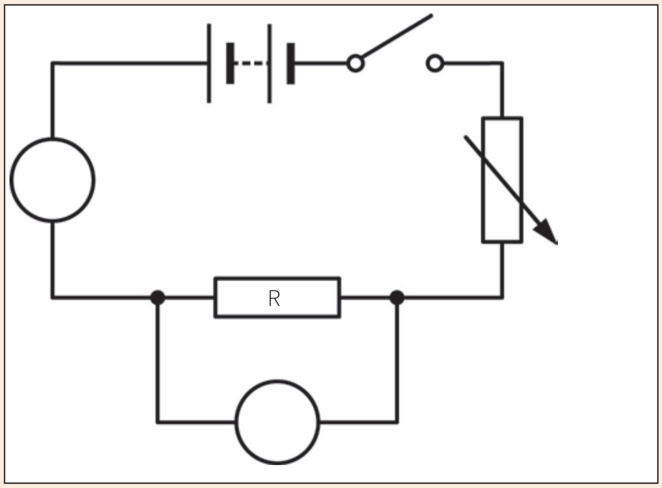


Fig. 14.01.18.

Inquiry

A Using PhET Simulations or the actual physical components, **build** a series and a parallel circuit and complete the following tasks:

(i) **Compare** the brightness of:

(a) Two bulbs in a series circuit to two bulbs in a parallel circuit

(b) Three bulbs in a series circuit to three bulbs in a parallel circuit.

(ii) **Design** a circuit such that when one bulb blows, the rest stay lit.

(iii) **Compare** the current of:

(a) Two bulbs in a series circuit to two bulbs in a parallel ciruit

(b) Three bulbs in a series circuit to three bulbs in a parallel circuit.

B A diode is a specialised electronic component made up of two terminals: the negative cathode and the positive anode. The primary function of a diode is to restrict current flow to one direction. When current is allowed to flow through the diode, it is said to be in forward bias. When current is not allowed to flow, it is said to be in reverse bias. **Prepare** a PowerPoint/video presentation discussing the following points:

(i) what diodes are typically made of

(ii) how to tell if a diode is in forward or reverse bias (include photos or a video of setting up the demonstration)

(iii) common uses of diodes

(iv) how diodes affect Alternating Current

(v) when it is connected correctly it allows current to flow through it.

C If a large electromagnetic pulse hit our planet, could we survive it? Where could such a pulse naturally occur in our universe? **Create** a poster on this subject.

UNIT

16.2 Cycles of Energy

Learning Outcomes

ESLO 6. Research different energy sources; formulate and communicate an informed view of ways that current and future energy needs on Earth can be met.

NSLO 2. Recognise questions that are appropriate for scientific investigation; pose testable hypotheses and evaluate and compare strategies for investigating hypotheses.

NSLO 3. Design, plan and conduct investigations; explain how reliability, accuracy, precision, fairness, safety, ethics and a selection of suitable equipment have been considered.

NSLO 4. Produce and select data (qualitatively/quantitatively); critically analyse data to identify patterns and relationships; identify anomalous **observations; draw and justify conclusions.**

NSLO 5. Review and reflect on the skills and thinking used in carrying out investigations, and apply learning and skills to solving problems in unfamiliar contexts.

NSLO 7. Organise and communicate research and investigate findings in a variety of ways fit for purpose and audience, using relevant scientific terminology and representations.

PWLO 6. Explain energy conservation and analyse natural processes in terms of energy changes and dissipation.

PWLO 8. Research and discuss the ethical and sustainability issues that arise from generation and consumption of electricity.

R Teacher's reference

KEYWORDS

biofuels
biomass
conserve
dam
fermented
fossil fuels
geothermal
hydro-electric
hydrogen
methane
non-renewable
nuclear
renewable
sustainable

LEARNING INTENTIONS

At the end of this unit you should:

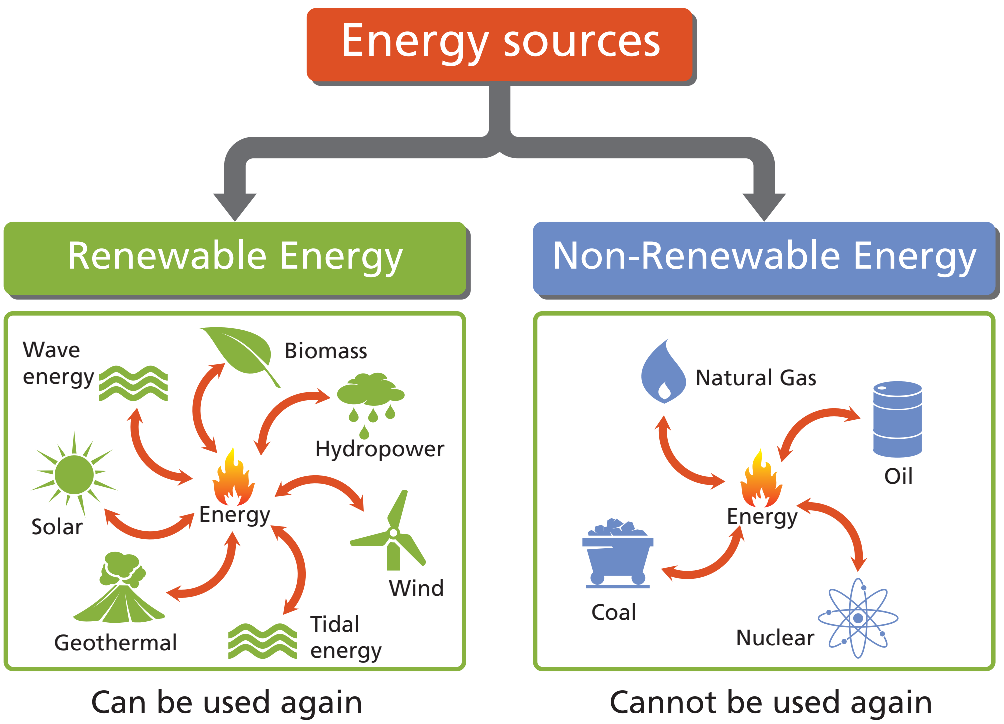
1. Understand the differences between energy sources: non-renewable and renewable.
2. Be able to explain the effect of non-renewable energy sources on the environment.
3. Understand what will happen non-renewable energy sources in Ireland and globally.
4. Understand the need to conserve energy and identify where energy may be wasted.

Energy and You

Energy causes things to happen. It powers things. Think of all the times you have flicked a switch to turn something on: the television, the hairdryer, the computer, the kettle, the light switch in your bedroom. Think of when fuel has been burned to produce heat in your house or to power your family's car. Each time you did any of these things, you needed and used energy.

We obtain most of our energy from the burning of coal, oil and natural gas. A car uses petrol or diesel, which come from oil. The electricity that powers your house or school comes from power stations that burn coal, oil or natural gas to produce the electricity. Other sources are increasingly being used to power electricity globally – solar, wind, wave and hydro-electric – but we still predominantly use fossil fuels to produce our energy.

Which releases the most energy: renewable or non-renewable sources of energy?



Non-Renewable Energy vs Renewable Energy

Before considering what energy source to use, we must think about what happens during the process of turning a particular source into the energy we need. Take a look at the headings in *Table 16.02.01* overleaf. Which source do you think is the most viable option for Ireland?

Non-renewable	Sustainability	Can they be used again	Damage to atmosphere	Availability	Damage to area/habitat when built	Initial costs	Energy amounts	Weather dependent	Ireland's use of these energy sources
	The Cons of Non-Renewable					*The Pros of Non-Renewable*			
	Limited supply; will run out; used quicker than they can be replaced	Once used, cannot be reused	Release carbon dioxide (a greenhouse gas) and other pollutants	Only in some areas and some countries	Some damage	Low in comparison to renewable set-up costs	Very high	Does not rely on the weather	91.7%

Renewable	Sustainability	Can they be used again	Damage to atmosphere	Availability	Damage to area/habitat when built	Initial costs	Energy amounts	Weather dependent	Ireland's use of these energy sources
	The Pros of Renewable					*The Cons of Renewable*			
	Always replenished; will never run out	Always replenished; will never run out; once used, can be reused	No damage; a clean energy (however, if biomass is burned it results in air pollution)	Everywhere	Some damage but not as much as non-renewables	Expensive to install or build (but maintenance costs are low)	Energy amounts produced are low	Energy amounts depend on the weather, which reduces their reliability, e.g. wind turbines need a certain wind speed to rotate	6.8%

Table 16.02.01 Non-renewable vs renewable energy sources.

Oil: A Non-Renewable Source

When we fill a car with petrol (made from oil) and drive the car, the fuel is being used. The petrol used to drive the car is used up in the car's engine and cannot be used again. The petrol tank will become empty and will have to be refilled. This non-renewable source is derived from fossil fuels, which were produced over millions of years by the death, decay and fossilisation of dead plants and animals.

Solar Energy: A Renewable Source

When solar panels absorb heat energy from the sun, this energy can be used to heat water. Heat energy from the sun can be used again, and more water can be heated up.

What Do Scientists Think?

Scientists believe that climate change is happening at a faster rate today in comparison to the last few hundred years. In *Unit 16.1,* we looked at the negative effects of burning fossil fuels, which is leading to an increase in greenhouse gas emissions. Scientists cannot accurately predict the long-term effects of global warming, but they say it will be damaging to us, other animals and plants.

The focus therefore is on developing and using renewable energy. This will reduce the amount of greenhouse gases in the atmosphere, which in turn will reduce our contribution to climate change.

Non-renewable: Where an energy source is used and cannot be used again.

Renewable: Where an energy source is used and can be used again.

Checkpoint 1

(a) Name two types of energy sources and explain the difference between them.

(b) Coal, oil and natural gas are examples of what kind of energy?

(c) List five sources of energy that can be reused.

(d) Why is there a move in Ireland and globally to use sources of energy that can be reused?

A Closer Look at Renewable Energies

Wave Energy

The waves at sea hold a lot of energy. This energy is harnessed to drive a turbine and make electricity.

How does it work?

There are several ways of getting energy from waves. Two examples are:

1. Floating: A wave energy machine floats out at sea. The waves move parts of the machine, causing an internal generator to spin, which then produces electricity. Example: the Pelamis in Scotland (*Fig. 16.02.01*).
2. Fixed: Water enters a chamber and its movement turns a turbine, which is linked to a generator that produces electricity (*Fig. 16.02.02*).

Did you know?
The Pelamis is longer than a football pitch.

Fig. 16.02.01 The floating Pelamis.

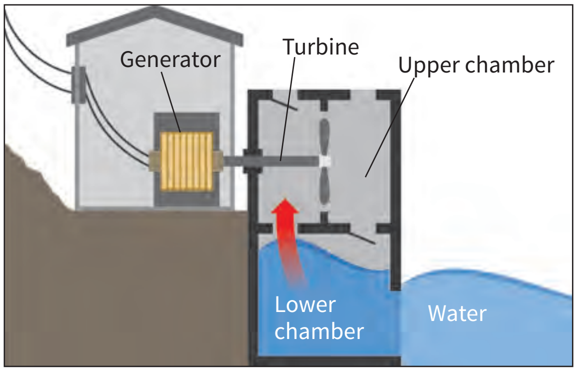


Fig. 16.02.02 The workings of the fixed machine.

Advantages

- Renewable – it will never run out
- Reliable
- Maintenance costs are low
- No fuel costs needed to run
- No pollutants given off
- Large amounts of energy can be produced – with strong waves

Disadvantages

- Expensive to build
- May damage marine life
- Some can be noisy

Solar Energy

Solar energy is energy from the sun. The sun gives out heat and light energy, which are both used.

How does it work?

The sun's energy is captured and can then be used in many different ways.

1. Solar cells in panels are used to convert sunlight directly into electricity.
2. A building is designed purposely to use the sun's heat energy.
3. The sun's energy can be used to provide hot water for buildings (including heating).

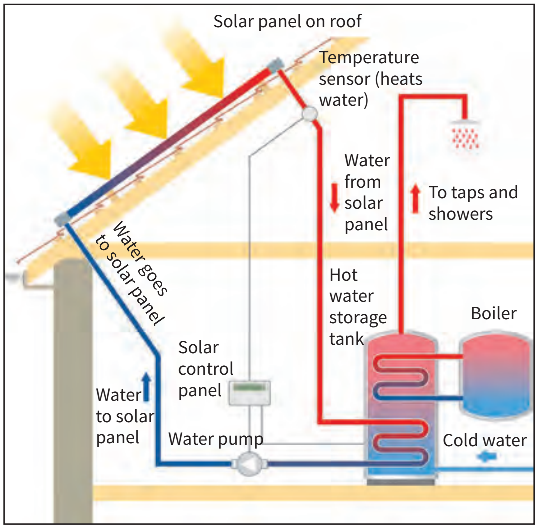


Fig. 16.02.03 Solar energy being transferred and used to heat a tank of water.

Fig. 16.02.04 A solar-powered battery charger.

Advantages

- Renewable – it will never run out
- Easy to install
- Maintenance costs are low
- No fuel costs needed to run
- No pollutants given off
- Remote or valley areas can have access to electricity

Disadvantages

- Can be unreliable as is weather-dependent
- No sunlight or energy captured at night
- Expensive to install

EARTH & SPACE

Tidal Energy

Electricity is generated from the movement of the tides. (Note that wave and tidal energy are not the same thing.)

How does it work?

They are several ways of getting energy from waves. Two examples are:

1. A barrage: Like a dam, it has a well to collect the water. A turbine underneath the dam turns with the power of the tides and causes a generator to work, which makes electricity.
2. A turbine: An underwater device, the turbine works on the flow of water through it. It is linked to a generator, which produces electricity.

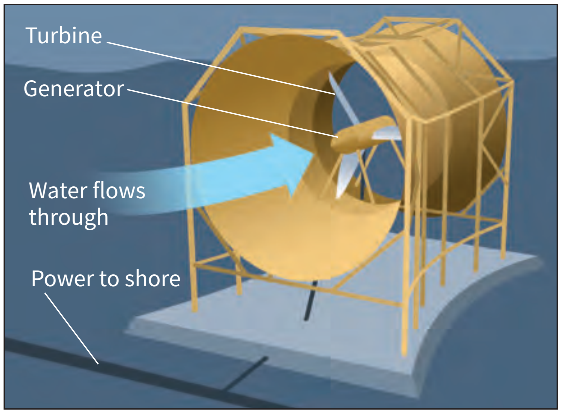


Fig. 16.02.05 How a tidal turbine machine works.

Fig. 16.02.06 Tidal turbine machine being installed.

Advantages

- Renewable – it will never run out
- Maintenance costs are low
- No fuel costs needed to run
- No pollutants given off
- Turbine is installed deep in the seabed and moves slowly, so avoids harm to marine life

Disadvantages

- Expensive to install
- Barrage can negatively affect the environment
- Some can be noisy

Biomass Energy

Biomass is plant and animal matter such as the wood from trees, food waste from farms or restaurants, or sewage from farms.

How does it work?

1. Plants: trees grown just for fuel purposes are burned.
2. Wood chips or sawdust from trees are burned, with the heat energy used to heat water or generate electricity.
3. Waste material rots, giving off methane gas. The gas is collected and used to make steam, which moves a generator, which makes electricity.
4. The waste material is burned, which produces heat energy, which is then harnessed to produce electricity.

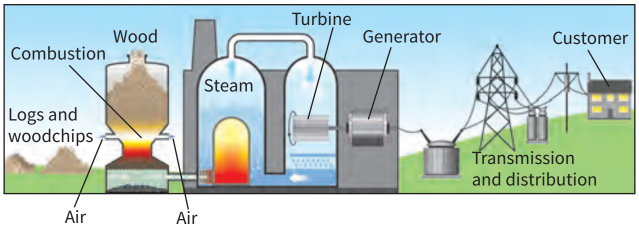


Fig. 16.02.07 The workings of a biomass plant.

Fig. 16.02.08 A biomass plant in Co. Offaly.

Advantages

- Renewable – it will never run out
- Fuel sources are cheap
- Waste at landfill sites can be used
- Methane gas is used rather than being released into the air

Disadvantages

- Air pollution as carbon dioxide is released
- Trees are cut down so habitats are lost
- Costs can be high as trees need to replanted

Wind Energy

Wind energy is harnessed by wind turbines. The energy is produced when the wind turbine blades rotate. Wind speed increases higher above the ground, so wind turbines are tall or placed on hills. Wind speed is also higher in areas where there are no buildings to disrupt the flow. Therefore, wind turbines are usually in open areas or at sea.

How does it work?

At the top of the wind turbine there is a shaft and a generator. The force of the wind causes the blades of the rotor to spin, which causes the shaft to work the generator. The generator produces electricity as it works.

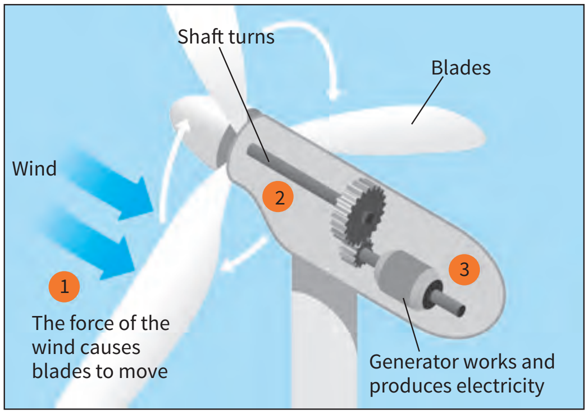


Fig. 16.02.09 The workings of a wind turbine.

Fig. 16.02.10 Carnsore Windfarm, Co. Wicklow.

Advantages

- Renewable – it will never run out
- Maintenance costs are low
- No fuel costs needed to run
- No pollutants given off
- The land on which the wind turbine is built can also be used for agriculture

Disadvantages

- Large and noisy
- A danger to birds or bats
- Does not work without wind
- Not all areas are suitable
- Expensive
- Wind turbines can be unsightly

Hydroelectric Energy

Hydroelectric energy is electricity created from the force of flowing water. It is sometimes called 'hydropower'.

How does it work?

1. Hydroelectric dams: Water from rivers (usually fast-flowing) is collected in a reservoir (a dam) which creates water pressure. Water flows down pipes under pressure, past a turbine, which turns to work a generator, which produces electricity.
2. Pumped station: Two reservoirs are needed, the first situated at a higher level than the second. The water then flows down pipes under pressure, which turns a turbine, which works a generator, which produces electricity.

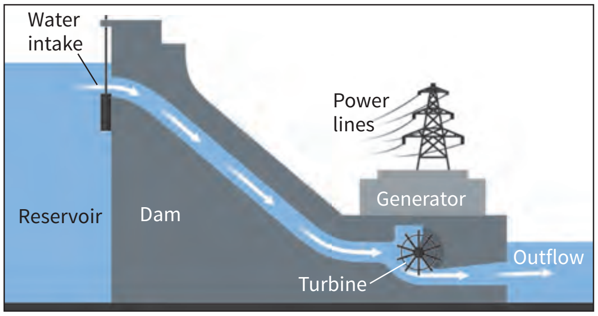


Fig. 16.02.11 The workings of a hydroelectric power plant.

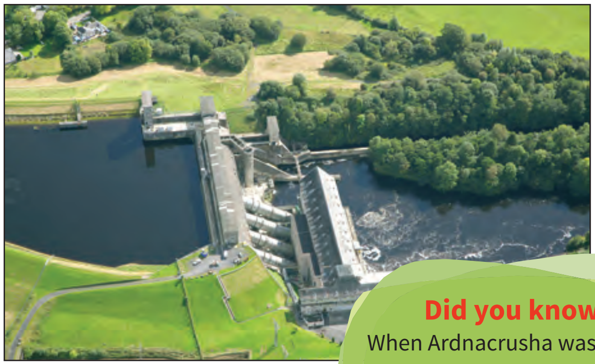


Fig. 16.02.12 The hydroelectric power plant at Ardnacrusha, on the River Shannon.

Did you know?
When Ardnacrusha was built in 1929, it was the largest scheme of its kind in the world. It is Ireland's largest generating unit using renewable energy.

Advantages

- Renewable – it will never run out
- Cheap to run
- No fuel costs needed to run
- No pollutants given off
- Water can be stored at the dam – this deals with constant and often high demands on electricity
- Recreational: Boating and fishing trips can be taken on reservoirs

Disadvantages

- Expensive to build
- Wildlife and environment can be affected
- Flooding can occur
- Homes can be lost due to construction or flooding
- Can only be built in certain places

EARTH & SPACE

Geothermal Energy

This is the heat energy that is naturally found in the earth's core and used to make electricity. This heat rises out of the ground either as a liquid or a gas.

How does it work?

A liquid (hot water) or a gas (steam) rises to the surface and turns a turbine, which works a generator, which produces electricity. The water goes through a cooling station and returns underground.

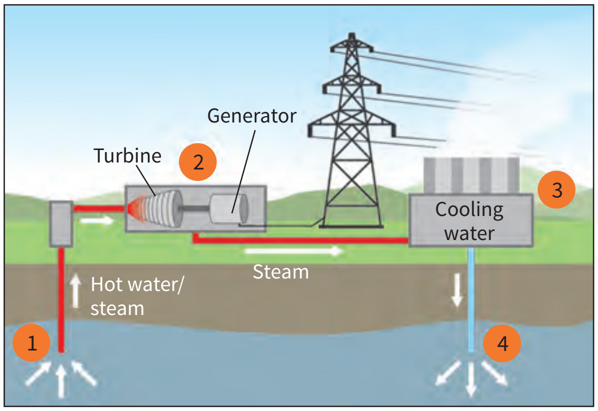


Fig. 16.02.13 The workings of a geothermal site.

Fig. 16.02.14 A geothermal power plant.

Advantages

- Renewable – it will never run out
- Cheap to run
- No fuel costs
- No pollutants given off
- Temperatures below ground level are constant so heat energy is produced consistently
- Can be used to heat water directly

Disadvantages

- Expensive to build
- Pipes can corrode
- Can only be built in suitable areas

Checkpoint 2

(a) Why do we use non-renewable energy sources when the evidence proves that renewable is better?

(b) Do any of the renewable sources become non-renewable?

(c) What disadvantage is common to most of the renewable sources of energy?

(d) Give one advantage and one disadvantage of using solar, wind and hydroelectric energy.

(e) Give one disadvantage of using wave, geothermal and biomass energy.

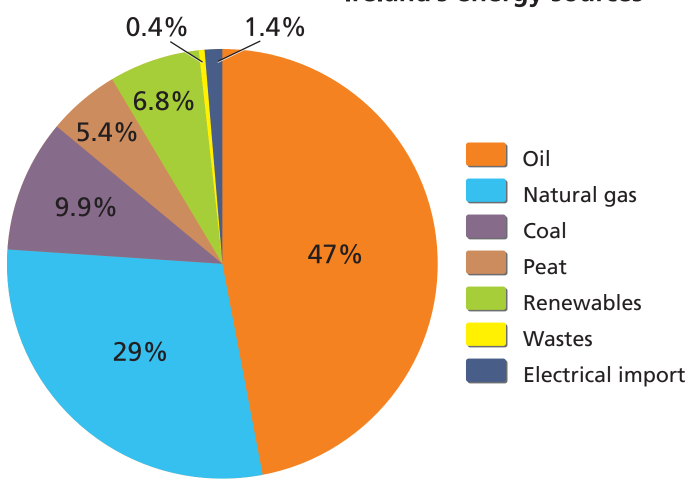
(f) Suggest one source of renewable energy that you think Ireland should invest more money into. Support your choice with an explanation.

Conserving Energy

Conserving energy means reducing our energy waste and managing our energy sources wisely. We need to think about the energy needs of future generations.

The Sustainable Energy Authority of Ireland (SEAI) released figures as depicted in the chart below on Ireland's use of energy sources. Peat is considered a non-renewable source of energy, but it is not used throughout Europe, so it is not often displayed in global statistics. The total amount of energy used from renewable sources is 6.8%. This is the figure that Ireland wants to increase

Ireland's energy sources



- Most of Ireland's power stations make electricity by burning fossil fuels. Our target is to have 40% of our electricity generated from renewable sources.
- By using renewable sources of energy, Ireland can become more self-sustainable. At present, we import most of our fossil fuels.

Think About It

How do you use or waste energy? How does your school use or waste energy? How do local businesses use or waste energy?

- Analyse how you travel. Do you use a renewable or non-renewable source?
- Have you burned a fossil fuel unnecessarily at home?
- Is your house insulated?
- Is the boiler insulated?
- Have you ever left the television on when not watching it, or left a light switched on in a room when not in it?

Small changes make a big difference to our energy consumption.

Checkpoint 3

(a) Why is it important to conserve energy?

(b) *Table 16.02.02* displays information from the SEAI regarding where Ireland's energy needs go.

(i) Display the information in the table on a graph.

(ii) Which percentage are you surprised with? Why?

Energy need	Amount
Agri/Fisheries	2.3%
Transport	32.7%
Industry	23.7%
Residential	26.8%
Services	14.5%

Table 16.02.02 Ireland's energy needs.

Alternative Energy Sources and Supplies

By increasing our use of renewable resources, we can achieve a more secure and stable energy supply for the future. Ireland has a lot of renewable sources of energy, but currently we only utilise a small amount.

Did you know?
A race car has been developed which is powered by waste from chocolate. It can reach up to 135 mph!

R Biofuels

Also known as biomass energy or bio-energy. As we have discussed, biofuels are energy sources made from living things or the waste produced by living things. They are therefore a renewable energy source. Biofuels are a possible replacement for diesel and petrol.

Fig. 16.02.15 A car powered by waste.

There are two main sources for the generation of biofuels:

1. **Crops**
- Crops or plants are grown specifically to be used as an energy source, for example: wood, sugar beet and oilseed rape.
- Crops can be fermented to produce ethanol, which is very similar to petrol.
- However, growing crops specifically for this purpose reduces the amount of farmland available for the production of food, and thus impacts on food supplies.

2. **Waste**
- Already in development through the burning of bark and sawdust, but food, farm and plant waste can also be used.
- Food wastes such as oil can be used to produce biodiesel, and is in use in Germany and Austria.
- The methane released from farm or crop waste or sewage plants can be burnt and steam produced. This steam can then turn a turbine to generate electricity or heat energy.

How does the burning of the fuel result in the production of energy? The fuel burns with oxygen; this burning is combustion, which releases carbon dioxide, water and energy. Heat energy is produced.

The fuel + oxygen = carbon dioxide + water + energy

EARTH & SPACE

Checkpoint 4

(a) **List two ways to produce bio-energy.**
(b) **Explain how burning a fuel can produce energy.**

Hydrogen Fuel

This is when hydrogen gas is used as a fuel and converted into electricity to power vehicles, for example. Think of a normal car: when it is low on fuel, it is refilled. In the case of hydrogen fuel, when the vehicle is low, it is filled with hydrogen.

How does it work?

Hydrogen fuel works in two ways.

1. Hydrogen is burned to produce energy directly in an engine. Water is the product.
   Hydrogen + Oxygen = Water
2. Hydrogen fuel cells: In cells, the hydrogen reacts with the oxygen but it is not burned. The energy that is produced powers an electric motor.

Advantages

- No carbon dioxide or other pollutants are released into the environment – is a 'clean energy'
- Efficient, noiseless process
- The size of the fuel cell can be changed to suit the need

Disadvantages

- Hydrogen is flammable, so structures have to be put in place so it does not ignite
- Hydrogen is sourced from burning fossil fuels, which, as we know, are non-renewable sources – this therefore defeats the purpose of proposing this as an alternative fuel source
- The fuel cells are currently expensive

WHAT I HAVE LEARNED...

- Energy sources are either non-renewable or renewable.
- Non-renewable sources are coal, oil and natural gas. They cannot be used again and cause pollution by releasing gases into the atmosphere.
- Coal, oil and natural gas are fossil fuels.
- Renewable source of energy are energy sources that can be reused. Examples are: wave, solar, tidal, biomass, wind, hydroelectric and geothermal.
- To 'conserve energy' means to use our energy sources wisely and not waste energy.

Question Time

Copy and Complete

In this unit I learned that energy __________ things. Energy sources are either __________ or___-_______. Renewable means they _________ be used again, non-renewable sources ________ be __________ again. Coal, __________, __________ _____and nuclear are examples of non-renewable energy. When non-renewable energies are burned to release their energy, they give off ______ that damage our atmosphere. An example is _______ _______. Too much carbon dioxide is __________ for our environment; it is one of the __________ gases and contributes to __________ warming. Renewable energy examples are wind, wave, tidal, _______, biomass, __________ and __________ . A lot of the renewable energies use the energy to turn turbines, to work a __________ that then produces __________. The advantages of using renewable energy is that they are ___________, never run out, no __________ are given off and therefore no damage is caused to the __________. We must ________

Questions

1. Why are fossil fuels running out?
2. Write a short paragraph on why the use of renewable sources of energy is better than using non-renewable sources.
3. Suggest why it is important that energy sources are sustainable, in your opinion.
4. Why is Ireland a good place for wind energy?
5. Suggest ways in which your school could conserve its use of energy. Put together a short-term and a long-term plan.
6. Why is it essential to find alternative energy sources?

Inquiry

A Nuclear energy is an example of an energy source. It is the only electricity-production source that creates large amounts of energy or power. It is reliable and does not give off greenhouse gases.
Research and **write** a short paragraph on why nuclear energy is not in greater use across the world.

B Nuclear energy is energy in the nucleus of cells. Today's nuclear power plants use fission to release the energy. **Research** how this process works. (*Hint:* See *Unit 11.1*.)

C Solar energy can be used in many ways. **Research** how the design of a building can use and make the most of the sun as a source of energy.

D **Carry out** a renewable energy survey across your year group to see who may already be using renewable energy sources.

Investigating Science is an exciting new textbook for **Junior Cycle Science**. The inquiry-based approach allows students to actively seek solutions, design investigations and ask new questions as they learn about the nature of science.

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- **Learning outcomes** are referenced for the teacher and translated into student-friendly **learning intentions**.
- The **Nature of Science** strand is integrated throughout and referenced in the learning outcomes.
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- **Lightbulb questions** throughout the units encourage students to explore their prior knowledge.
- **Investigations** develop an understanding of scientific processes and how to use evidence to support explanations and develop inquiry skills.
- **Demonstrations** can be done by the teacher, but some are easily converted into whole-class exercises.
- Concise and student-friendly **definitions** of key concepts present an appropriate level of information.
- **Checkpoint questions** throughout the units can be used as a form of assessment for learning (AfL) and as homework.
- The **'What I have learned'** summary at the end of each unit allows for assessment of progress.
- **Question Time** at the end of each unit incorporates fill in the blanks, comprehension and inquiry questions.

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