Exploring Science

for the new Junior Cycle

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Edco
The Educational Company of Ireland

The paper used in this book comes from Managed Forests in Northern Europe
For every tree felled, at least one new tree is planted

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Introduction

For the student

Welcome to secondary school and your new science textbook, *Exploring Science*. Your textbook comes with a **Student Portfolio Book,** a **Glossary of Terms** and a range of **digital resources**. This book will build on your learning of science from primary school by helping you to understand the world around you and the wider universe. It aims to develop your learning skills in science. You will develop these skills yourself while also learning from your teacher and your fellow students.

For the teacher

Written for the new Junior Cycle, *Exploring Science* aims to give students a sense of enjoyment and an interest in the learning of science. The book is based on the **Statements of learning** from the NCCA specification (see *juniorcycle.ie*). It develops students' knowledge of and about science through the unifying strand called the **Nature of Science**, and the four contextual strands (or units): **Biological World**, **Chemical World**, **Physical World** and **Earth and Space**.

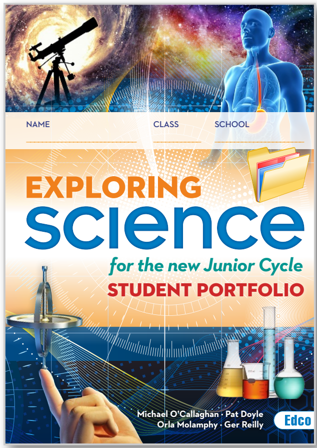
Features of *Exploring Science*

- The **Nature of Science** strand is explored in the opening chapter and highlighted throughout the text using four different logos (understanding science, investigating in science, communicating in science, and science and society).
- The rest of the book is divided into the **four contextual strands** or units, which are highlighted by different coloured tabs on the side of each page.
- **Learning outcomes** are stated at the beginning of each chapter in student-friendly language.
- **Keywords** are listed at the start of each chapter to allow students to become familiar with important new terms.
- **Activities** allow students to build on their knowledge by completing research.
- **Diagrams** have been fully labelled and are drawn in a simple style so that students can replicate them easily.
- **Questions** are interspersed within the text to offer teachers the opportunity to use different teaching strategies. In particular, there are chances for group work and pair work.
- **Did you know?** boxes feature interesting facts to stimulate students' interest in science.

- The **language** used is clear and simple to allow for use by students of varying reading levels.
- Simple and helpful **logos** are used throughout to enhance student understanding.

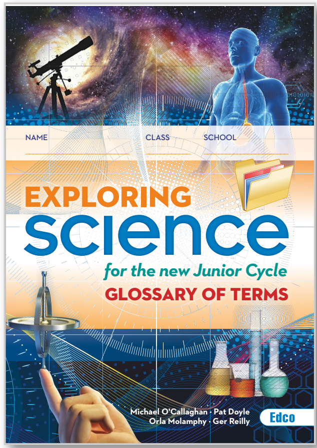
	Activity		Group work
	Question		Key fact
portfolio 68	Corresponding page in Student Portfolio		Research

Student Portfolio



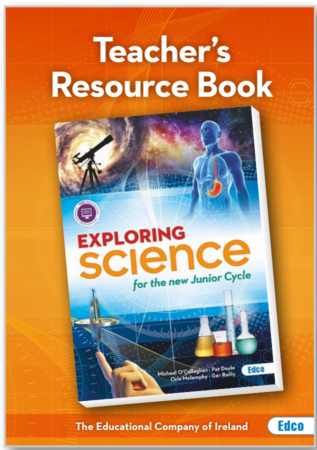
The Student Portfolio book provides additional material, activities and tasks. The portfolio book enables students to maintain a record of specific activities and reflect on their learning, as well as focusing on key words and key facts, through mind maps and comprehension and recall activities. It also contains templates for self-assessment and peer assessment. This book works in conjunction with the textbook.

Glossary of Terms Booklet



A comprehensive Glossary of Terms cross-referenced to the Textbook and Student Portfolio Book.

Teacher's Resource Book



The teacher's book works in conjunction with the textbook and the Student Portfolio book by providing:

- An outline of the new specification and NCCA guidelines
- Learning outcomes for each chapter with explanations of how they are incorporated into lessons
- Information on topics, questions and research ideas that can be used to enhance the students' learning
- Answers to all student questions in the textbook and student portfolio book
- Outlines of digital resources for each chapter and suggestions for integrating them into classroom work
- Suggestions of ways to assess student activities with assessment templates

- A range of other information and suggestions to support teachers in the delivery of the new course
- Key skills, statements of learning and literacy and numeracy linked to relevant chapters
- Guidance for the teacher through the chapter and a suggested yearly schedule
- Additional activities and research activities.

Digital resources

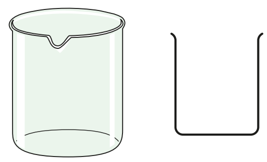
The *Exploring Science* **digital resources** will further enhance classroom learning. These resources have been designed to integrate with the student textbook and to complement lessons suggested in the Teacher's Resource Book. Following the Principles for Junior Cycle Education, material is provided to suit a range of learner types and to encourage participation and engagement on the part of the student.

A series of **videos** and **animated diagrams** allows students to observe science in action across all units. These videos reinforce the topic at hand and allow for other perspectives, which may be discussed in class. Similarly, a series of **animated scientist biographies** presents a lively gateway to develop students' interest in science and initiate student-led research.

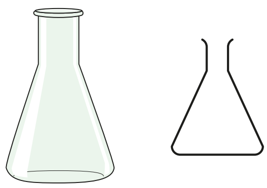
Further classroom discussion and participation is opened up through **PowerPoint presentations**, including a thematic presentation of information from the student textbook. **Experiment videos** allow for a visual review of activities carried out in the classroom.

A set of useful **report and template documents** geared towards the new curriculum is also available for teachers online. These documents can be used across the course for any year group. Guidance for integration of digital resources in the classroom is provided by the **digital resource symbols** (Communicating C_6 Investigating i_2 Society S_9) used throughout the student textbook, as well as the provision of detailed notes and suggestions in the Teacher's Resource Book.

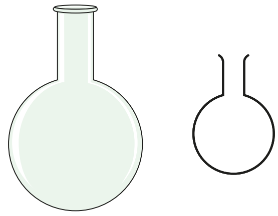
Laboratory equipment



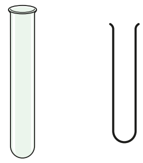
Beaker



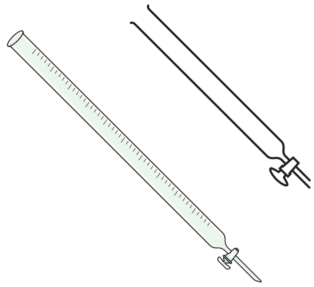
Conical flask



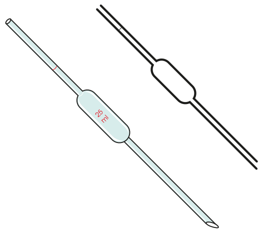
Round-bottomed flask



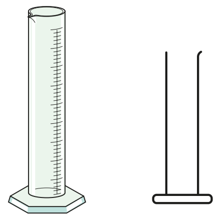
Test tube



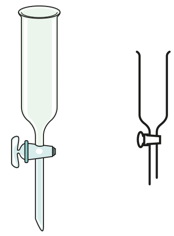
Burette



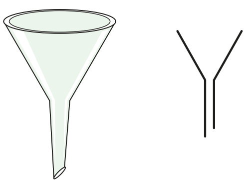
Pipette



Graduated cylinder

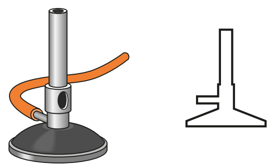


Tap funnel

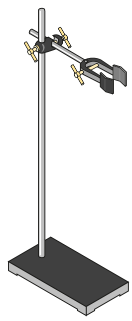


Filter funnel

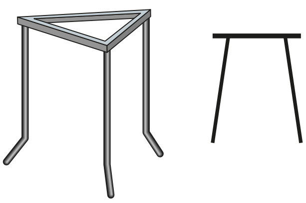
Evaporation dish



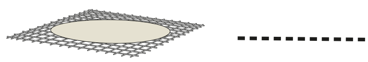
Bunsen burner



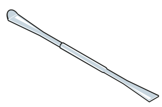
Stand



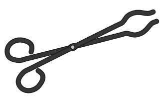
Tripod



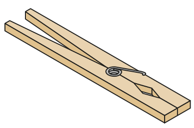
Gauze



Spatula

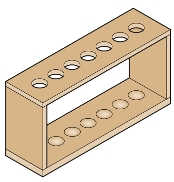


Tongs

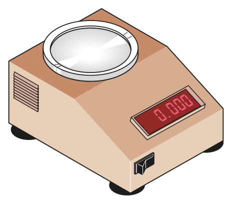


Test tube holder

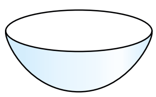
Thermometer



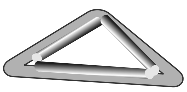
Test tube rack



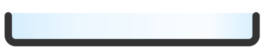
Balance



Crucible



Pipe clay triangle



Petri dish

Laboratory safety rules for pupils

The following rules are enforced to keep you and your classmates safe while in a school laboratory.

1. Do not enter the laboratory without permission.
2. Do not use any equipment unless permitted to do so by your teacher.
3. Make sure you know exactly what you are supposed to do. If in doubt, ask your teacher.
4. Make sure you know the position of all safety equipment in the laboratory, e.g. the fire extinguishers, first aid equipment etc.
5. Always wear eye protection or gloves when instructed to do so.
6. Long hair must be tied back during practical classes.
7. Place your bag and other personal items safely out of the way.
8. Never handle any chemicals with bare hands.
9. Nothing must be eaten, tasted or drunk in the laboratory.
10. Any cut, burn or other accident must be reported at once to your teacher.
11. Always check that the label on the bottle is exactly the same as the material you require. If in doubt, ask your teacher.
12. Any chemical spilled on the skin or clothing must be washed at once with plenty of water and reported to your teacher.
13. Test tubes should never be overfilled. When heating a test tube ensure that the mouth of the test tube is pointed away from you and everyone else.
14. All equipment should be cleaned and put back in its correct place after use.
15. Always wash your hands after practical work.
16. Students should behave in a responsible manner at all times in the laboratory.

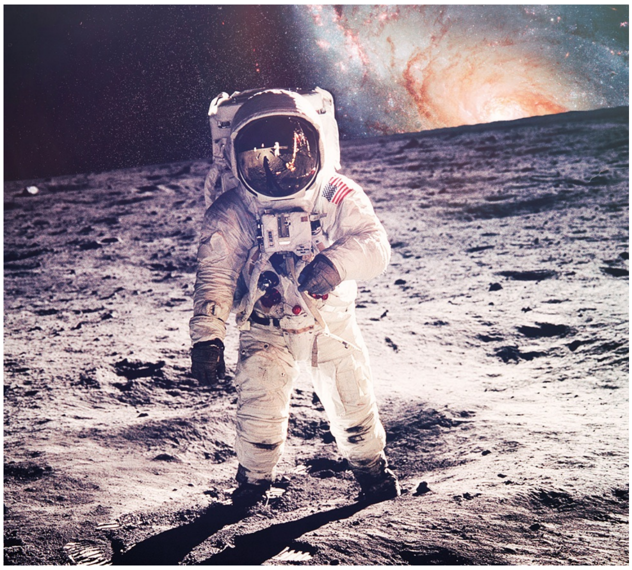
Safety labels

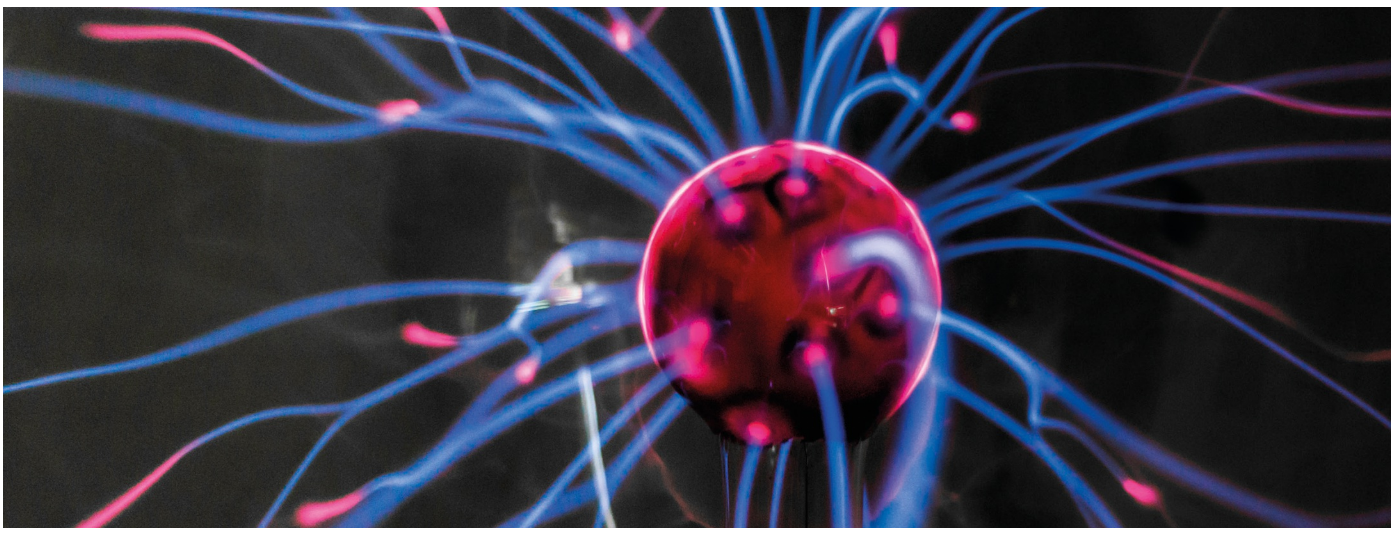
The following labels appear on bottles in the laboratory. They also appear on many everyday chemicals such as cleaning products and solvents. These labels indicate chemicals that could be dangerous if not used or handled properly. We use these warning symbols on activities in this book.

Toxic		Substances which can cause death if they are swallowed, breathed in or absorbed through the skin. Example: weedkiller.
Harmful or irritant		Substances which should not be eaten, breathed in or handled without gloves. Though not as dangerous as toxic substances they may cause a rash, sickness or an allergic reaction.
Oxidising		Substances which provide oxygen, allowing other materials to burn more intensely. Example: hair bleach.
Highly flammable		Substances which easily catch fire. Example: petrol.
Corrosive		Substances which attack and destroy living tissue, including skin and eyes. Example: oven cleaner.
Warning sign		This sign is used to draw attention to a warning of danger, hazards and the unexpected.
Safety glasses		Wear safety glasses to protect your eyes.

UNIT 1

NATURE OF SCIENCE





CHAPTER 1

UNIT 1

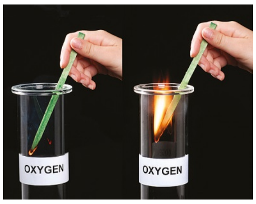
The nature of science

What is science?

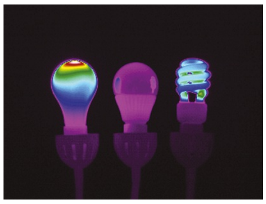
Science comes from a Latin word *scientia*, meaning knowledge. Science is the study and knowledge of the (physical and natural) world around us. Science can be divided into different subject areas. In this book we will examine:

- The biological world, by investigating living things
- The chemical world, by investigating substances and how they react
- The physical world, by investigating matter and energy and how they interact
- Earth and space, by investigating the planet Earth and the universe.

Ebola viruses bursting out of a cell



Oxygen relights a glowing splint



The heat given off by an old-fashioned (incandescent) bulb, a light emitting diode (LED) and a compact fluorescent bulb

The lights of Europe from the International Space Station (London is the brightest city shown)

Figure 1.1 *Topics in science*

The nature of science means how scientific knowledge is developed. This mainly involves understanding how science works, carrying out investigations, communicating scientific ideas and considering the role and value of science and scientists to society.

The nature of science will be outlined in this chapter. However, it is not really intended that you should learn all this material in isolation. The nature of science is included in every chapter of this book. It forms the basis of all the content and activities in each chapter. This chapter is included to allow you to understand how science works.

Understanding about science

Curiosity and questions

Science works initially by people being curious. Asking questions and being curious is a key part of being a good scientist. Very often important knowledge has been gained because someone was curious and asked a simple question.

How science answers questions

It is very difficult to answer big questions in science. However, we can ask smaller questions. These questions may be more suited to scientific investigations or experiments and so we might be able to find answers to them.

Question

For example, we could ask the question: 'Is the boiling point of water affected by adding salt?' In answering this question we start by finding out as much as we can about the problem and then suggesting what we think might happen. Such a suggestion is called a **prediction**.

Prediction

We could predict that: *adding salt will change the boiling point of water*. If a prediction can be tested it is called a **hypothesis**.

Hypothesis

A hypothesis is often written as an **If ... then ...** statement. For example: ***If*** *salt is added to water* ***then*** *the boiling point of the water will change.*

A hypothesis is a suggested explanation for something we observe or notice. Examples of hypotheses are:

- If we study then our exam results will improve.
- If drivers use a mobile phone while driving then they are more likely to crash.
- If we practise sprinting then we will get faster.

Having formed a possible explanation or hypothesis, the next step is to design a way to investigate the hypothesis.

Investigating in science

Investigating a hypothesis

A hypothesis is tested by carrying out an investigation or an experiment. Normally two sets of apparatus are set up:

- One set of apparatus is the **investigation**.
- The second set of apparatus is a comparison or **control**. Both sets of apparatus should be identical, *except for one difference*.

For example, returning to our hypothesis above, we could boil some tap water in a beaker and use a thermometer to record the temperature at which it boils. We could then add salt to some tap water and record the temperature at which the salt water boils. When we look at the results:

- If both water samples boil at the same temperature then our hypothesis is incorrect.
- If the salt water boils at a higher temperature than the tap water then our hypothesis is supported.

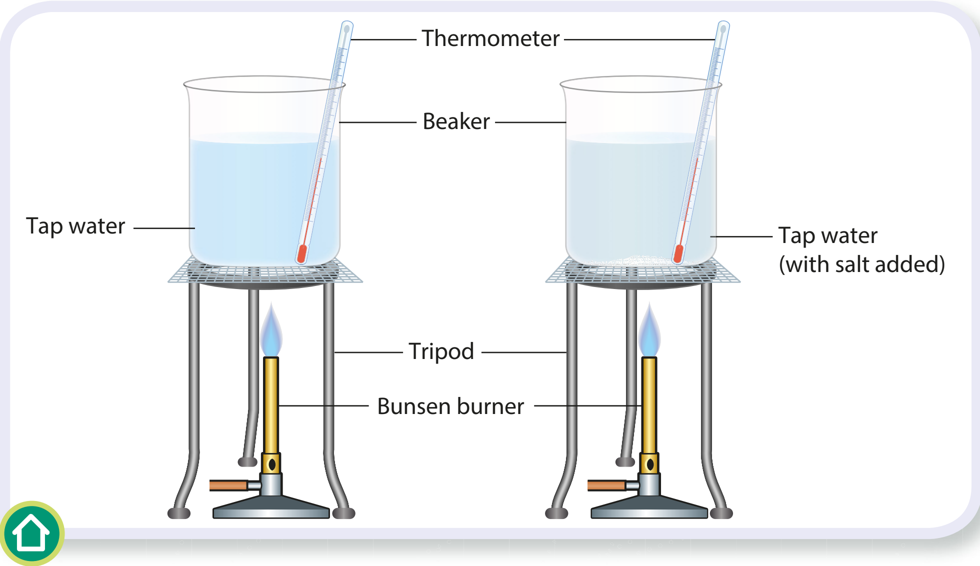


Figure 1.2 *Nature of science – investigating whether adding salt to tap water will change the boiling point of water*

The result(s) of an experiment often causes us to change our hypothesis. So, if the salt water is found to boil at a higher temperature than the tap water, we would revise the original hypothesis by saying: ***If*** *salt is added to water* ***then*** *the boiling point of the water will increase.*

Different types of investigations

Some investigations are laboratory based. However, many investigations take place outside laboratories. Scientists work in all sorts of exciting places, such as outdoors in forest parks and boglands, under the sea, in rainforests, close to volcanoes, near glaciers; or designing spacecraft, cars, computers, phones and a broad range of new technologies.

Some scientists work alone. But many scientists work in groups. That is why it is important for students to be able to work to a high standard alone, but also to be able to co-operate and work as part of a team.

Figure 1.3 *A team of scientists collecting animals in a forest*

Figure 1.4 *Scientists working in a laboratory*

Figure 1.5 *Scientist taking lava samples near a volcano*

The results of investigations

Scientists report on how they carried out their experiments and the results they got in **scientific journals**. These are special types of publications that are read by science experts, e.g. journals such as *Science* or *Nature*. In this way other scientists can read them, think about them and repeat the research if necessary.

If experiments are repeated (or replicated) and the same results are obtained, then they are likely to be valid and reliable. In other words, if investigations are checked by other experts it is more likely that they are genuine and not just made up by the original author or fluke results obtained.

The idea of other scientists reading and checking on investigations is called **peer review**. This acts as a quality control system, i.e. the work and findings are reliable and can be trusted to be true.

Investigations (or experiments)

When investigating a hypothesis the experiments have to be carefully planned. This means:

- Thinking about the problem
- Deciding what methods and equipment are to be used
- Carrying out the investigation so that it is safe, fair and will give reliable results.

Variables

In investigations scientists design an experiment so that the change in one item causes something else to change. These changing quantities are called variables.

There are three kinds of variable:

- **Independent variable**, where one thing is changed (for example when salt is added to the investigation on the previous page) and the results of the one change are observed.
- **Dependent variable**, which is the factor that changes as a result of our investigation. The scientist will focus on the dependent variable (for example the temperature at which the water boils) to see if it responds to the change (the addition of salt).
- **Controlled variable**, where all other factors are the same. For example, this might include using the same amount of tap water and the same size beaker in each case. This makes it a fair test.

Accuracy and precision

In any experiment it is vital that our measurements and readings are as accurate and precise as possible. We should not guess or estimate the volume of water added to each beaker; we should carefully measure the same volume of water using a suitable measuring device.

Data

Data is the information, measurements or observations collected in an experiment. Data can be:

- **Quantitative**, where the data involves the use of numbers. For example, the temperature is 20°C, or the distance is 100 metres.
- **Qualitative**, which describes something without the use of numbers. Very often qualitative data is obtained by using our senses. For example, we say something feels soft, or an object looks green, or a gas smells terrible.

For example, ‘We breathe out more carbon dioxide than we breathe in’ is a qualitative observation. However, if we say, ‘We breathe out 4% carbon dioxide but we breathe in only 0.04% carbon dioxide’, this is a quantitative observation or measurement.

The data obtained in any investigation should be analysed to reach a suitable conclusion.

The **analysis** should:

- Try to explain any unusual or strange observations that may have arisen.
- Include consideration of anything that was hard to do or caused difficulty during the investigation.
- Give rise to a discussion of how the investigation could be improved or altered if it was to be repeated, so that more information could be obtained on the topic under investigation.

The **conclusion** is a summary of the findings in the investigation. The conclusion should either support or contradict the hypothesis.

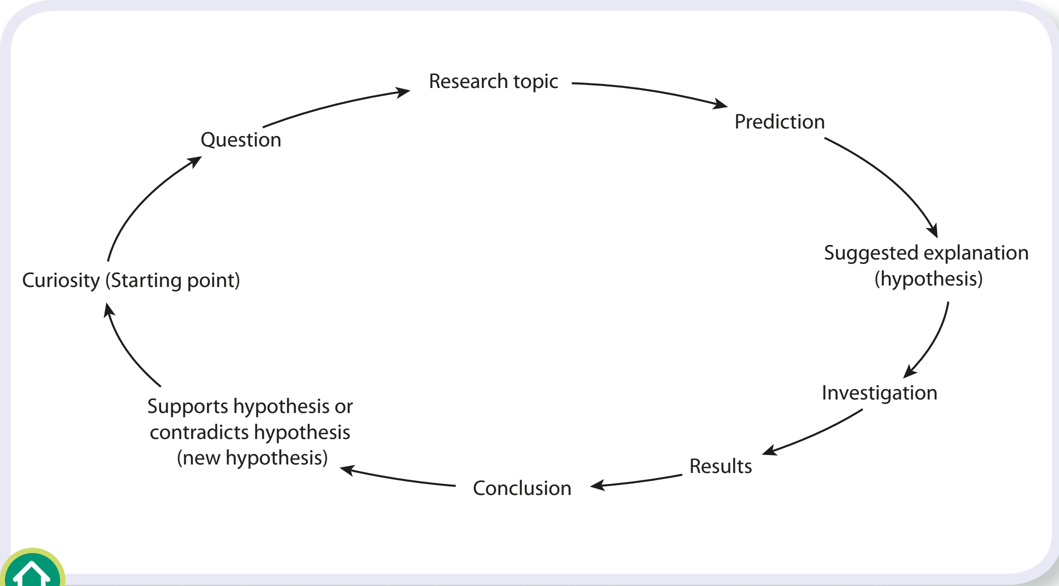


Figure 1.6 *Summary of how science works*

Reviewing and reflecting on investigations

By thinking back over the skills, methods and ideas used to carry out a series of investigations you should become better at applying scientific learning and skills in new and varied ways.

In particular you should be able to think and act like a scientist. This means you should be able to identify questions that are suited to scientific investigations. You should then be able to form a prediction, make a hypothesis that can be tested by investigation and carry out a proper scientific investigation of a new, unfamiliar problem.

Scientific ideas change over time

Science is not a fixed, unchanging set of ideas. It changes all the time. As a result of carrying out investigations our hypothesis is supported or contradicted. Over time a new hypothesis may arise to replace an old, unsupported hypothesis. This means that scientific thinking is constantly changing in line with new investigations that are carried out.

Communicating in science

How to communicate research

An important aspect of science is the ability to tell others what you did, how you did it and what you have discovered. This often involves writing a report of your investigation. In your report it is important that you present your information in a form that is clear, accurate and easy for others to understand.

This may involve a written report, the use of diagrams and photographs, tables to show any numerical data you obtained, or the use of graphs, pie charts or bar charts. Sometimes it involves preparing a poster to outline your work or telling others about your work using a PowerPoint presentation or other multimedia resources.

You will have to adapt your presentation to suit the people to whom you are reporting. For example, a report to your class who shared the investigation with you might be different from reporting to another class or a group of parents.

Conduct research

When carrying out an investigation it is important to find out as much as you can about the topic before you start. This involves researching it using books, libraries, internet and media (such as newspapers, scientific magazines or TV programmes), or any other relevant sources.

Evaluating media-based arguments

Of course you cannot always believe all you see or read. It is important that you make judgements as to how reliable or accurate a source is. A properly conducted scientific report is much more valid than a newspaper report giving a person's (or a group's) point of view. It is very important to be able to detect that a source may be unfair or show bias.

Very often media reports on a scientific issue are based on information given to the media by groups who want to promote their own ideas and plans. It is important to be aware of the source of the information and of the reasons for releasing the information. This is true for all media sources, but is especially true for the internet.

Some of the main features to look for in an internet source you can trust are:

- The name of the author is given.
- The date is given for any research findings that are listed.
- Reliable sources are given (or is the information just personal opinion?)
- In general, websites from universities, governments and organisations such as the BBC or NASA are more reliable.
- Good site design can indicate a more reliable source.
- Good grammar and spelling indicate a more credible site.
- If the information is similar across three different sites it is more likely to be true.

Figure 1.7 *Students studying in a library*

Science in society

Contribution and impact of scientists on society

The nature of science means that it is important to be aware of the role scientists have played in making the world a better place. Through their discoveries and inventions they have expanded our knowledge and understanding of how things work. They have allowed more food to be produced, more diseases to be controlled, new materials to be designed,

Figure 1.8 *Engines are good for transport but bad for the environment*

new technologies to be available and new understandings to be made about our own planet and the rest of the known universe.

You should be able to research and present information on what exactly different scientists have achieved. Some of these scientists are now legends of history. However, many major discoveries are being made by scientists who are still living.

Most of these effects have been for the better but, sadly, sometimes scientific discoveries may be used for negative reasons or have negative results. For example, the invention of engines that could burn petrol has given rise to cars, buses and fast means of transport. However, it has also resulted in carbon dioxide levels rising, which are contributing to global warming and climate change.

Role and importance of science in society

Science and society are deeply interlinked. It is obvious that science affects society by developing new discoveries, processes and materials. Science does not exist simply for itself. It should try to provide solutions that help make the world a better place for everyone. This has been done by developments such as electricity, electronics, digital technologies, communications, disease control, improved healthcare, new materials and drugs, discoveries about our Solar System (and beyond it) and new methods to supply our energy needs as oil and other fuel supplies run out.

However, the link between science and society is a two-way process. Society also relates to science and scientists. Society often guides or encourages scientific research in different areas. This can happen due to laws being passed, public money being made available to fund science and the general interests, values and public opinion as to what science needs to do next. In addition scientists are influenced by the culture in which they grew up. For example, scientists may not want to carry out certain types of research because it goes against what they believe in.

Science has had a huge role in making the world a better place. The role of science will be even more important in the future as we try to come to terms with our growing human population numbers, the need for new forms of energy, our desire to improve our health, our attempts to control disorders such as cancer and Alzheimer's disease, and the need to limit the effects of global warming.

Figure 1.9 *Scientist Stephen Hawking*

These are all huge and complex problems. Remember, however, that science starts in a very simple way: by being curious and asking questions. As Stephen Hawking said:

> 'Look up at the stars and not down at your feet. Try to make sense of what you see and wonder about what makes the universe exist. Be curious.'