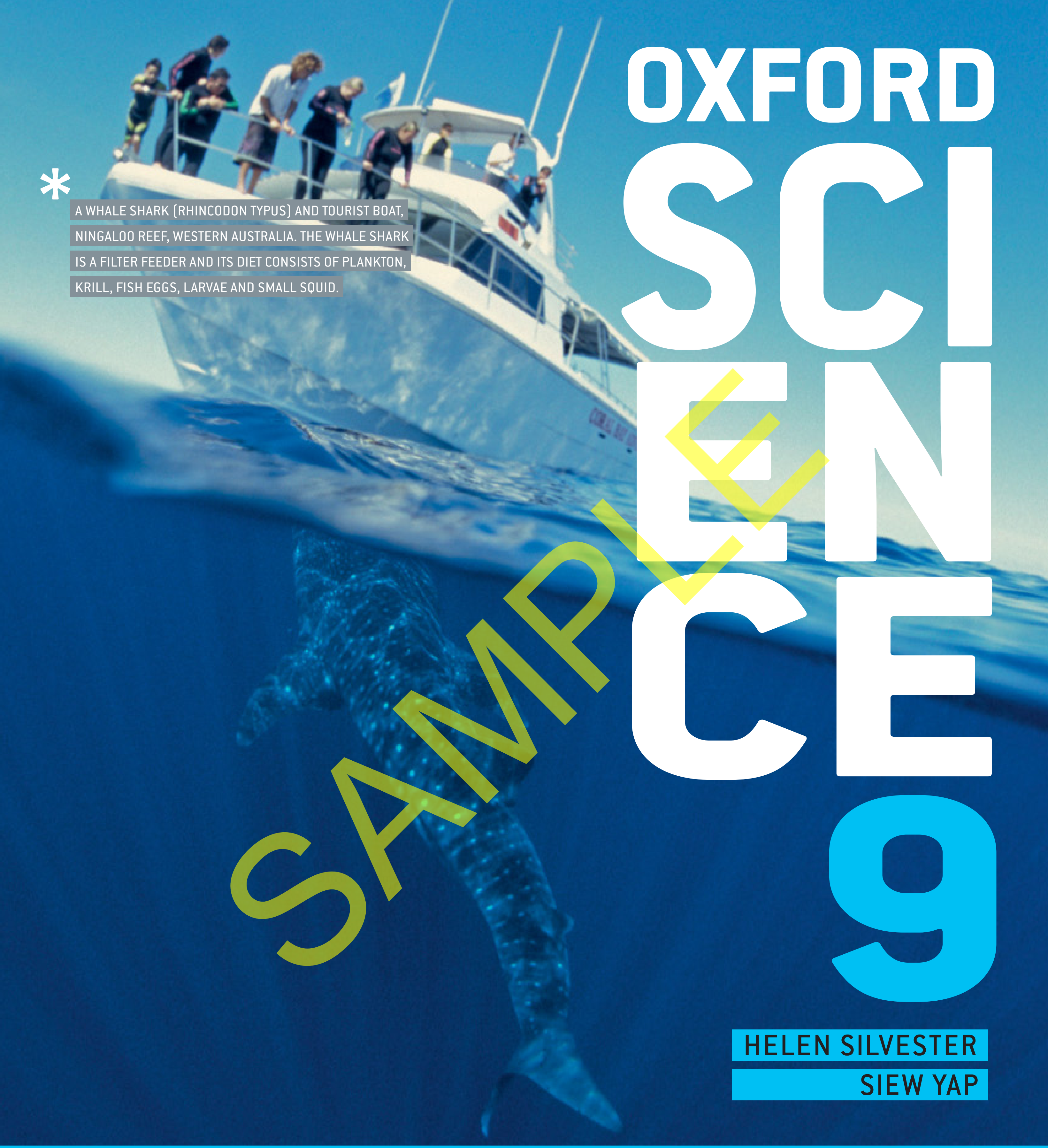

* A WHALE SHARK (RHINCODON TYPUS) AND TOURIST BOAT, NINGALOO REEF, WESTERN AUSTRALIA. THE WHALE SHARK IS A FILTER FEEDER AND ITS DIET CONSISTS OF PLANKTON, KRILL, FISH EGGS, LARVAE AND SMALL SQUID.

OXFORD SCIENCE 9

HELEN SILVESTER
SIEW YAP

WESTERN AUSTRALIAN CURRICULUM

OXFORD

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Science toolkit 1

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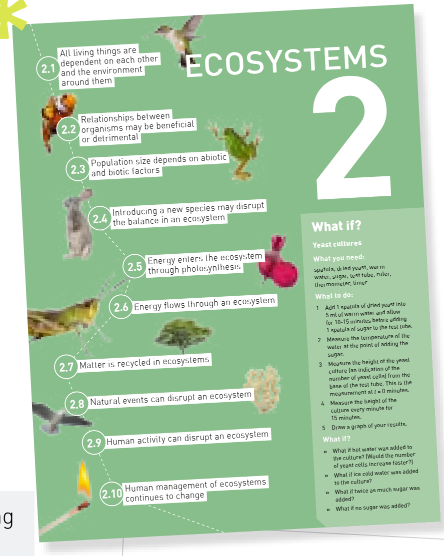
CONTENTS

Using Oxford Science

Oxford Science is a series developed to meet the requirements of the Western Australian Curriculum: Science across Years 7 to 10. Taking a concept development approach, each double-page spread of Oxford Science represents **one concept** and **one lesson**.



What if?

Student-directed inquiry is encouraged throughout this series using a simple questioning technique. As the series progresses, students discover that their own *What if* questions are actually testable '*if and then*' hypotheses. For example, 'What if *the bubble is touched with a finger*' becomes 'If *the bubble is touched with a finger*, then *it will pop*'.

Concept development

Students are given access to the chapter concepts at the start of every chapter. Each double-page spread of this series represents **one concept**. Students explore concepts one-by-one, encouraging incremental learning and, by the end of the chapter, complete understanding.

The unit heading introduces the concept.

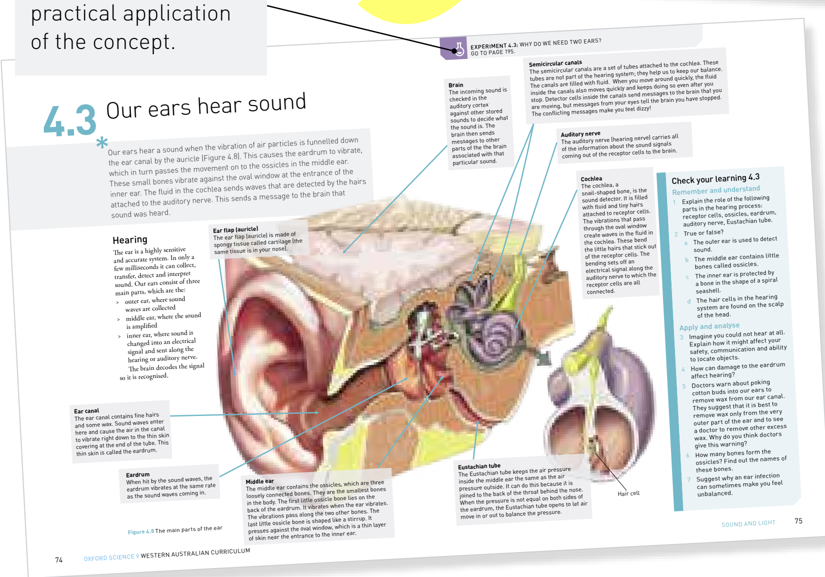
Each unit begins with a short summary of the concept.

Body text elaborates on the concept in clear and accessible language.

Every spread is linked to one or more experiment, challenge or skills task as a practical application of the concept.

Diagrams and photos are used to illustrate the concept and engage students.

Every double-page spread ends with **Check your learning** questions, allowing students to consolidate their understanding. Questions are graded according to Bloom's Taxonomy – catering for a range of abilities and learning styles.



Accessibility and engagement

Oxford Science has been engineered to be accessible to all science students. We believe that science students are served best when they are free to focus on learning the knowledge and skills of science in simple accessible language, crafted into short sentences. Students will be engaged by the inclusion of stunning photography throughout.

Science as a human endeavour

Concepts are linked to real-world applications in the highly engaging **Science as a human endeavour** spreads. The **Extend your understanding** questions on these spreads are designed to be used flexibly as either homework tasks or an extended project.

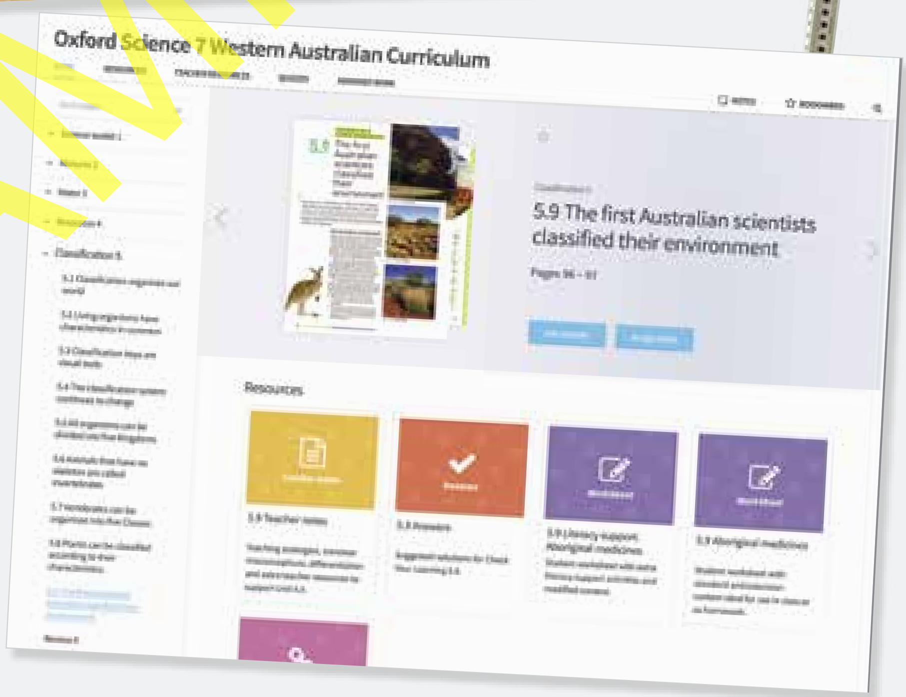
Experiments

Uniquely, experiments are organised at the end of the book in an extended experiments chapter, rather than being confined to each double-page spread. There is a link on most double-page spreads to an experiment, challenge or inquiry task to ensure that practical activites remain aligned to the content.

Integrated teaching and learning support

obook assess

obook assess provides an interactive electronic version of the student book in an easy-to-read format. It features multimedia links, interactive learning objects, videos, note-taking, highlighting and bookmarking tools, and live question blocks. **obook** is compatible with laptops, iPads, tablets and IWBs, and also offers page view (in flipbook format) that can be used offline. **assess** provides 24/7 online assessment designed to support student progression and understanding.



DASHBOARD

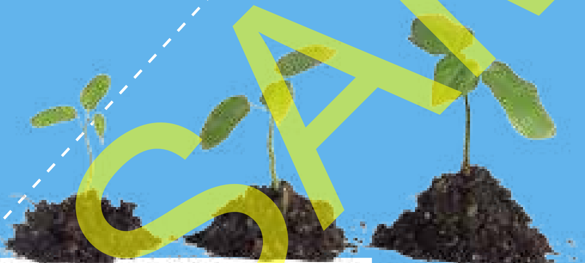
Oxford Science is supported by teaching strategies, lesson ideas, planning tips, assessment advice and answers to all activities. **obook assess** allows teachers to manage their classes by assigning work, tracking progress and planning assessment. Teacher Dashboard is your online lesson control centre, which allows you to instantly preview or assign related teacher resources to deliver incredibly engaging digital learning experiences. Students can also toggle from their **obook** to the Dashboard to interact with student resources for each topic.

SCIENCE TOOLKIT 1

1.1 Scientists can test manufacturers' claims

1.2 Scientists must be aware of experimental errors

1.3 Scientists prepare Safety Data Sheets



1.4 Scientists present their data accurately

1.5 Scientists investigate consumer products

What if?

Staples

What you need:

10 sheets of A4 paper, a variety of staplers with staples

What to do:

1 Fold an A4 sheet of paper in two.
2 Staple the two sheets of paper together with one of the staplers.
3 Add another sheet of paper to the folded paper so that there are now three sheets over the top of each other.
4 Staple all the sheets together with the same stapler.
5 Repeat steps 3 and 4 until the staple is unable to penetrate all the sheets of paper effectively.

What if?

» What if another stapler was used?
» What if another brand of staples was used?
» What if different paper was used?

1.1 Scientists can test manufacturers' claims

No matter what you buy – toilet paper, a smartphone or a bottle of water – you are being a consumer. As a consumer you make choices and you expect certain things from the products you buy. Consumer science is a branch of science that involves applying the scientific method to the claims made by manufacturers.

Figure 1.1 Ribena was found to contain less vitamin C than its competition, despite the manufacturer's claims.

Consumer science case study

Several years ago, two New Zealand science students, Jenny Suo and Anna Devathasan, exposed a startling fact about the fruit juice drink Ribena while performing research for their school's science fair. Jenny and Anna decided to compare the vitamin C content of different fruit juice drinks to see if the manufacturer's claims on the labels were correct. The label on Ribena, which contains blackcurrant juice, implied that it had a much higher vitamin C content than the other fruit juice drinks they tested. It said: 'The blackcurrants in Ribena contain four times the vitamin C of oranges'. The students therefore predicted that Ribena would have four times the vitamin C content of orange fruit juice drinks.

Jenny and Anna then analysed the vitamin C content of Ribena and several other fruit juice drinks, using the scientific method. They ensured that their tests were fair and objective. The only difference between the drinks during their tests was the brands. Jenny and Anna performed three trials to ensure the accuracy of their results. After each trial, they re-examined their data.

The students were surprised to find that the vitamin C content of Ribena was far lower than most other brands. But because they had followed the scientific method, they were confident that their results were reliable. For this reason they contacted the manufacturer about the misleading labelling and advertising. When no response was received, they brought their case to a national consumer affairs program.

After their case was broadcast, and after further testing of Ribena, the New Zealand Commerce Commission brought 15 charges against the manufacturer under the Fair Trading Act.

The scientific method at work

Jenny and Anna were sure of their results because they followed the scientific method.

Hypothesis

The scientific method involves developing a plan to test a theory or hypothesis that arises as a result of a 'what if' question. For Jenny and Anna, this question was:

'*What if* the vitamin C content of Ribena was compared with other fruit juice drinks'.

This then became a hypothesis using the words 'if' and 'then':

'*If* the vitamin C content of Ribena was compared with other fruit juice drinks, *then* Ribena will have more vitamin C/mL.'

Figure 1.2 Anna Devathasan and Jenny Suo

EXPERIMENT 1.1: WHAT IF THE ABSORBENCY OF DIFFERENT PAPER TOWELS WAS COMPARED?
GO TO PAGE 178.

A hypothesis should be based on some underlying suspicion, prediction or idea that is based on previous observations. It must be very specific so that it can be tested.

Variables

A hypothesis should be tested in an objective way. For example, for a fair comparison of the fruit juice drinks, Jenny and Anna needed to design an experiment that identified all the **variables** that would be operating. The variables in an experiment are the factors that will affect the results in some way. These could include the volume of the fruit juice drinks tested, the age and temperature of the fruit juice drinks and the quality of the chemicals used in the testing.

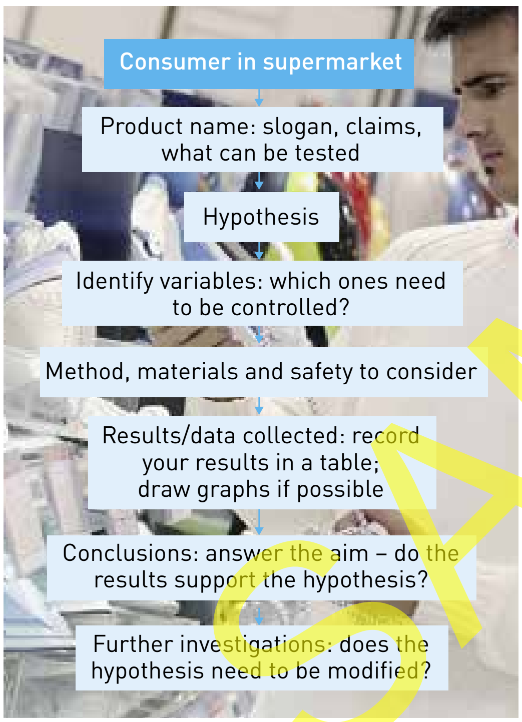


Figure 1.3 Using the scientific method to test manufacturers' claims

To test the hypothesis, all of the variables should be controlled except for the one being tested. This is known as the **independent variable** and in Jenny and Anna's case it was the brand of the fruit juice drink being tested. The variable being measured is the **dependent variable**, such as amount of vitamin C in a fruit juice drink.

Method

In this section, a scientist describes the materials and equipment they used, including the concentrations and brands they tested. Diagrams are also useful to illustrate the steps taken. Remember to label all equipment in the diagram and to give the diagram a title.

The number of times you repeat an entire experiment is referred to as repetition. The greater the number of times an experiment is repeated and the results are averaged, the more likely it is that the results are reliable.

The **sample size** refers to the number of subjects being tested or used in the experiment. The greater the sample size, the more reliable the results will be and the stronger the evidence available to support the conclusion.

Results

The observations, or data, that you make during your experiment are written down as the results. All observations should be what you *actually* see and not what you *expect* to see. Data can be organised into a table format and a graph to make it easier to understand.

Conclusion

A conclusion should answer the initial question asked about the experiment. It should provide evidence that supports or refutes the hypothesis. Any further investigations that may need to be done can be outlined here.

Check your learning 1.1

Remember and understand

1 What is a hypothesis? Give one example.
2 Why should an experiment have a clear and detailed method?
3 Does an increased sample size give greater validity to an experiment? Give reasons for your answer.
4 If your hypothesis is shown to be wrong, was your experiment still useful? Justify your answer.
5 Often scientists have to present their findings to the public in order to get action taken. Sometimes this is very difficult, so they need to be quite sure that their findings are reliable. Explain how the scientific method ensures that the findings are reliable.

1.2 Scientists must be aware of experimental errors

In scientific investigation, measurements can only show that a hypothesis is correct if the measurements are accurate. To achieve maximum accuracy, the measurement must be carefully taken with the most suitable measuring device. This device must have a scale appropriate to the accuracy that you require.

Figure 1.4 A burette is a laboratory instrument used to accurately measure the volumes of liquids.

Choosing the right device

Choosing the right instrument is the first step in achieving accuracy. For example, if you need to accurately measure the volume of a liquid, then you would use a burette or a measuring cylinder, and certainly not a beaker. A burette has a more accurate scale than a measuring cylinder. A beaker has no scale.

Errors and accuracy

Choosing the right instrument is only part of the job a scientist must do. It is very important to take care with your measurements. The most common errors in measurement are parallax errors, zero errors and reading errors.

A **reading error** can result when guesswork is involved when taking a reading. For example, when a reading lies between the divisions on scale, a guess of the actual reading will result in a reading error (Figure 1.5).

A **parallax error** occurs when the eye is not placed directly opposite the scale when the reading is being taken. You can avoid parallax errors by ensuring that your eye is placed in the correct position when taking the reading. For example, when reading the level of a liquid in a measuring cylinder, place the cylinder on the bench and line up your eye with the bottom of the meniscus (Figure 1.6).

A **zero error** happens when an instrument has not been correctly adjusted to zero or the reading has not taken into account the weight of empty containers. For example, scales must be set to zero correctly before making a weight measurement of substances (Figure 1.7).

Scientists will often repeat measurements and then find an average measurement to improve their accuracy.

Mathematical accuracy

When conducting a scientific investigation, mathematical accuracy is very important. Not only must your equipment be appropriate and precise to avoid errors, but your calculations must also be mathematically accurate. When taking a reading, you should quote the maximum allowed number of **significant figures**. This can represent the accuracy of a measurement or reading. When results are recorded, it is important to know the number of significant figures the instrument allows. The final answer can only be quoted correct to the number of significant figures present in the least accurate result. For example, if one measuring device measures to 0.22 and a second device measures to 0.345, the final answer should only have two figures after the decimal point. This might require a **rounding off** procedure.

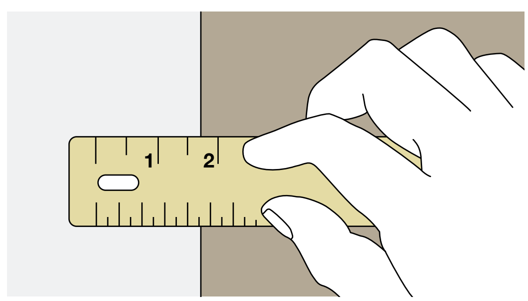


Figure 1.5 Guessing the measurement between units of measurement (for example, between 1.5 and 2) can produce a reading error.

Measurements and units

Scientists measure fundamental quantities, such as mass, time and length, in a standard unit that has been agreed upon by scientists

CHALLENGE 1.2: AVOIDING ERRORS AND IMPROVING ACCURACY
GO TO PAGE 179.

across the world. The international system of units, known as the **SI system** of units, is based on the metric system. Table 1.1 shows some SI units. Other measurements, such as volume, are calculated from those basic units and so are termed **derived units**.

Although the SI unit for mass is the kilogram, this is not always the most suitable unit to use. Some objects are too heavy or too light for this to be the most convenient unit. The measurement would have too many zeroes in it. For example, masses of 0.000 000 007 43 kg or 850 000 000 kg are very inconvenient to write. So, scientists and mathematicians choose a unit that requires as few zeroes as possible. They denote this by using a system of prefixes before the basic measurement unit, shown in Table 1.2.

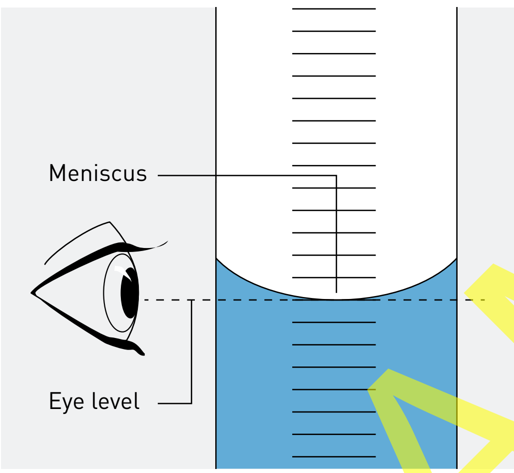


Figure 1.6 To avoid parallax error, make sure your eye is correctly lined up with the bottom of the meniscus.

Table 1.1 SI units

PHYSICAL QUANTITY	SI UNIT	ABBREVIATION OR SYMBOL
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Thermodynamic temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A

Notice that when the number is larger than the basic measurement, the prefix is a capital letter. When it is only a fraction of the basic measurement, the prefix is a small (i.e. lower case) letter. For example, a megalitre, which is a million litres, is written as ML, while a millilitre, which is one-thousandth of a litre, is written as mL. Kilograms is an exception to this general rule. A kilogram is 1000 grams and its symbol is kg.

Figure 1.7 Scales must be zeroed correctly before weighing yourself.

Table 1.2 Standard prefixes and meanings

NAME	SYMBOL	VALUE	MEANING
peta	P	10^{15}	One thousand million million
tera	T	10^{12}	One thousand million
giga	G	10^{9}	One billion
mega	M	10^{6}	One million
kilo	k	10^{3}	One thousand
centi	c	10^{-2}	One-hundredth
milli	m	10^{-3}	One-thousandth
micro	μ	10^{-6}	One-millionth
nano	n	10^{-9}	One-billionth
pico	p	10^{-12}	One-millionth of one million

Check your learning 1.2

Remember and understand

1. List three kinds of errors that can occur during an experiment.
2. How can these errors be reduced to improve accuracy?
3. Why do scientists often repeat experiments and then take an average?
4. What symbol would you write for:
   a. millionths of a gram?
   b. billions of litres?
   c. thousandths of an ampere?
   d. thousands of metres?

Apply and analyse

5. State the number of significant figures in each of the following measurements.
   a. 45.22 mL
   b. 9.0 s
   c. 8000 L
   d. 3.005 m
6. A student took the following measurements for an experiment:
   5.6 volts, 2.97 amperes, 3000 seconds
   To how many significant figures should the final answer be stated? Justify your answer.

1.3 Scientists prepare Safety Data Sheets

A Safety Data Sheet (SDS) is an important tool for maintaining safety in a science laboratory. It contains information about a chemical such as its various names, the dangers involved in its use and the precautions scientists should take when handling the chemical. SDSs should be prepared for all the reactants used and the products produced during science experiments.

SAFETY DATA SHEET
Sodium chloride: Hazardous chemical

Section 1 - Chemical Product and Company Identification	
SDS name:	Sodium chloride
Synonyms:	Common salt; Halite; Rock salt; Saline; Salt; Sea salt; Table salt.
Company identification:	Chemical company
Section 2 - Hazards Identification	
Eye and skin:	May cause eye irritation.
Ingestion:	Ingestion of large amounts may cause gastrointestinal irritation. Ingestion of large amounts may cause nausea and vomiting, rigidity or convulsions.
Inhalation:	May cause respiratory tract irritation.
Section 3 - Handling and Storage	
Handling:	Use with adequate ventilation. Minimise dust generation and accumulation. Avoid contact with eyes, skin, and clothing. Keep container tightly closed. Store in a cool, dry, well-ventilated area away from incompatible substances. Store protected from moisture.
Section 4 - Exposure Controls, Personal Protection	
Engineering controls:	Good general ventilation should be used.
Personal protective equipment	
Eyes:	Wear safety glasses with side shields.
Skin:	Wear appropriate gloves to prevent skin exposure.
Clothing:	Wear appropriate protective clothing to minimise contact with skin.
Section 5 - First Aid Measures	
Eyes:	Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid.
Skin:	Flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists. Wash clothing before reuse.
Ingestion:	If victim is conscious and alert, give 2-4 cupsful water. Get medical aid. Wash mouth out with water.
Inhalation:	Remove from exposure to fresh air immediately. If breathing is difficult, give oxygen. Get medical aid if cough or other symptoms appear.
Section 6 - Physical and Chemical Properties	
Physical state:	Solid
Appearance:	Colourless or white
Odour:	Odourless
Boiling point:	1413 deg C
Freezing/melting point:	801 deg C
Solubility:	Soluble
Specific gravity/density:	2.165
Molecular formula:	NaCl
Molecular weight:	58
Section 7 - Accidental Release Measures	
Spills/leaks:	Vacuum or sweep up material and place into a suitable disposal container. Clean up spills immediately, observing precautions in the Protective Equipment section. Avoid generating dusty conditions. Provide ventilation.
Section 8 - Fire Fighting Measures	
General information:	Water runoff can cause environmental damage. Collect water used to fight fire. Wear appropriate protective clothing to prevent contact with skin and eyes. Wear a self-contained breathing apparatus (SCBA) to prevent contact with thermal decomposition products. Substance is noncombustible.

Figure 1.8 Example of an SDS from a manufacturer or certified provider

Anticipate, recognise and eliminate

Scientists work with many hazardous materials when completing experiments. As a result, they need to be aware of anything that might affect their health or safety in the laboratory. The laboratory is a safe place provided hazards are:

> anticipated
> recognised
> eliminated or controlled.

A Safety Data Sheet (SDS) provides scientists and emergency personnel with information on how to use a particular substance. An SDS also helps scientists understand more about how the chemical is used during the experiment.

Figure 1.9 Emergency workers in sealed positive pressure protective suits communicating with each other

SAFETY DATA SHEETS

The information on a Safety Data Sheet includes the following.

- **The various names of the chemical** includes its chemical name and its common generic name, its concentration and structure. For example, DL-threo-2-(methylamino)-1-phenylpropan-1-ol is also called pseudoephedrine or Sudafed.
- **The contact details of the manufacturer**
- **The hazard level of the chemical** All chemicals should contain labels relating to their particular dangers. This may include their flammability, corrosive ability, toxicity and ability to cause long-term damage such as cancers. The risks can be shown using descriptions or the symbols on the right.
- **Usage instructions and restrictions** Some chemicals may form a dust that can explode. For example, workers in flour mills need to be especially aware of flour dust.
- **Protective measures** The SDS should contain information on the eye and face protection needed, the type of gloves or skin protection required and the possible need for masks.
- **The physical and chemical properties of the chemical** Everyone in a laboratory should be able to easily identify the chemical. The SDS should include the colour, smell, pH, flammability, solubility, melting and boiling points of the chemical.
- **What to do in the case of a spill (in the laboratory or the environment)**

Figure 1.10 SDSs are used in many industries, including the mining industry.

This includes first aid measures, any antidotes, symptoms that might result from exposure and whether personal protective equipment (PPE) is recommended for first aiders. Advice may be needed on how to cover drains to prevent the chemical making its way into groundwater.

- **Fire-fighting measures** Some chemicals produce toxic fumes or are highly flammable. Other chemicals become more dangerous if they are exposed to water. Firefighters may need special equipment.
- **How to dispose of the chemical safely** This section should include what disposal containers should be used, the effects of sewage disposal and the special precautions that may be needed to ensure safety for both individuals and the environment.
- **How to transport the chemical** Information should include any special precautions for transporting this chemical. This may include the Hazchem code (the code provided by the government for each class of chemical).
- **An Australian telephone number of the Office of Chemical Safety**
- **The date the SDS was last reviewed**

Check your learning 1.3

Remember and understand

1. What does SDS stand for?
2. Why is it important to prepare an SDS before starting an experiment?
3. Why is it important to have all the various names of a chemical on the SDS?
4. What type of personal protective equipment do you have in your laboratory?
5. What is the phone number of the Office of Chemical Safety in your state?

1.4 Scientists present their data accurately

The results section is often the most important part of an experiment report. It must present an accurate picture of the findings. Outliers are values that are very different from the main group of data. Outliers can affect the mean (average) of the overall results. The median (middle number of data when placed in increasing order) or the mode (most common result) is less affected by outliers. Positive correlation of data does not mean one event caused another event.

Outliers

Occasionally the data that scientists collect contains a value that is far away from the main group of data. These values are called **outliers** and may be due to inaccurate measurements or experimental errors.

For example, an outlier may occur when measuring the height of seedlings after 3 weeks of growth.

Table 1.3 Seeding growth

SEEDLING NUMBER	HEIGHT (cm)
1	3.6
2	4.0
3	4.1
4	4.0
5	0.1
6	3.5
7	4.3

All seedlings except seedling 5 grew between 3.5 and 4.3 cm. The average (or mean) growth of the seedlings (including seedling 5) was 3.3 cm. This average is well below the growth of any of the seedlings other than seedling 5. This shows how one outlier can present an artificial result of the seedling growth.

If the average is determined without using seedling 5, the average becomes 3.9 cm. This is a closer representation of the actual growth. However, is it fair to discard any results that we don't like?

Are the results 'pure' if some are left out? For this reason, an outlier is only excluded if it is explained how the results are modified and the reason for doing so. For example, the discussion might include the statement that 'Seedling 5 was excluded from the analysis due to a fungal infection that affected its growth'.

Median

The median is the middle value of the data after all numbers have been placed in increasing order. For the previous data, this means:

0.1, 3.5, 3.6, 4.0, 4.0, 4.1, 4.3

↑

Median

The median amount the seedling grew was 4.0 cm. If the outlier is removed, the median growth is still 4.0 cm. So the median value of the data is not affected as much by outliers as the mean/average.

Mode

The mode is the most common number in the set of data. In our set of data, the number 4.0 occurs twice (seedlings 2 and 4).

This means the mode, or most common amount the seedlings grew, was 4.0 cm. If the outlier was removed, the mode of the seedling growth would still be 4.0 cm. An outlier does not affect the mode value.

Correlation of data

When two sets of data are strongly linked (as one changes, the other changes a similar amount), the data has a strong correlation. When both values increase at the same rate, it is called a positive correlation. If one value increases as the other decreases, then it has a negative correlation. This can be shown on a graph.

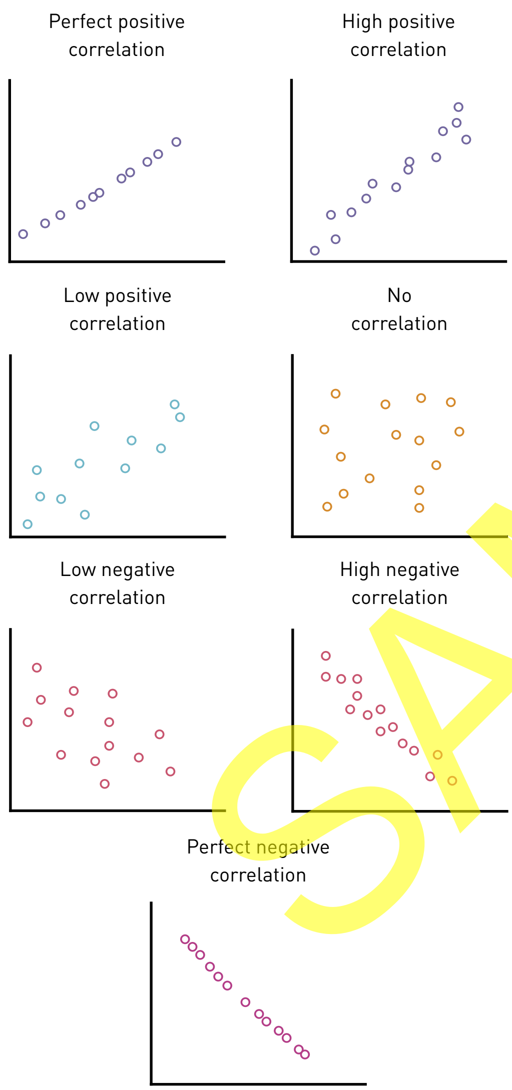


Figure 1.11 Correlation of data

Check your learning 1.4

Remember and understand

1. Why is it best to present your data in table form?
2. What is an outlier? Should an outlier be included? Give reasons for your answer.
3. What is meant by the:
   a. mean?
   b. median?
   c. mode?

Apply and analyse

4. Draw a graph of the following set of data.

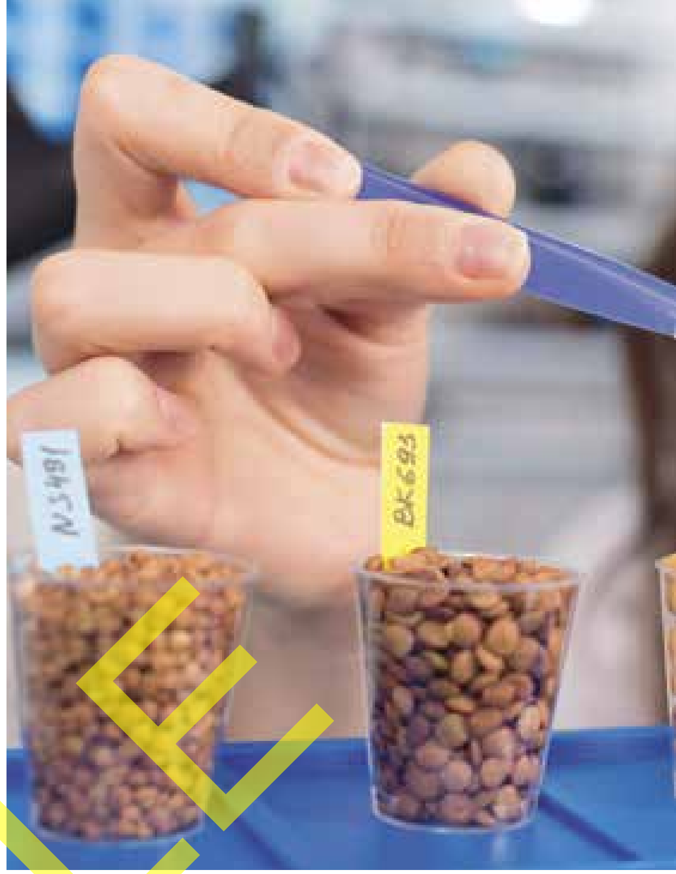
Ice-cream sales vs temperature

TEMPERATURE (°C)	SALES ($)
14.2	215
16.4	325
11.9	185
15.2	332
18.5	406
22.1	522
19.4	412
25.1	614
23.4	544
18.1	421
22.6	445
17.2	408

   a. Is there any correlation between the daily temperature and ice-cream sales?
   b. Could you say that the daily temperature has an effect on the number of ice creams sold that day?
   c. What would you expect to happen to ice-cream sales if the daily temperature was to increase to 40°C?

//SCIENCE AS A HUMAN ENDEAVOUR//

1.5 Scientists investigate consumer products



Working in groups of two or three, design an experiment to investigate an everyday consumer product. Your aim will be to practise using the scientific method. You will need to ensure that you follow the scientific method.

Think

Choose a consumer product to investigate and discuss what you already know about the product. Identify any claims or slogans that may be tested. Then design an experiment to investigate these claims or slogans, following the scientific method.

You will need to research the product thoroughly. This may mean visiting a supermarket and comparing prices and packaging of different brands, as well as searching the Internet, journals, books and encyclopaedias to identify the science behind your product.

Ideas

Here are some ideas for your investigation.

> Do all brands of bubble gum make the same size bubble?
> Do all washing detergents produce the same amount of bubbles and clean the same number of dishes?
> How permanent are permanent markers? What solvents (for example, water, alcohol, vinegar, detergent solution) will remove the ink? Do different brands/types of markers produce the same result?
> Do consumers prefer bleached paper products or natural coloured paper products? Why?
> Is laundry detergent as effective if you use less than the recommended amount? What if you used more than the recommended amount?
> Is bottled water more pure than tap water? How does distilled water compare with drinking water?
> How does the pH of juice change with time? How does temperature affect the rate of this chemical change?
> Do all hairsprays hold equally well? And equally long? Does the type of hair affect the results?
> Do all nail polishes dry at the same rate?
> Do some lipsticks stay on longer?
> How absorbent are nappies?
> Do all batteries have the same battery life?
> How long can the life of cut flowers be prolonged?

Evaluate

As a class, discuss each experiment design by answering the following questions.

> Does the design follow the scientific method?
> Are there any steps that require more scientific information to be supplied?
> Have all the safety considerations been taken into account?
> What changes could be made to improve the design?

Planning for errors

Before you carry out your consumer science challenge, you will need to think about reducing your errors and improving your accuracy.

> What variables will you need to control to ensure a fair test?

> How will you make sure your data is accurate and free of errors?

> What type of equipment will you be using? Is this the most appropriate equipment?

> How will you reduce parallax, reading and zero errors with your data measurements?

> What other factors could introduce errors into your investigation? How will you minimise these?

Presenting your results

Once you have completed your consumer science investigation, you will need to analyse your data appropriately.

> Are there any outliers? Can you explain these?

> What methods of data presentation will you use and why?

> What method will you use to describe your results? Mean, median or mode?

> Are there any correlations between the sets of data in your results? Does this imply causation?

> Does the conclusion provide evidence that supports or refutes the hypothesis?

You will also need to complete a presentation about your investigation. This could be done as a web page, a PowerPoint presentation, an advertisement, a video, or an article for *Choice* magazine, comparing your findings with the manufacturers' claims. Present your findings to the class.

*REVIEW

1

Remember and understand

1 List the main steps used when conducting an experimental investigation by the scientific method.

2 What is a variable?

3 Why are consumer scientists interested in what can be observed and tested rather than in the slogans and claims of manufacturers?

4 How do scientists find out about the safety risks involved in an experiment they are planning?

5 Suppose you are conducting a fair experiment in which you have identified six variables. How can you be sure of the effect of one particular variable?

6 Why aren't beakers used to measure volumes?

7 What is the difference between instrumental error and parallax error?

8 What is an SI unit?

9 State the SI unit for:

a time

b mass

c length.

10 What do the following prefixes for a quantity mean?

a mega

b micro

c kilo

11 Explain why scientists have developed an internationally agreed system of units.

Apply and analyse

12 A consumer scientist wanted to test the effect of a lotion for treating acne. At first she tested the lotion on a group of 20 teenagers, all aged 15, but then she decided to conduct some more tests. So she then tested 100 teenagers, all aged 15.

a Is this an example of experimental repetition or increasing the sample size?

b Which result is likely to lead to the most reliable conclusion? Justify your answer.

13 A scientist was commissioned by a jeans manufacturer to test various denims. The manufacturer wanted a more durable fabric than the one they were currently using. How might the scientist test a fabric for durability in a fair and objective way? Why is this important?

14 State the number of significant figures in each of the following measurements.

a 65.301 g

b 0.006 420 kg

c 40 L

15 Determine the mean, median and mode of the following set of data:

15, 13, 18, 16, 14, 17, 12, 14, 19

16 A lipstick manufacturer claims that their brand of high-gloss lipstick will stay on for at least 6 hours, even during eating and drinking. Design an experiment based on the scientific method to test this claim. First state your hypothesis. Identify the variables you will be considering. What measurements will you take and how will you ensure that they are accurate?

17 For the experiment you designed in question 16, outline the results you would expect to obtain if your stated hypothesis was correct.

Evaluate and create

18 For the experiment you designed in question 16, assess how accurate your results may be, and suggest what further investigation you could take to improve the reliability of your conclusion.

19 For the experiment you designed in question 16, if you found that the manufacturer's claim was correct, create a scientifically accurate slogan or advertisement for the lipstick based on your findings.

20 One source of information for consumers is *Choice* magazine. The magazine reports the results of testing a variety of brands of consumer products. If a consumer scientist was reading a report on the safety of children's pyjamas, what evidence might they look for to see if the report was fair and objective? If they conclude that it is, how might the public be convinced to read such reports before purchasing children's pyjamas?

Research

21 Choose one of the following topics for a research project. Some questions have been included to help you begin your research. Present your findings in a format of your choosing.

> **Mobile phone safety**

Research is continuing into the safety of mobile phones, although most people in the Western world have one or use one. You are an advisor to the minister of communications and technology. Produce a report, of at least 10 points, detailing any research that has taken place into mobile phone safety. Make sure to include the outcomes or conclusions reached in any of these studies.

> **Bottled water**

Many people in Australia spend a lot of money on bottled drinking water. Are they doing this because of the way the water is marketed or are there scientifically supported health benefits in drinking bottled water rather than tap water? Is tap water unsafe to drink? Have there been any cases where water bottlers have been fraudulent in their claims about the water they are selling? Investigate this issue. Find out what dentists and medical experts say about bottled water. What scientific tests are performed to check that the claims are correct and what results have been obtained? After researching and comparing a range of evidence, what is your conclusion? Should we drink bottled water here in Australia and not tap water? Or does this depend on where you live?

> **Artificial colourings and flavourings in foods**

Some people claim that certain artificial colourings and flavourings in foods can cause problems, such as hyperactivity in children. Use the Internet and other resources to investigate this issue. What is the meaning of the term 'opposing evidence'? Are there warnings based on anecdotal evidence or scientific evidence? Can anecdotal evidence be of value to scientists? Discuss.

*KEY WORDS

1

dependent variable
the variable being tested in an experiment

derived units
units of measurement that are calculated from the international system of units; for example, volume (cm^3) and area (cm^2)

independent variable
the variable that is deliberately changed or tested during an experiment

outlier
a value that is outside the normal range of all other results

parallax error
an error that occurs when the reader's eye is not placed directly above a mark

reading error
an error that occurs when markings on a scale are not read correctly

rounding off
reducing the number of significant figures by increasing or decreasing to the nearest significant figure; for example, 7.6 cm is rounded up to 8 cm, 7.2 cm is rounded down to 7 cm

sample size
the number of subjects being tested or used in an experiment

SI system
international system of units based on the metric system; for example, kilogram, metre, kilometre

significant figures
the number of digits in a number that contribute to its overall value

variable
anything that can change the outcome or result of an experiment

zero error
an error that occurs when an instrument has not been adjusted to zero before the measurement was taken