Rick **Armstrong** | Jennifer **Barnett** | Gareth **Jones** | Elani **McDonald** | 2nd edition

Science 1

for the international student

NELSON
CENGAGE Learning

Rick Armstrong
series editor

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Elani McDonald has dedicated her entire teaching career to working in IB schools. She is a workshop leader and a MYP visiting team member. She has been involved in monitoring and moderation of assessment and was involved in writing the Science and Personal Project 2014 guides, as well as the 2014 Teacher Support Material for Physics. Elani is dedicated to making learning relevant and engaging and was shortlisted for the TES Maths teacher of the year 2014/15 award. Elani is teaching Mathematics and Sciences full-time and doing consultancy work part-time.

How to use this series

The *Science for the international student* series provides students with a variety of engaging and stimulating formats for learning, understanding and immersion in both the Middle Years Programme (MYP) philosophy of the International Baccalaureate (IB) and the science content. The features of the student book have been specifically designed to support this and to deliver exciting content in a variety of ways.

Specific MYP features

Each unit begins with a unit opening page that specifies:

- the key concept that is covered in the unit
- the related concepts that are covered in the unit
- the Global Context of the unit
- the Statement of Inquiry
- inquiry questions, divided into factual, conceptual and debatable questions.

Key and related concepts

Each unit is based around one *key concept* of an enduring transdisciplinary nature and a small number of *related concepts* designed to help frame the unit in the minds of the students.

Global Context

Students will be encouraged to see science in the *global context* of its ability to provide a basis for creative inventions that are capable of enriching our lives in areas such as space, materials, sports and medicines.

Statement of Inquiry

The *Statement of Inquiry* drives the unit and is strongly related to the units' concepts and context.

The inquiry questions are divided into factual, conceptual and debatable questions. Factual questions are related to the unit content, conceptual questions are related to the unit concepts and debatable questions are related to both and designed to stimulate deeper thinking.

Performance assessment tasks

Opportunities for assessment tasks occur throughout each unit and these are each identified by a *performance assessment task* icon.

The *summative performance assessment task* associated with the Statement of Inquiry is identified at the beginning of each unit. The criteria assessed by the assessment task are also identified.

Approaches to Learning

Opportunities to develop and apply *Approaches to Learning* skills are identified by an 'ATL' icon. Teachers can use these prompts to discuss and reinforce learning strategies.

Investigation

Investigations challenge students to design and perform their own experiments either individually or in groups. Investigations are designed to satisfy criteria B and C.

Experiments

Experiments provide students with the opportunity to develop and practise their skills, by following processes and procedures, to discover information for themselves and to build a greater understanding of, and interest in, scientific concepts. Experiments are designed to satisfy criterion C.

Taking action

Taking action suggestions are identified by a 'TA' icon and are designed to satisfy the MYP requirements for service as action.

Other features

Review

Review boxes contain questions and break the content into smaller sections, allowing students to review what they have learnt so far.

Activity

Activity boxes reinforce or develop concepts and skills through short, fun and hands-on activities.

Weblinks

Weblinks are identified by an icon and direct students to exciting websites to further explore the world of science.

Unit questions

Unit questions conclude each unit. They include review questions sorted under the MYP assessment criterion A, levels 1–8. Reflection questions are included to review the concepts underpinning the unit, to encourage further consideration of the debatable inquiry questions, and at times to consider further lines of inquiry.

NelsonNetBook

The *Science for the international student* NelsonNetBook is an interactive ebook that can be used online or offline. It is compatible with interactive whiteboards, computers and tablets, with optional Web 2.0 functionality for class groups. Students can add highlights, annotations, audio and video clips, and weblinks, and teachers can use it to share their personalised version with the class.

Visit the NelsonNet portal at www.nelsonnet.com.au to find out more, register or log in if already registered.

NelsonNet teacher website

The NelsonNet teacher website contains further valuable advice, including draft MYP unit plans covering the first two pages of the revised MYP planner, and a curriculum overview as required by the IB. Other resources include blackline masters (BLMs) containing possible further experimental work and classroom activities, ideas for further resources, and further advice relating to teaching in a conceptual way and for the use of the Approaches to Learning framework. Answers are also provided for all questions, as well as a list of extra resources for each unit.

Contact your sales representative for information about access codes.

Introduction

To the student

We hope you will enjoy using this exciting student book, which has been designed to provide an up-to-date science experience around the principles of the new enriched Middle Years Programme (MYP) offered by the International Baccalaureate (IB). You are likely to already be an experienced IB student, proud of being an *internationally minded* student, and familiar with the distinctive way IB students work in science. These revised books provide a greater emphasis on the global contexts for learning in science, ranging from the challenge to provide better and more equal access to medicines worldwide, to considering global environmental challenges such as global warming. The books emphasise investigative and experimental work and expect you to work and think like a real scientist. As you will be well aware, the IB is also about encouraging you to develop effective learning skills that will stay with you for life, and you will see in these books many suggestions to help you with this challenge. We wish you all the success possible with MYP Science and beyond.

To the teacher

We have reviewed our original series, published in 2010–2011, to take account of the innovative developments and improvements in the MYP. In this new edition, we have deepened our coverage of MYP principles within each unit. The units are now much more contextual and more explicitly driven by the Statement of Inquiry. As you will be aware, the IB has attempted to give schools more flexibility in their delivery of the MYP and there certainly is no 'correct' model of how to put the MYP into practice. For that reason, we feel we should explain some of our approaches to constructing our units.

1 **Conceptual framework:** We have closely followed the suggested framework but have added a small number of extra related concepts that will be useful to teachers and will allow coverage of the US cross-cutting concepts. We have also used concepts from other subjects when we felt their use would enhance the unit. Importantly, we accept that the key to teaching conceptually lies in appropriate classroom practices. To help this practice, we have included activities and questions to help strengthen students' understanding of the conceptual framework as well as some further guidance in the teacher materials.
2 **Content:** We have included academically challenging content that will provide an effective transition from MYP 1 to 5, the new e-examinations, and to higher study in the Diploma Programme (DP) or in other national systems. This content should also help teachers meet the requirements of local curricula. We have covered all the expected content for MYP Sciences e-examination in Books 4/5. Some of this content is also covered in more detail in Books 1, 2 and 3. We have ensured that the scope and sequence of our MYP Books 1–5 is well thought out and offers a coherent framework for the development of deep understanding based on the big unifying concepts in science.
3 **Global Contexts:** The development of the Areas of interaction into the Global Contexts is very liberating and opens the door for much more creative uses of contexts in the planning of MYP units. To take advantage of this potential, we have associated the Global Context chosen for the unit with a more specific 'exploration into' statement. This 'exploration into' feeds clearly into the Statement of Inquiry for each unit. This has helped us to make the science content up to date, interesting and relevant to the real world.

4 **Statements of Inquiry:** We have written simple and clear Statements of Inquiry that are understandable to students and to teachers. We have been flexible in relation to trying to build all the chosen concepts into the Statements of Inquiry. Our priority has been to ensure that the Statement of Inquiry is easy to understand, has a conceptual feel, and, importantly, relates to the chosen Global Context.

5 **Assessment tasks:** Most science units will require more than one summative performance assessment task because it is artificial to try to bring together a number of the sciences criteria in one task. Therefore, most units include assessments relating to investigation work (criteria B and C), a performance-type task relating to the impacts of science (criterion D) and end-of-unit questions to assess criterion A. At the beginning of each unit, you will see a summative performance assessment task that relates closely to the Statement of Inquiry. We have given this task the most authentic performance nature possible. Other performance assessment tasks are included in each unit that can be used summatively or formatively. We expect that not all of the assessment suggestions will be used for summative purposes.

6 **Approaches to Learning:** We are very impressed by the revised Approaches to Learning framework based on the ten clusters of ATL skills. We understand that the effective implementation of ATL is a whole-school challenge but have made suggestions for when teachers can explicitly introduce these skills and dispositions, both as part of summative assessment tasks, and also more generally in their daily teaching. You will also see a simplified ATL framework in the appendices that we think will be of great help to teachers.

7 **Service learning:** We have also suggested a possible service learning activity (labelled 'TA' (Taking action)) for each unit.

The NelsonNet teacher website contains draft MYP unit plans, curriculum overviews, BLMs for experimental work and classroom activities, ideas for interdisciplinary tasks, further resources and advice for using the ATL framework, and answers to all questions.

We realise there may seem to be an inherent conflict between the idea of teachers working in a creative and collaborative way to produce MYP units of work and the use of a textbook. Schools will use this book in different ways. Some new schools might find it an invaluable stepping stone to getting a MYP Sciences programme up and running. Others may use it to enhance their existing courses. We encourage you not to use these books the way traditional textbooks have been used. Be creative, add to them, choose the bits you like, encourage the students to interact with them. They are there to help students in their deep learning of science, to encourage their interest and motivation. We hope the availability of materials of this kind will make your life as the teacher a little easier and give you more time to focus on the actual teaching and learning. Enjoy them.

Rick Armstrong (Series editor)

UNIT 1

BEING A SCIENTIST IN THE MYP

KEY CONCEPT

Relationships

RELATED CONCEPTS

Evidence

Patterns

Development

GLOBAL CONTEXT

Scientific and technical innovation: an exploration into how the world of science works

STATEMENT OF INQUIRY

Scientists develop our understanding of the world by looking for patterns and carrying out experiments to gain evidence to explain relationships.

INQUIRY QUESTIONS

FACTUAL

1 What are the steps involved in the scientific method?
2 What are the key features of MYP science?

CONCEPTUAL

3 Why is the control of variables (fair testing) important in science?
4 Why are concepts important to learning in science?
5 How does the use of global contexts help learning in science?

DEBATABLE

6 Does science provide the answers to all questions?
7 What factors may prevent science from solving problems or issues?

Introduction

Questioning is part of human nature. The need to understand, explain and measure inspires our need to create. Throughout time, humans have invented new ways of unlocking the mysteries of our world and the universe. Discoveries in health, medicine, technology, space and energy have influenced culture and society.

FIGURE 1.1 Scientific discoveries opened up the possibility of space travel.

FIGURE 1.2 The first magnetic compass was probably made in China during the Qin dynasty, 200 BCE and used for early navigation.

Without the discoveries of determined scientists, our lives would not be what they are today. Similarly, future discoveries will enrich our lives further. Here are just a few examples of how scientific discoveries and new technologies have changed our lives.

- Medicine – new technologies are helping people live longer, healthier lives. Years ago, cuts and scrapes that became infected could kill people, as could burns, disease and even childbirth. Vaccinations save thousands of lives from diseases that can be prevented.
- Communication – we can share our ideas in ways that were unimaginable in the past. We know almost instantly what is happening around the world, and can keep in close contact with family and friends.
- Agriculture – we can grow much more and better quality food.

- Arts – many more people are able to become artists, and more people can access high-quality art.
- Education – new technologies are improving access to education worldwide, and we understand much better how people learn.

Technology has also changed the way we play sport, use textiles and travel. But not everyone has benefitted equally from these developments. Bringing these technologies to everyone remains one of the most serious challenges facing the world.

Scientists are often portrayed as men and women in white coats studying an array of chemicals. In reality, they are people who are curious about the world or want to improve our lives. There are more types of scientists than there are letters in the alphabet! From archaeologists to zoologists, scientists carry out investigations to find answers to questions. Some become journalists, authors or politicians, and a special kind become teachers of the next generation of scientists.

FIGURE 1.3 Modern medicine allows premature babies to be cared for and thrive, when once they may have died.

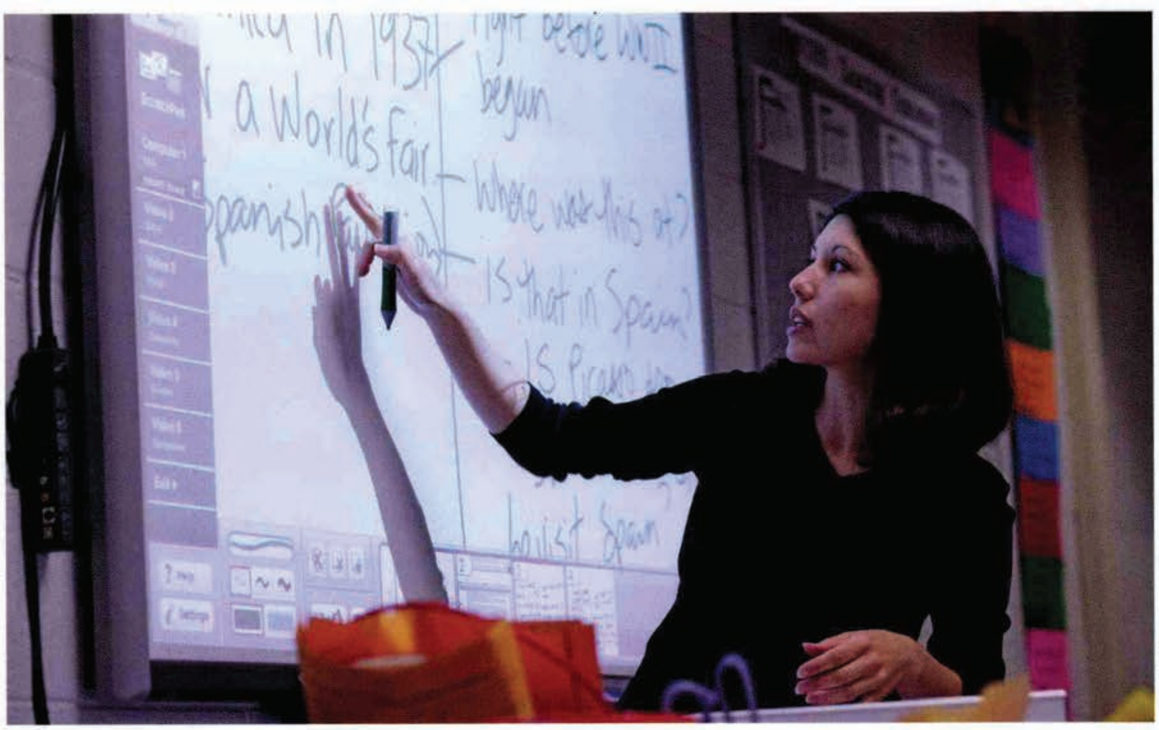


FIGURE 1.4 Technology such as computers, interactive whiteboards and projectors helps to improve education worldwide.

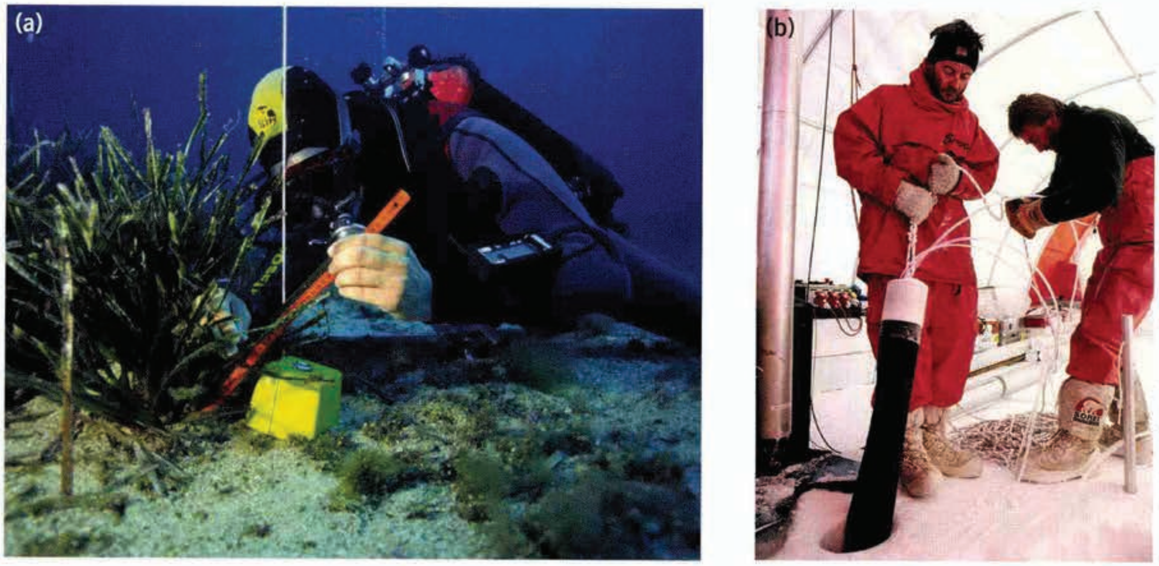


FIGURE 1.5 (a) Marine biologists and (b) climate scientists work in different environments to find answers to questions about the ocean and the climate.

FIGURE 1.6 Angela Merkel, Chancellor of Germany, was a scientist. She worked as a research chemist before becoming a politician.

SUMMATIVE PERFORMANCE ASSESSMENT TASK
CRITERIA B AND C

Understanding how pendulums swing

INVESTIGATION 1.1

Near the end of this unit, you will carry out a scientific investigation with little guidance from your teacher. You will use what you will learn from Investigation 1.2 into gummy bears, for which you will receive considerable guidance from your teacher.

YOUR CHALLENGE

To investigate how the length of a pendulum affects how fast it swings.

ATL

CRITICAL THINKING
Designing investigations. Designing, carrying out, and considering the results of any investigation in any subject requires a high level of careful and critical thinking.

THIS MIGHT HELP

You can make a pendulum by attaching a weight to a piece of thin, flexible string. Tie the pendulum to the clamp on a clamp stand and check that it swings smoothly. It is difficult to measure the time for just one swing. It is best to measure the time for 10 swings and divide the result by 10.

Carry out and write up the investigation by following the guide in Appendix 3 on page 169, or as advised by your teacher.

ACTIVITY Gallery walk of your ideas about science

On different coloured pieces of paper, answer the following questions.

1 Name four important scientists and describe their contributions.
2 Name four different sciences and describe each area of study, e.g. botany – the study of plants.
3 Suggest the four most important scientific discoveries of all time.
4 Suggest four qualities a good scientist should have.

Stick your answers on a wall and carry out a gallery walk of the answers.

How does science work?

Science is a way of explaining the natural world. Science is based on careful **investigation**, on collecting **evidence** and considering it critically. Scientific theories about the natural world can be changed, developed further or even rejected. You probably know that before the work of Copernicus in the 16th century, people thought the Sun moved around the Earth.

The idea of carrying out careful observations and experiments can be traced back to early times. For example, in Imperial China by around 300 BCE, people had studied how the symptoms of various diseases changed. In India around 600 BCE, people knew how to carry out operations for cataracts in eyes. Science flourished over the Islamic Golden Age from around 800 to 1300 and helped lay the foundation for the scientific revolution in Europe from around 1500 to 1700.

One of the first people to develop a more scientific way of working was the English physicist Sir Isaac Newton (1643–1727) (Figure 1.7). He carefully recorded his observations and repeated his investigations many times. Newton averaged his data, thought about his results, made conclusions and considered new ways to get better answers. His work led to a completely new theory about how objects move that we now call Newton's laws of motion.

FIGURE 1.7 Sir Isaac Newton used a scientific way of investigating motion.

Science is continually developing as theories are improved, and new theories sometimes replace older theories. Even Newton's ideas on motion have since been improved by Einstein's theories on relativity.

ACTIVITY History of science

The origins of science go back a long time and involve many cultures. Carry out some research about the history of scientific developments that took place in one of the following cultures and share your results with the class in a 5-minute presentation:

- Ancient Babylon and Ancient Egypt
- Ancient Greece
- Ancient India
- Imperial China
- Islamic Golden Age
- Europe in the Middle Ages.

Care with scientific claims

We need to be careful about scientific claims, particularly in areas such as diet and medicine. Many of these claims are **pseudoscience** – they appear to be scientific but lack reliable evidence. Many people find it difficult to distinguish between reliable scientific claims and unreliable pseudoscience. For example, some people spend a lot of money on various minerals and vitamins, but in most cases there is no reliable scientific evidence for any health benefits from consuming these dietary supplements. This problem has increased with more widespread access to the internet.

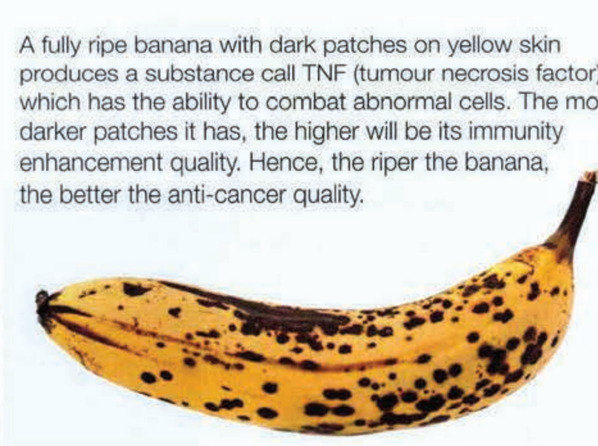


FIGURE 1.8 This seems like a pseudoscience claim about bananas.

Not all useful knowledge about the world is a result of scientific investigation. Personal experience can be a very valuable way of investigating something new. An example is an anthropologist looking to understand the customs of another culture. Many questions cannot be solved by a scientific approach, such as judgements about the quality of art or questions about religion. These are sometimes said to be examples of **non-science**. If you continue on in the IB until the Diploma Programme, then you will study these sorts of issues in Theory of Knowledge.

PERFORMANCE ASSESSMENT TASK
CRITERION A

The science of superheroes

ACTIVITY

Some of the special powers of superheroes are inspired by science, even if in reality humans could only possess these powers with special technological support. It is interesting and educational to consider the scientific implications of these super powers. For example, how does Storm in X-Men produce lightning bolts?

Some superheroes are scientists. For example, Spider-Man (Peter Parker) is a science student, and the Incredible Hulk (Bruce Banner) is a nuclear physicist.

FIGURE 1.9 The powers of superheroes can be inspired by science.

TASK 1 DISCUSS YOUR FAVOURITE SUPERHEROES

Choose one of your favourite superheroes and conduct some research into the scientific basis of their super power(s). Produce a poster explaining their super power(s) and discussing their scientific implications.

TASK 2 INVENT A NEW SUPERHERO

Invent a new superhero whose role is to protect the environment. Describe the super power(s) he or she has, discuss the science involved and create a short cartoon showing your superhero in action. You will see some examples from other students in the adjacent weblink.

Go to http://mypsci1.nelsonnet.com.au and click on **Superheroes**. Use the weblinks to help you carry out research into the science of superheroes.

Go to http://mypsci1.nelsonnet.com.au and click on **New superheroes** to see some examples of students inventing new superheroes.

Being a brilliant MYP scientist

Science education in schools around the world has changed a lot in recent years. It used to mainly involve a lot of rote-learning scientific facts, a lot of study from books and a lot of talking from teachers. These days in most countries, the major aim of science education in schools is to help students develop the skills of real scientists. Therefore, students are taught to think in a scientific way, to carry out scientific investigations (Figure 1.10), to relate their science to real-world problems and to understand scientific ideas. This is particularly true in the MYP.

Alamy/Cultura Creative (RF)

FIGURE 1.10 Students carry out scientific investigations as part of their science course.

The scientific method

Although different types of scientists work in different ways, there are a lot of similarities in their approach. This is sometimes referred to as the **scientific method**. Scientists often work collaboratively and discuss each step in their investigation (Figure 1.11). In the MYP, when we carry out scientific investigations, we can use the model in Figure 1.11 to help us. Each of the steps will be explained as you work through the unit.

1 Describe the research question or problem to investigate.
↓
2 Outline and explain a hypothesis (prediction).
↓
3 Describe how to control the variables to make it a fair test.
↓
4 Design the method with appropriate materials and equipment.
↓
5 Collect and present the data.
↓
6 Conclusion: interpret and explain your data.
↓
7 Evaluation: discuss how well the investigation worked, the errors, possible improvements to the method and further experiments that could be carried out.

FIGURE 1.11 Steps in the scientific method

Investigation 1.2 is your first MYP scientific investigation to work on together as a class, step by step, with support from your teacher.

A practice investigation: the gummy bear challenge

INVESTIGATION 1.2

ATL

TRANSFER

Using skills in new situations. We are using a teaching idea called scaffolding during this investigation. This means we will give you the structure for how to carry out this scientific investigation so that next time you will be able to carry out the investigation with less guidance.

Gummy bears were first made in Germany in 1920. You can use any other gelatin-covered jelly sweet, such as jelly babies, for this investigation. Teachers may like to substitute this investigation with one on another topic if they prefer.

You will use the seven steps listed in Figure 1.11 to help you carry out your first MYP scientific investigation.

1 DESCRIBE THE RESEARCH QUESTION OR PROBLEM TO INVESTIGATE

First you need a question or a problem to investigate. This question or problem should be developed by you. Often, research questions come from

FIGURE 1.12 Gummy bears

observations we have made. Sometimes we carry out further research to find out more about the topic.

Put the gummy bear into a container with water, leave it overnight and observe what happens. This observation should give you some ideas for a good research question.

FIGURE 1.13 The growth of a gummy bear when left in water

What are you thinking? How fast did the gummy bear grow? How much did it grow? What happens if you add other substances to the water? What happens if you increase the temperature? Do gummy bears of all colours grow in the same way?

Here are some quite simple research questions.

- Do gummy bears of all colours grow at the same speed?
- How does the speed of growth change over time?
- Does the growth change if you add other substances such as sugar to the water?
- Does the temperature of the water affect how fast they grow?

A more sophisticated research question could be as follows.

- What factors control how much a gummy bear grows in water?

Write your research question for your investigation. For this task, concentrate on the effect of adding sugar to the water.

2 OUTLINE AND EXPLAIN A HYPOTHESIS (PREDICTION)

Scientists usually have an idea or theory about the results they are likely to obtain. This idea or theory is called a **hypothesis**. A hypothesis is similar to a prediction. Try to suggest a reason for your hypothesis (this can be difficult in some situations). Here is an example.

'My hypothesis is that gummy bears of all colours will grow the same amount. I think this is because the colour is a very small part of the gummy bear and is unlikely to have any effect.'

Write your hypothesis (prediction).

>

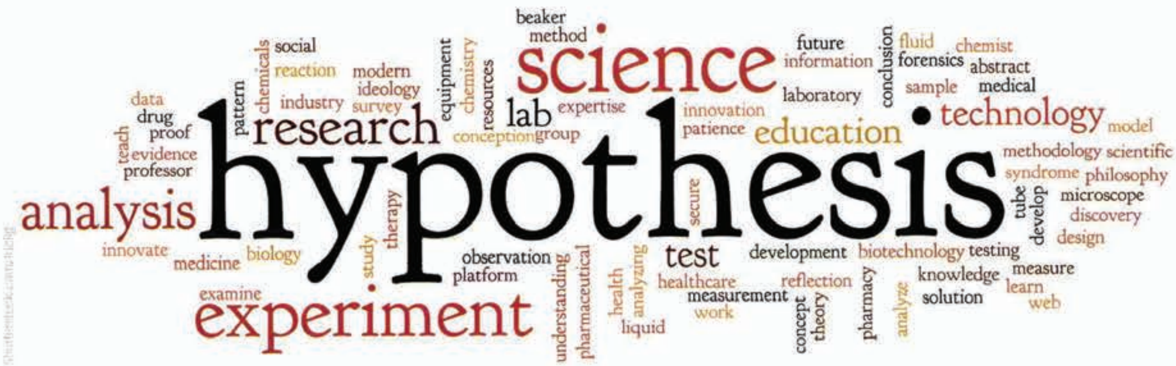


FIGURE 1.14 The hypothesis at the centre of scientific investigation

3 DESCRIBE HOW TO CONTROL THE VARIABLES TO MAKE IT A FAIR TEST

Your investigation needs to be a **fair test**. For example, if you were investigating the amount of sugar added to the water, and you used different-sized gummy bears in your experiment, it would not be a fair test. You could not compare the results from one gummy bear to another.

The word **variable** is very important in science. It means the property of something involved in the experiment that can change. Variables that you change are called **independent variables.** For an investigation to be a fair test, only one variable may be changed at a time – all other variables must be kept the same. For example, in this investigation you could decide to investigate the effect of changing the amount of sugar in the water. The amount of sugar would be the independent variable. The difference between the largest and the smallest values in the independent variable is called the **range**.

You need to keep the other variables the same. This would include keeping the type, size, and colour of gummy bear; the amount of water; the time; the temperature; and the size of the containers the same. These variables are called the **control variables**. If you control these variables, you can say that it was a fair test.

Go to http://mypsci1.nelsonnet.com.au and click on **Variables** to see a video that explains the idea of variables.

During an investigation, you will be measuring the outcome. In this investigation, this is the size of the gummy bear. This is called the **dependent variable** because it depends on the changes you are making to the independent variable. As you gain more experience with scientific investigations, you will state in your hypothesis the relationship between the independent and dependent variable.

List one independent variable to investigate, the dependent variable to measure and the control variables that you will keep the same.

4 DESIGN THE METHOD WITH APPROPRIATE MATERIALS AND EQUIPMENT

You should have a detailed plan for your investigation. Before you start, think about the following types of questions.

- What equipment and materials do you need?
- How will you set them up?
- How will you make sure the method is safe?
- What steps will you follow to carry out your investigation?
- How will you change your independent variable?
- What data will you collect?
- How will you measure the change in size of the gummy bear?

Scientists need to share with other scientists exactly how they do their investigations, so a clear and logical plan is important. Your plan needs to be clear and easy to repeat so that other scientists can repeat your experiment. This is a very important aspect of how science works.

You should also state what data you will collect. In this case, you could simply say that you will carry out five different experiments: one with pure water and four with different numbers of teaspoons of sugar.

Where possible, scientists should repeat their results. Simply carrying out the experiments with one gummy bear each time would not be good science. Experiments can have errors and sometimes an unreliable result can be obtained. Repeating the experiment gives us more reliable results. In this case it is a good idea to use three or four gummy bears each time, or three or four different trials.

Write your method for your experiments. A diagram is likely to help.

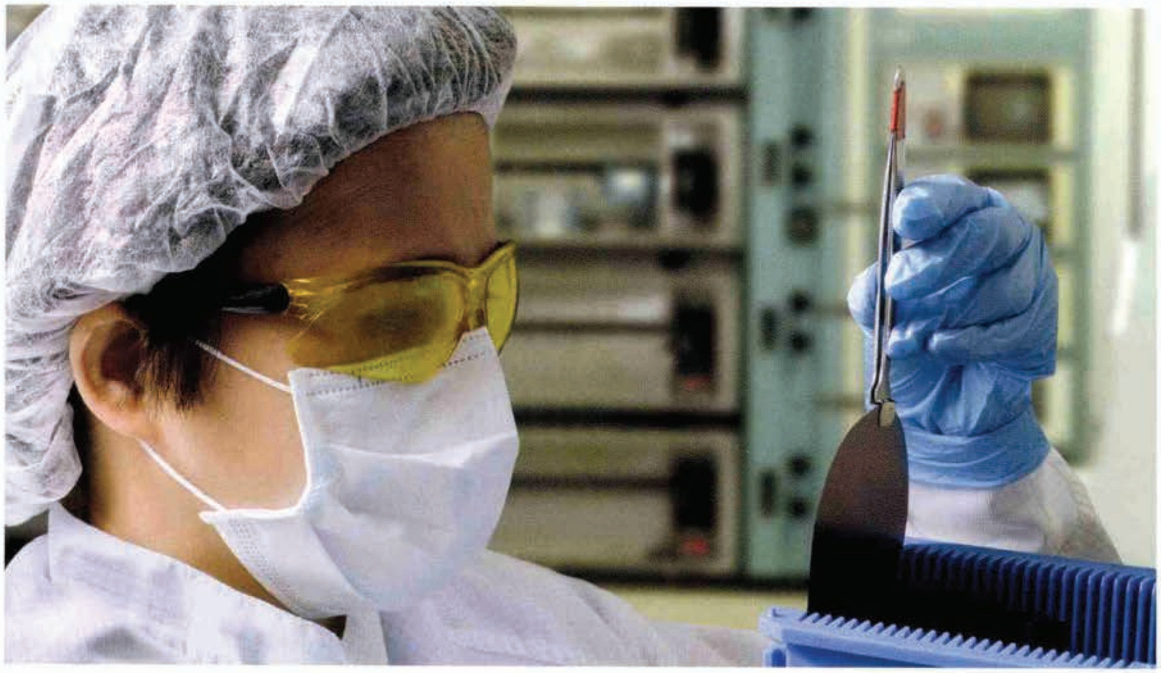


FIGURE 1.15 It is important that you design a method that is safe.

5 COLLECT AND PRESENT THE DATA

During your investigation, carefully watch any changes that occur and take any necessary measurements. This is called **experimental data**. Data can be collected in many ways, including measurements with suitable apparatus (for example, a ruler, photos or videos). The data is then recorded in a table. Sometimes it will be simply well-organised, written observations. If you have repeated your experiment and have more than one measurement, then you will often need to work out the **mean** (a type of average) of your results.

In your gummy bear investigation, you will need a table to record the original length of the gummy bear(s) and final length(s). Think about the headings your table will have. Don't forget to include the units of any measurements you have made. (Table 1.1 is given as an example.)

TABLE 1.1 Sample results table

Amount of sugar added (teaspoons)	Initial length of gummy bear (cm)	Final length of gummy bear (cm)	Difference in length (cm)

If your results include numbers, then a good way to show the results is by drawing a graph (Figure 1.16), such as a line graph, pie graph or column graph (bar chart). For this investigation, you could use a line graph. Talk with your teacher about how to draw and label the graph. You also need to draw a **line of best fit**, which is a straight line or curve that goes through as many points as possible, with an equal number of points above and below the line.

Design your results table, carry out your experiments to collect the data, and then present your results using a graph.

>

6 CONCLUSION: INTERPRET AND EXPLAIN YOUR DATA

When your investigation is finished, you need to communicate what you have learnt. Your explanation should be organised and well thought out and show good scientific thinking. Draw a graph to help see more clearly the relationship between the amount of sugar added to the water and the increase in length of the gummy bear. What pattern does the graph show? What shape is it? Are there any points that do not fit with the rest of your results? These points are called **anomalies** (or outliers) (Figure 1.17).

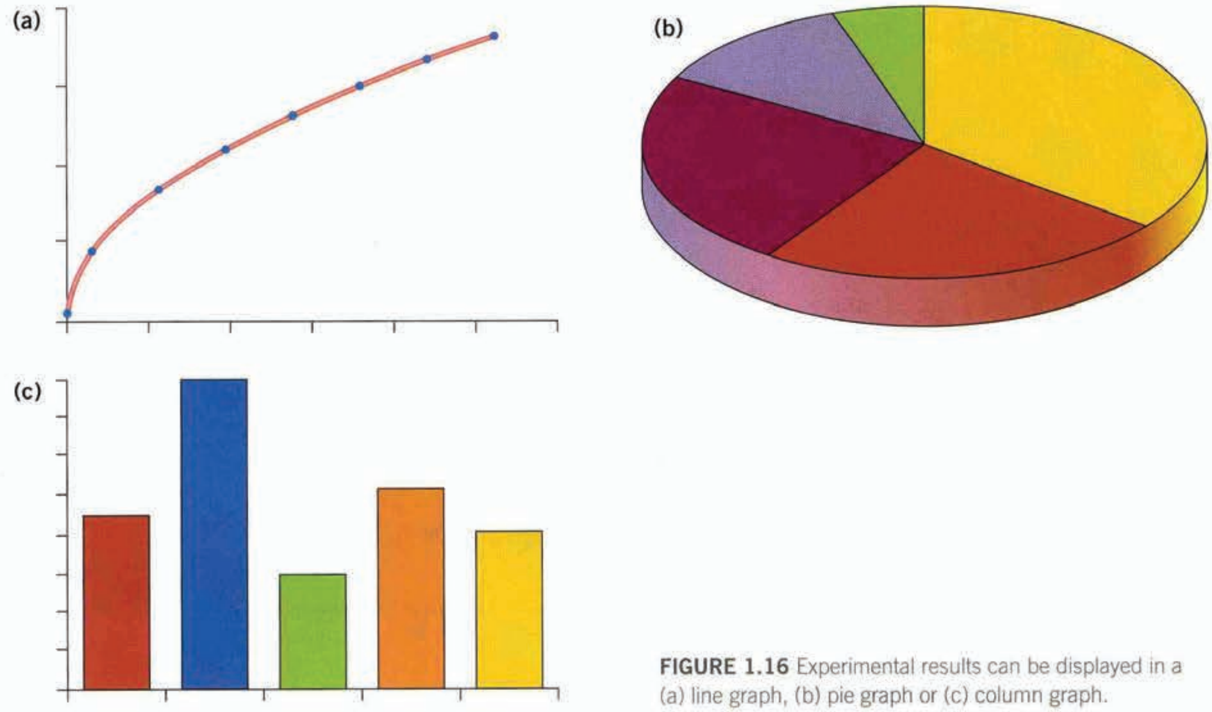


FIGURE 1.16 Experimental results can be displayed in a (a) line graph, (b) pie graph or (c) column graph.

The best science happens when you work collaboratively and you are prepared to argue about the interpretation of your results. It is important to be sceptical – question whether the method and the evidence were good enough to make these claims. Sometimes, results from experiments are not very clear, so you might need to say that there are no clear **trends**. In this case, it is likely more experiments need to be done.

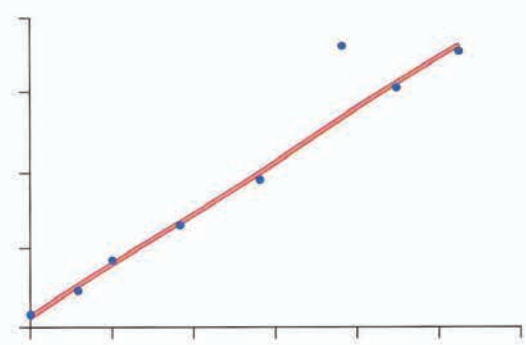


FIGURE 1.17 A line graph showing an anomalous result – an outlier does not fit with the rest of the line.

Write your conclusion to show how you have interpreted and explained your results.

Your teacher will probably guide you on this, particularly on the importance of being very careful about how you interpret the evidence and the need for very carefully written conclusions.

>

7 EVALUATION: DISCUSS HOW WELL THE INVESTIGATION WORKED, THE ERRORS, POSSIBLE IMPROVEMENTS TO THE METHOD, FURTHER EXPERIMENTS THAT COULD BE CARRIED OUT AND WHETHER YOUR RESULTS AGREED WITH THE HYPOTHESIS

This is the reflective part of an investigation. This can be challenging, but in science this is considered to be very important. Think about whether your investigation was successful – whether it actually tested the hypothesis. In a **valid** experiment, you can trust your data. All experimental measurements involve some errors. The important idea is that the results are sufficiently **accurate** and **precise** to make the experiment valid. A valid experiment also means that it really was a fair test. It means you really did control the variables sufficiently.

Try to suggest how to improve the experiment. How would you change the method? Also suggest other experiments you could do to find out more about this research question. For instance, in this investigation, you could change the independent variable to time, or to temperature.

Reflect on your hypothesis. What do the results tell you about your original theory? Perhaps you were trying to find out if adding sugar to water affected the amount the gummy bears expanded. Do your results support your original hypothesis?

Complete your evaluation of the investigation.

That is your first MYP scientific investigation completed.

In the next section, you will learn about how this investigation could be assessed.

REVIEW

1 Outline what is meant by a scientific investigation.
2 State the seven steps in the model of scientific investigation described in this unit.
3 Outline what is meant by a fair test.
4 State what is meant by variables in a scientific investigation.
5 Outline the three types of variables that are involved in any scientific investigation.
6 Imagine that during an experiment, your partner looked at the results and quickly concluded what they showed, but you had doubts about the results and the validity of the experiment. Suggest what you might say to your partner.
7 When vinegar is added to baking powder, it fizzes and gives off a gas. An experiment was designed (see Figure 1.18) to measure the volume of this gas over 4 minutes.

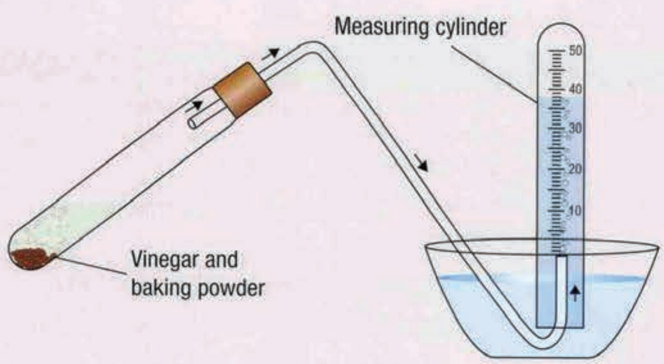


FIGURE 1.18 Apparatus used to measure the volume of gas given off

>

The results are displayed in the following table.

Time (min)	Volume of gas (litres)
0.5	0.30
1.0	0.50
1.5	0.55
2.0	0.59
2.5	0.60
3.0	0.60
3.5	0.60
4.0	0.60

a Plot a graph of the results.
b Are there any anomalous results?
c Interpret these results; that is, describe what happens to the volume of gas over time.
d State the independent variable in this experiment.
e State the dependent variable in this experiment.
f State what the control variables could have been in this experiment.
g Suggest a different independent variable that could be investigated in this experiment.

8 Suggest a hypothesis for an investigation into how increasing the amount of fertiliser affects the growth of plants. Try to explain your hypothesis.

9 **a** Write two questions that can be answered by science.
b Write two questions that cannot be answered by science.

10 Explain what is meant by pseudoscience.

What makes MYP Science special?

Assessment in MYP Science

A special feature of MYP Science is the way the assessment works. You will gain levels in relation to four different **assessment criteria**. Table 1.2 shows the criteria and ways they could be assessed.

TABLE 1.2 MYP Science assessment criteria

Assessment criteria	Tasks that could be used for assessment
A. Knowing and understanding	Examinations, tests, quizzes, challenging questions, extended writing and explanations, presentations, posters, debates
B. Inquiring and designing	Scientific investigations (as described in the previous section)
C. Processing and evaluating	Scientific investigations or other experiments
D. Reflecting on the impacts of science (considering how science can be used to solve problems, for example, climate change)	Essays, presentations, debates, role plays, films

These four assessment criteria, and how they are used to award grades, are more fully explained in Appendix 1 on page 165. Successful MYP students learn to understand these assessment criteria. The criteria tell you what you need to do to gain top grades. Being a successful MYP Science student is not just about doing well in examinations. It is just as important to develop your experimental skills and to be interested in how science can be used to improve the world.

ACTIVITY Learning to use the assessment criteria

Use assessment criteria B and C to award levels to a write-up of the gummy bears investigation. Your teacher will give you a write-up from another student (or group of students). Your teacher will also give you some guidance on how to give and receive feedback. One commonly used approach for giving feedback is called 'two stars and a wish'. This approach acknowledges two areas where the student did well (the stars) and one area where they could improve (the wish).

1 Read the level descriptors for each of criteria B and C carefully and then decide which level the work corresponds to. It would be best to work on this in groups and to try to come to a consensus with the others in the group.
2 Give feedback to the original student(s) about the strengths and weaknesses of the work, and the level you would award. Also include feedback about how the work could be improved.
3 Discuss how you felt during this experience of giving and receiving feedback. How easy was it? How useful was it?
Remember, feedback should be kind, specific and helpful.

ATL

REFLECTION

Self-awareness of learning, giving and receiving feedback. One of the best ways for students to improve their learning is through the use of **formative assessment**. This means students understand the assessment criteria well and are using them to assess their own work, and to assess the work of other students.

TA HELPING OTHER STUDENTS CARRY OUT SCIENTIFIC INVESTIGATIONS

You could offer to help primary school students carry out scientific investigations, particularly on the idea of variables and fair testing. You could design an investigation for them to carry out, which could possibly be based on growing plants or dissolving sugar.

Emphasising big ideas – the use of concepts

Our scientific knowledge is increasing rapidly and is easily accessible via internet, so it makes no sense for schools to try to teach you everything worth knowing in science. Science education should emphasise the big ideas in science – the ideas that give structure to science, that help you work and think like a scientist. The use of big ideas or **concepts** should help you to understand ideas better, or more deeply. When you learn something, the neurons in your brain send electrical messages (Figure 1.19). Learning is about building connections between neurons in your brain so that concepts, such as about gravity or how plants grow, are clearly organised.

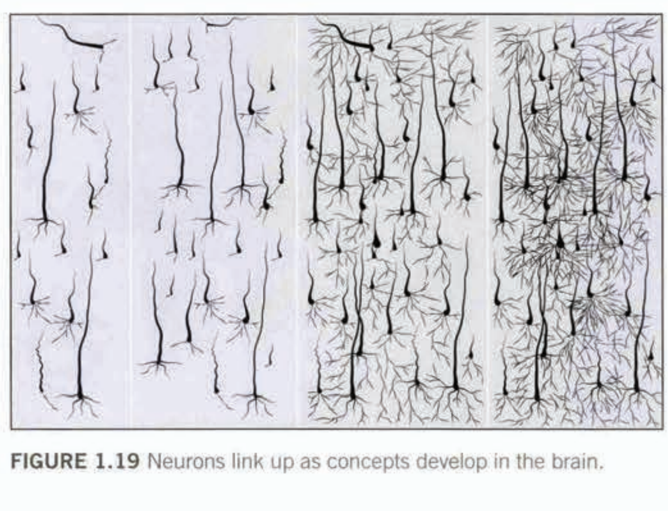


FIGURE 1.19 Neurons link up as concepts develop in the brain.

Some students think that teachers simply need to explain the scientific ideas for students to learn. This is not true.

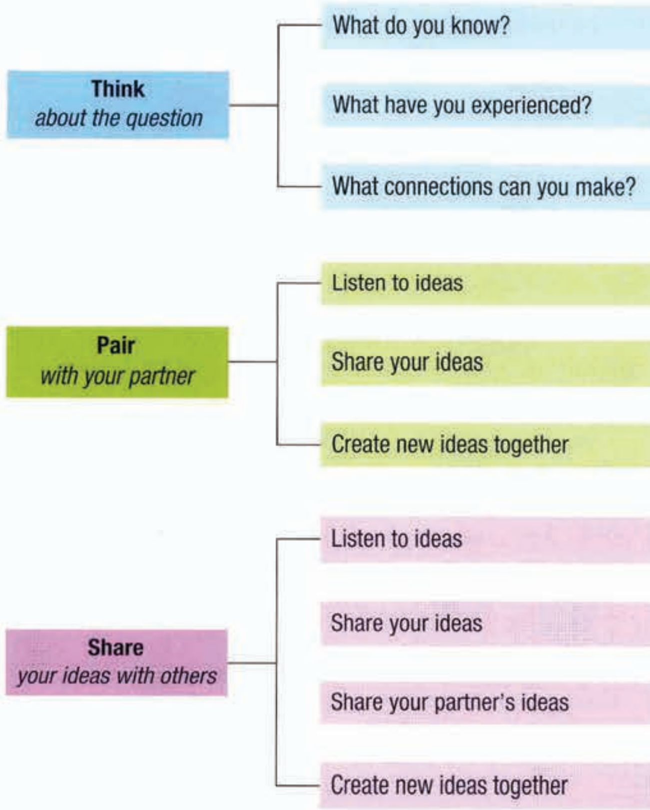


FIGURE 1.20 A think, pair, share activity will help with your science learning.

The learning is done by the student. The student is the one who needs to make an effort to ensure that their understanding has developed. This is why in science it very important that students ask questions and are prepared to discuss their ideas with other students. Teachers will often give you activities or questions to help you with these discussions. One such activity is called think, pair, share (Figure 1.20). Some students find mind maps very useful when organising their ideas (Figure 1.21).

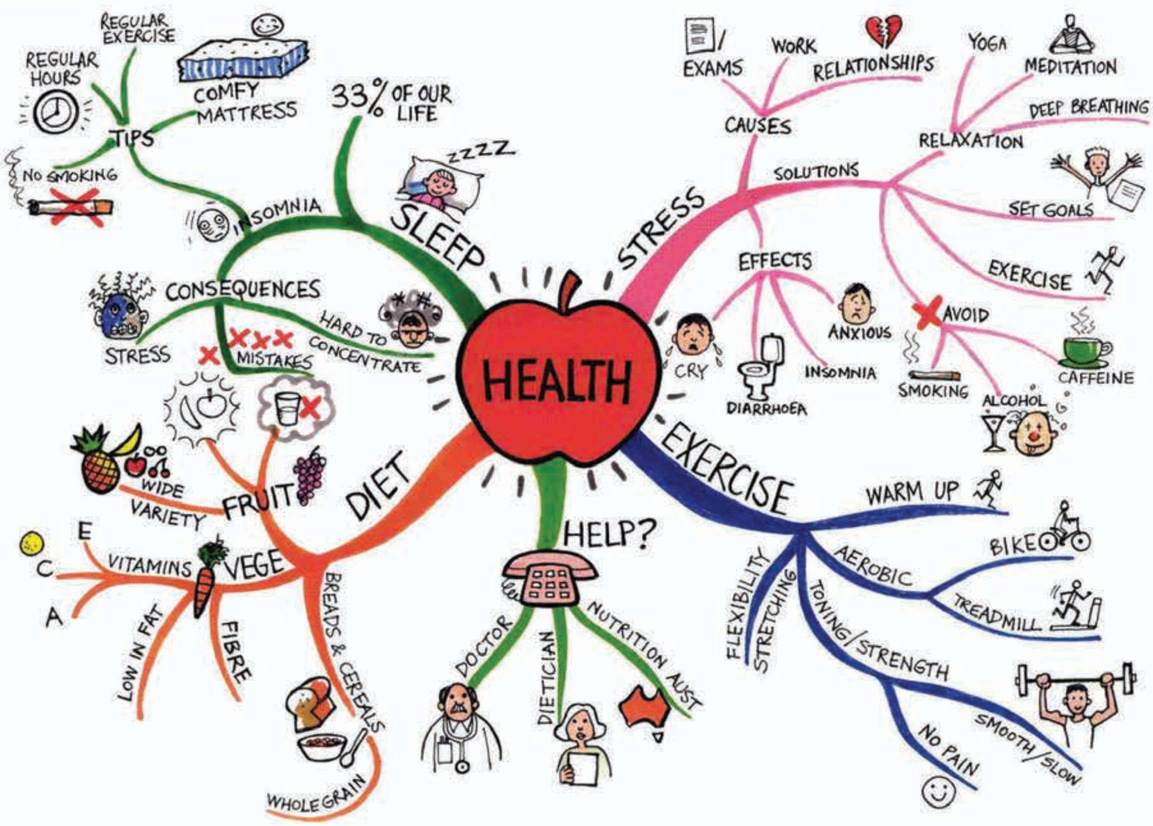


FIGURE 1.21 A mind map can help you learn about healthy living.

Misconceptions in science

In science, there is another difficulty about learning scientific concepts (theories). We all develop concepts about the world by simply being alive and being in the world. Sometimes these concepts are not scientifically correct and it is difficult to change these **misconceptions** to the correct scientific concepts. For example, some people think that electricity is used up in an electrical circuit, or that an object moving at a constant speed must have a force acting on it, or that plants get all their food from the soil. To overcome misconceptions, we need to have the opportunity to discuss our ideas with other people, and to answer special questions that challenge our thinking.

Key and related concepts in MYP Science

As you will be learning in other MYP subjects, each MYP unit of work is based on one key concept and usually two or three related concepts. These concepts are described in Appendix 4 on page 173. One key concept in science is systems, the idea of a group of related parts that move or work together. Examples include body systems such as the nervous system, and the solar system.

A related concept in science is patterns; for example, how scientists look for patterns in the weather, in the reactions of metals, and in results from experiments.

ACTIVITY

Organising your ideas

1 Use a think, pair, share activity to discuss the idea 'Looking for patterns is an important aspect of science'.
2 Discuss the following statements with another student or your teacher.
   - Energy is used up as a car moves.
   - A plant gets its food from the soil.
   - Gases do not weigh anything.
3 Use a mind map to show your understanding of an area of science you find interesting.

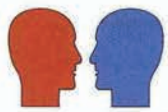
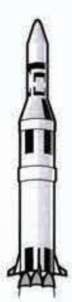
ATL

REFLECTIVE
Knowledgeable about aspects of learning such as the use of mind maps. Mind maps are very powerful tools to help you organise your ideas. They can help with organising a speech, writing an essay, or revising for examinations.

Relating MYP Science to the real-world use of global contexts

You will be learning in all subjects that every MYP unit of work is based on a **global context** (Table 1.3, page 18). This is to make sure learning has relevance for you. If you were a PYP student, you will recognise the global contexts as being very similar to the **PYP transdisciplinary themes**. In an MYP Science class, if someone asks you 'Why are you learning this?', you should be able to give a good answer. You might say 'I am learning about forces and motion because it will help me understand how to be safe in my life and hence support the development of my identity and relationships with others'.

TABLE 1.3 The use of MYP global contexts

Global context	
Identities and relationships 	**Who am I? Who are we?** In science, you could be involved in explorations relating to your health and/or your relationships with other people.
Orientation in space and time 	**What is the meaning of 'when' and 'where'?** In science, you could explore key moments in science, and how new scientific discoveries have changed the world.
Personal and cultural expression 	**What is the nature and purpose of creative expression?** You could explore the role of creativity in science and how culture affects science.
Globalisation and sustainability 	**How is everything connected?** In science, you could consider issues relating to access to resources, including minerals and energy. Also, you could explore issues related to protecting the environment, recycling and the need for sustainable lifestyles.
Fairness and development 	**What are the consequences of our common humanity?** In science, you could explore the rights of all people to an adequate diet, drinking water and health care.
Scientific and technical innovation 	**How do we understand the world in which we live?** Science offers many possible explorations relating to this global context. You could explore how new scientific developments in materials and medicines are affecting our lives.

ACTIVITY Use of global contexts

PERFORMANCE ASSESSMENT TASK CRITERION D

This activity will help you think about how the six different global contexts in the MYP can be used in science.

1 What are the global contexts and explorations chosen for the eight units in this book?

2 Imagine your teacher wants to teach the class about healthy diets. Explain how the use of each global context would change the way the unit is taught. For example, if the global context of fairness and development was chosen, then the teacher would emphasise considering the quality of diets of different people around the world.

3 Carry out some research into the Millennium Development Goals (Figure 1.22). Which global context could be used to study Goal 1 (Eradicate extreme poverty and hunger)?

UNDP Brazil

FIGURE 1.22 The eight Millennium Development Goals

4 Write a 400-word essay on the topic 'How science can help us to more fully meet Millennium Goal 1'.

Your teacher will discuss assessment criterion D with you – reflecting on the impacts of science. This will include a discussion of why other factors such as politics, economics and the environment are also part of the challenge to reduce poverty and hunger.

Getty Images/Hoang Dinh Nam

FIGURE 1.23 Doctors Without Borders (Médecins Sans Frontières) are helping meet the Millennium Goals.

Thinking about the profile of a successful scientist

If you were a PYP student, you will be very familiar with the IB Learner profile and its importance in the IB programs. Perhaps you could list all 10 attributes. The main idea is to remind us that the first purpose of education is to prepare students to become successful lifelong learners and internationally minded citizens. If you are new to the IB, then this is a good moment to learn more about the IB Learner profile.

Scientists showing the attributes of the IB Learner profile

ACTIVITY

Your teacher will provide you with a copy of the IB Learner profile. It includes the following 10 attributes: inquirer, knowledgeable, thinker, communicator, principled, open-minded, caring, risk-taker, balanced and reflective.

The following is a list of some attributes of a successful scientist.

- Can write up their investigations clearly
- Seeks and considers the points of view of others
- Has a natural curiosity and approaches problems with creativity and enthusiasm
- Is interested in relating their work to make a positive difference to the world
- Makes effective presentations at conferences
- Has a good life–work balance, and appreciates the importance of emotional and physical health
- Has high-quality research skills
- Shows a very reflective approach to experimentation and considers the evidence
- Reads scientific papers, attends conferences, and discusses with other scientists in other languages
- Is conscious of their strengths and weaknesses and the need for professional development
- Shows a careful, logical approach to the design of experiments
- Is honest in their work, and concerned about the social and environmental consequences of their work
- Enjoys a challenge and exploring new ideas, and copes well when things get tough
- Works effectively in research teams or other kinds of teams
- Has a deep understanding of their subject but also has interest in and good knowledge of other areas of science
- Analyses experimental results carefully and critically
- Shows a creative approach to their work

1 Read the IB Learner profile and think about how it would relate to being a successful scientist. Then work in small groups (or with the whole class) to associate each attribute, as described above, that scientists need to the corresponding learner profile attribute.

2 Compare your answers with those of other students.

3 Can you think of other attributes a successful scientist should have?

4 **a** What do you think are the three most important attributes for a scientist to have? Explain your answer.

b Are these also the attributes that are needed in other professions? Explain your answer.

Becoming great learners

At their centre of all IB programmes is the idea of helping students to become successful learners (i.e. Approaches to Learning (ATL)). This is one reason why universities like IB students. The 10 MYP ATL skill clusters are:

- Communication
- Collaboration
- Organisation
- Affective
- Reflection
- Information literacy
- Media literacy
- Critical thinking
- Creative thinking
- Transfer of knowledge.

At times, your teacher will make a special effort to help you develop these skills.

FIGURE 1.24 Working collaboratively

ACTIVITY Why ATL is important for science students

Read more about the 10 ATL learning clusters in Appendix 1 on page 165. Suggest one way each of the 10 ATL skill clusters could be developed though your work in science.

REVIEW

Use the appendices on pages 165–176 to answer the following questions.

1. List the four MYP Science criteria.
2. Name the three key concepts we use in science.
3. List six related concepts we use in science.
4. Give examples of how two global contexts could be used in science.
5. Which two ATL clusters would be most important in carrying out scientific investigations? Give your reasons.
6. What do you think are the two most important attributes for a scientist to possess from the IB Learner profile? Give your reasons.

UNIT QUESTIONS

CRITERION A

EXPLAINING SCIENTIFIC KNOWLEDGE

1 Write a hypothesis for each of the following testable questions. (Level 1–8)

- **a** Do plants grow better in water or soil?
- **b** Does Alka-Seltzer® fizz more as a whole tablet or as small pieces?
- **c** Does salt water, sugar water or pure water boil fastest?
- **d** Which has more germs: a telephone handset or a restroom tap handle?

2 In the investigations a–d in Question 1, identify the: (Level 1–8)

- **i** variable you are measuring
- **ii** variable you will change
- **iii** variables you will control (keep the same).

3 Compare and contrast a question that science can test and a question that science cannot test. (Level 7–8)

4 **a** Explain what is meant by a fair test.

- **b** Explain how this is related to an investigation being valid. (Level 5–8)

APPLYING SCIENTIFIC KNOWLEDGE AND UNDERSTANDING TO SOLVE A PROBLEM

5 Design an investigation to determine the best growing conditions for a new variety of tomato. (Level 1–8)

INTERPRETING INFORMATION

6 The following table shows the results for an investigation into how the time for sugar to dissolve changes as temperature is increased. (Level 1–8)

Temperature (°C)	Time for dissolving (s)
20	40
40	30
60	20
80	10

- **a** Draw a graph to show these results.
- **b** Make a conclusion about what these results show you.
- **c** Outline the errors you predict could be involved in this experiment and suggest how these errors could be reduced.
- **d** Outline some further experiments relating to this topic that could be worth carrying out.

REFLECTION

1 You have now been an MYP student for a few weeks. What similarities and differences do you see between MYP Science and your other subjects?

2 What do we mean when we say that science students need to be very careful about how they use the evidence they obtain from their experiments?

3 Discuss the idea that science theories are in a continued state of development.

4 Explain why the search for patterns is very important in science.

5 What type of questions can science not answer?

6 Suggest some reasons why millions of people in the world are dying of diseases even though we have the scientific understanding to cure most diseases.

UNIT 2

CLASSIFYING THE NATURAL WORLD

KEY CONCEPT

Systems

RELATED CONCEPTS

Patterns

Development

Evidence

GLOBAL CONTEXT

Orientation in space and time: an exploration into how scientists have used evidence over time to develop their understanding of the living world

STATEMENT OF INQUIRY

Throughout history, humans have sought to understand the natural world; through gathering evidence and identifying patterns, scientists have developed methods of classifying the world around us.

INQUIRY QUESTIONS

FACTUAL

1 What is living and non-living?
2 What are the six kingdoms?

CONCEPTUAL

3 How and why do we create dichotomous keys?
4 How do we group different organisms?

DEBATABLE

5 To what extent has binomial nomenclature enabled scientists to communicate globally?
6 To what extent has the classification of different species become clearer over time?

Introduction

At zoos, you will probably not see monkeys in the same cage as tigers, or antelopes in the same cage as lions, but you might see zebras in the same enclosure as giraffes. Animals in zoos are sorted into groups on the basis of their needs, such as how much space they need, what they eat, who eats them and how they reproduce.

Humans have sorted and grouped animals, and all other living things, since the time of Aristotle (384–322 BCE), an important Greek philosopher. In this unit, you will study the scientific way that we gather evidence to help us sort and group living things, and how we create systems of naming living things so that we can talk about them easily and without confusion.

SUMMATIVE PERFORMANCE ASSESSMENT TASK
CRITERION A (I AND II)

Giving a historical lecture

You are an important scientific historian who has been asked to give a lecture on the question 'Over time, how has scientific discovery enabled us to have a deeper understanding of how to classify living things?'. You can use a white board, slide show or video to present your lecture to your class. You should include:

- an introduction to the topic
- two different scientific discoveries
- information on how the discoveries have developed our knowledge of classification
- good scientific language
- at least two documented sources.

ATL
COMMUNICATION
Selecting your presentation technique so it is appropriate for your audience.

ATL
ORGANISATION
Planning your presentation and setting deadlines to ensure it is completed on time.

Sorting things

Who sorts things

You may not realise it, but you sort and group every day. Humans start grouping objects from a very young age. Even as babies, we use our sense of smell to recognise who is family and who is not. As we grow older, we sort our toys and our books, developing skills that we will use later in life. We do this by identifying different patterns that can be seen in the world around us. These patterns include the colour or shape of different items. Figure 2.1 shows a baby sorting blocks by shape. These classification skills are important in many school subjects; for example, in English, we classify types of words such as adjectives or nouns, and in Science, we classify different chemicals as corrosive or harmful.

FIGURE 2.1 A baby sorting blocks is classifying them according to colour or shape.

Why we sort things

'Hey, look at that four-legged grey thing with a tail!' yells your friend. You look, not knowing if you are going to see a tortoise, a rabbit, a cat, a squirrel or another type of animal. In fact, you see a horse. If your friend had instead said, 'Hey, look at that grey horse', you would have known what to expect. You know what a horse looks like because all horses have the same set of features and you have seen a horse before.

Humans have a natural tendency to want to sort large groups of objects into smaller groups. The groups are usually based on what the object looks like. Sorting helps us make sense of what is going on around us. It also makes us feel more secure because we can predict what might happen in the future in a particular situation. It makes talking about the objects a lot easier as well.

How we sort things

We usually sort things into groups on the basis of the features that they have in common. Identifying these patterns enables us to group the items.

ACTIVITY Sorting old phones

This activity uses mobile phones, but you could use any object that comes in a number of different types, shapes and colours, such as buttons, shoes or wooden blocks of different shapes, sizes and colours.

WHAT YOU NEED

- old used mobile phones collected from the whole class or school
- digital camera

SAFETY

Make sure that the SIM cards are no longer in the phones and all personal details are deleted.

WHAT TO DO

1 Work in a group of three. Collect at least 10 mobile phones. Choose one feature (such as colour) to sort them into two approximately equal groups. Take a photo of your two groups.
2 Choose another feature that will sort each group into two more groups. You do not need to use the same feature for each group of phones. Keep note of what feature you used each time. Keep sorting into groups until each group only contains one mobile phone.
3 Insert the photos into a multimedia presentation or print them and glue them onto an A3 sheet of paper.
4 Present your sorting and grouping system to the class.

WHAT DO YOU THINK?

1 Can the class work out what features you used each time you sorted the phones into groups?
2 List the features that you used to sort the phones into groups. Show this as a diagram.
3 What features did the rest of the class use to sort their phones into groups?
4 Were some phones hard to sort into groups? Why was this?
5 What can you conclude?
6 Look at the list of features that you used to sort your mobile phones into groups. What do all these features have in common?
7 Were the mobile phones in each group more similar at the beginning of the activity (when they were in one big group) or at the end after you had developed your sorting system (when they were in smaller groups)? Explain your answer.

TA RECYCLING MOBILE PHONES

Mobile phones are made up of many useful materials: 1 kg aluminium, 30 kg steel, 4 kg copper, 2 kg manganese, 1 kg nickel, 1 kg cadmium (a heavy metal that should never end up in landfill), 3 kg plastics and 1.5 kg brass can be recovered from 1300 mobile phones. Find out how to recycle mobile phones in your country, so these materials do not go to waste. At the end of the previous activity, you can donate all the mobile phones to a recycling centre in your country.

Go to http://mypsci1.nelsonnet.com.au and click on **Recycle mobile phones** to get some ideas about where, how and why we recycle.

FIGURE 2.2 Old mobile phones for recycling

REVIEW

1 Why do Suggest a reason for why humans tend to want to sort things into groups.
2 Outline the principles of sorting and grouping.
3 As the groups get smaller, do the objects within a group become more or less similar?
4 Imagine there is no sorting and grouping of the natural world. People communicate only by describing things to one another. Rewrite the sentence 'My cat ate a mouse' without using the words 'cat' or 'mouse'. Make sure that someone else would understand what you are trying to say.

Sorting and grouping the natural world

The natural world is made up of a huge number of different things: from stars to rocks, water, grass, animals and trees, just to name a few. To sort and group, or **classify**, all the things that we find in the natural world, we first need to determine whether they are **living** or **non-living**. But what does that mean? How do we define 'life'?

Living or non-living?

In Figure 2.3 you can see eight items from the natural world. Some of these are living and some are non-living.

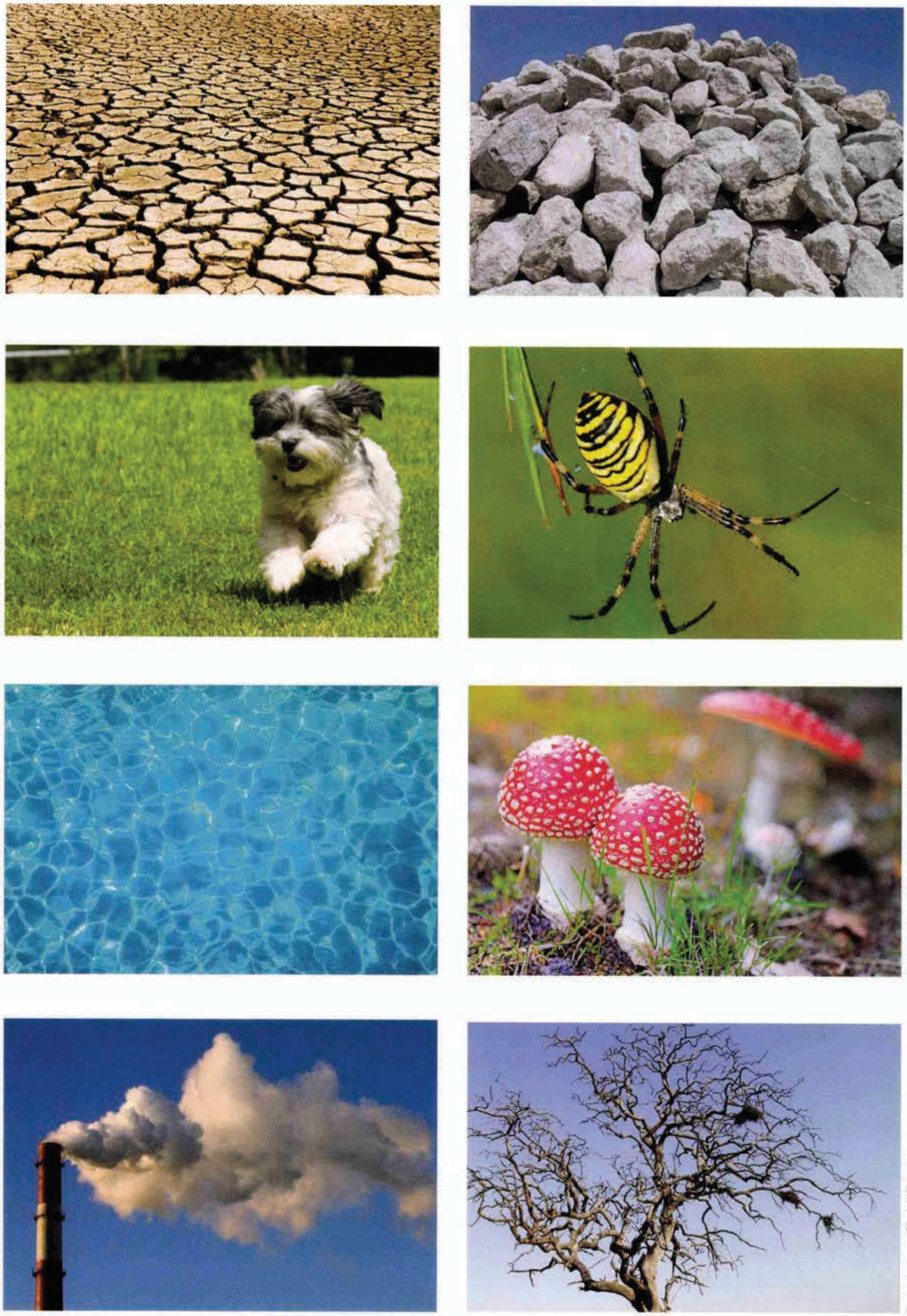


FIGURE 2.3 Which of these are living and which are non-living?

Go to http://mypsci1.nelsonnet.com.au and click on **Cytoplasmic streaming**. You will see cells from the freshwater plant *Elodea*. The moving objects are the chloroplasts inside the cell moving around in the cytoplasm. This is a sign that the cell is living.

Scientists use a list of criteria to work out if an object is living or non-living. If the answer to each criterion is 'Yes', the object is living. The criteria are as follows.

- Is it made up of one or more cells?
- Is it able to move? (This can be movement within the cell known as **cytoplasmic streaming**. See the adjacent weblink.)
- Does it respond to **stimuli**?
- Does it produce waste?
- Does it exchange gas with the environment?
- Does it need water?
- Does it need food in some form?
- Is it able to reproduce to make more individuals like itself?

Classifying the living world

In the second half of the 17th century, Antoni van Leeuwenhoek (1632–1723), a Dutch tradesman, began experimenting with lenses. He found that lenses could be used to **magnify** objects – make them look bigger. One of his discoveries was 'little animalcules' – or what we now know as **micro-organisms**. Up until this time, the existence of micro-organisms was unknown, so van Leeuwenhoek's discovery was met with a lot of doubt. It was not until 1680 that the Royal Society began to believe what he was saying. Van Leeuwenhoek continued observing and describing micro-organisms until his death.

Making the invisible visible

It is hard to believe, but a world-changing discovery was made because people didn't brush their teeth! On 17 September 1683, Antoni van Leeuwenhoek wrote a letter to the Royal Society in London describing 'a little white matter, which is as thick as if it were batter'. What he was describing was dental plaque – the white material that forms on your teeth if you don't brush them properly. Van Leeuwenhoek was studying plaque using a microscope he had made himself. He did not limit his investigations to his own teeth. He also looked at plaque from his wife, his daughter and 'two old men who had never cleaned their teeth in their life'.

Van Leeuwenhoek shared his observations with the Royal Society: 'I then most always saw, with great wonder, that in the said matter there were many very little living animalcules, very prettily a-moving. The biggest sort … had a very strong and swift motion, and shot through the water [most likely spit] like a fish does through water.'

What van Leeuwenhoek was describing were the **bacteria** that live in plaque and cause tooth decay. He was the first person to see these micro-organisms. This discovery opened up a new world of microscopic organisms to the scientists of the day.

Once they knew about this mini-world, inventors went to work, building more powerful microscopes to see these mysterious tiny organisms in more detail. Figure 2.4 shows an image of the bacteria that are present in plaque, taken with a more powerful microscope than the one that van Leeuwenhoek used.