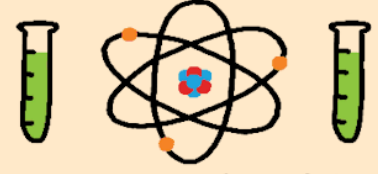
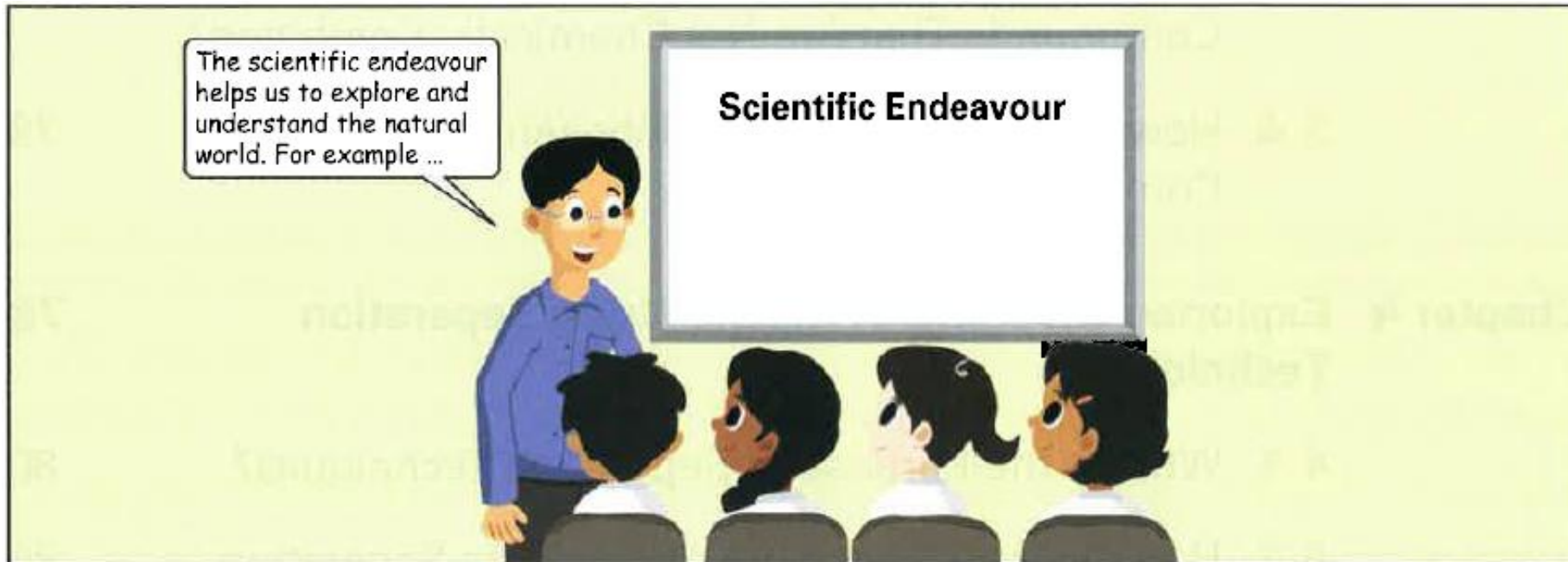


1

THE SCIENTIFIC ENDEAVOUR

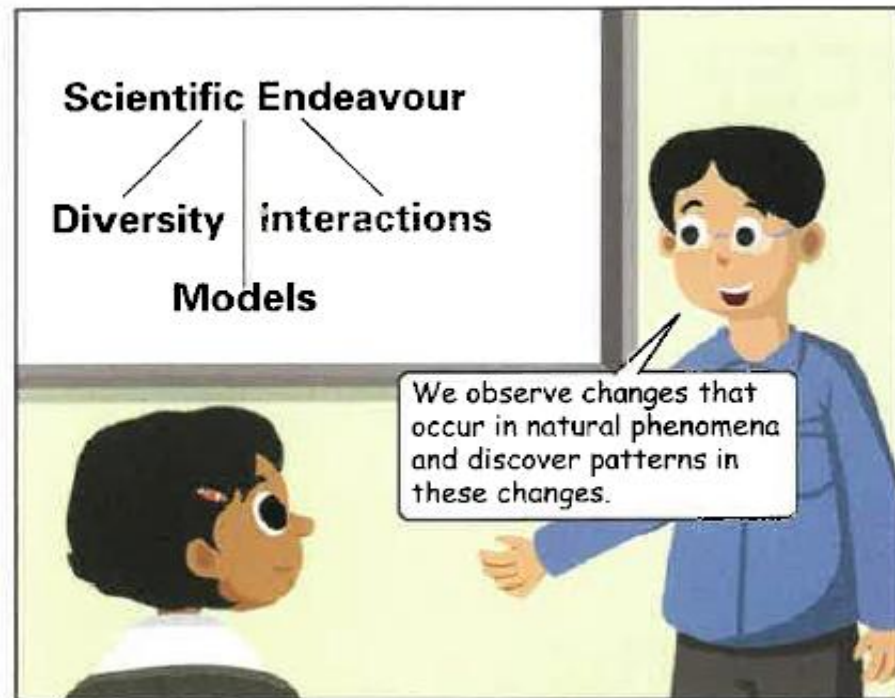
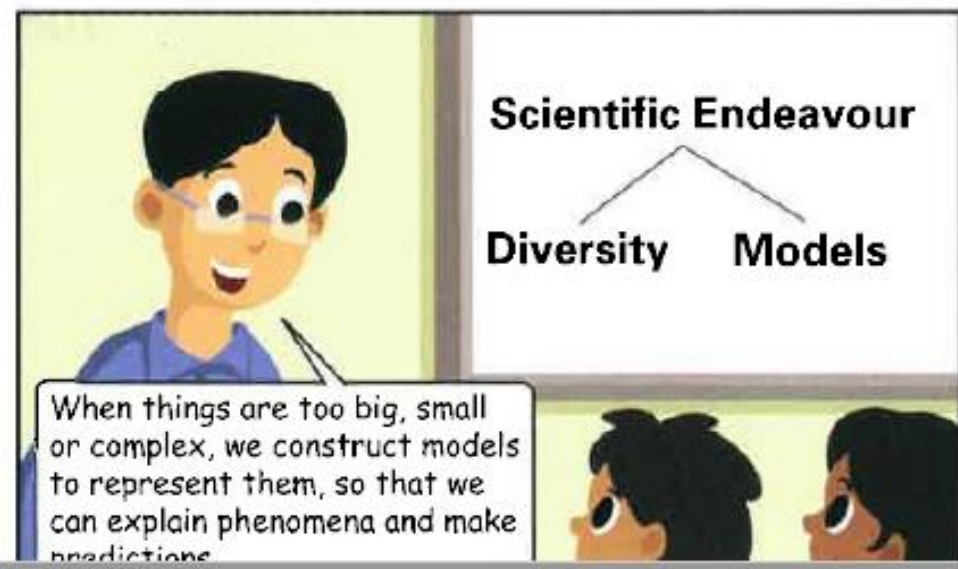
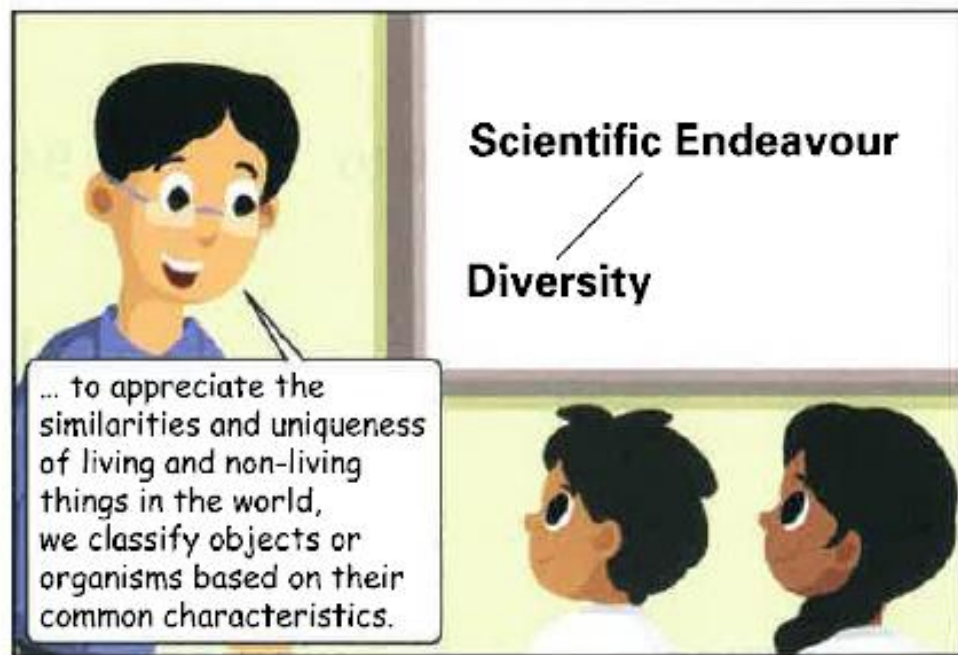
SCIENCE

IT'S LIKE
⚡MAGIC⚡
BUT REAL

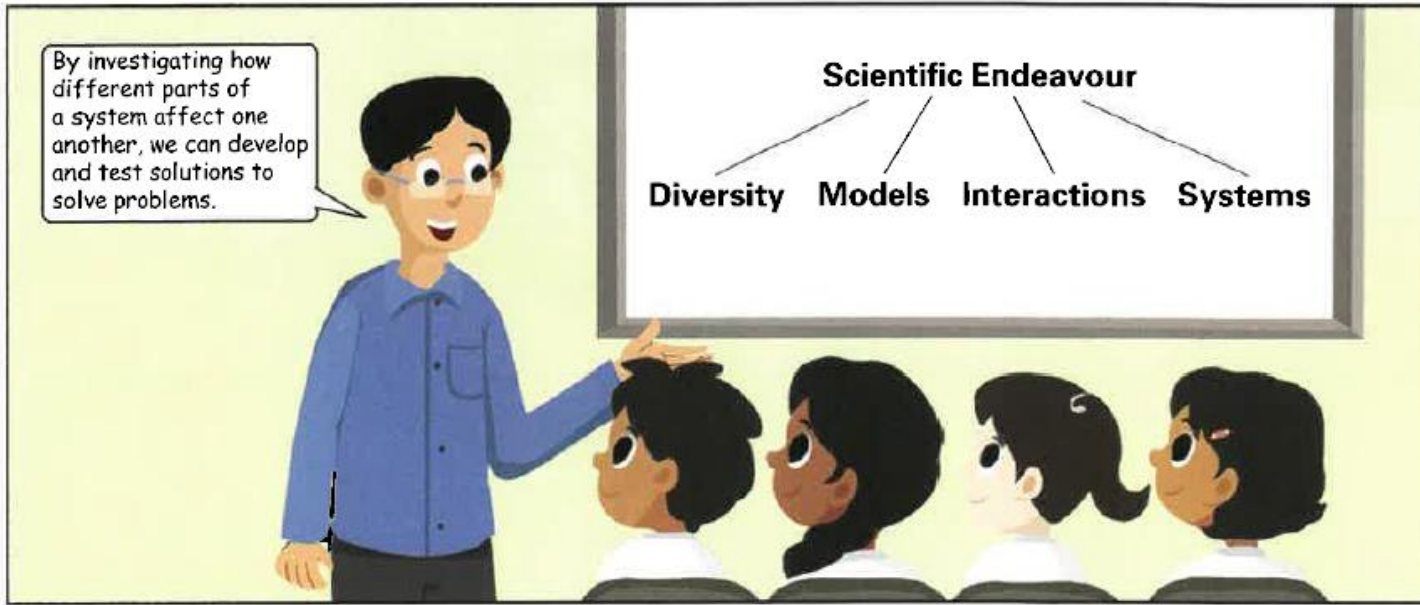


Being in charge of our own learning...

- Key words will be underlined or under coloured highlight
- Please either fill in the blanks using your pen or highlight the important points.
- Look out for the **copy** icon!







As the world changes, scientists are constantly reviewing how to answer the questions about the world and improve lives by applying scientific solutions to problems.



What are we going to learn?

- 1.1 What is Science?
- 1.2 What is the nature of scientific knowledge?
- 1.3 How do we practice science?
- 1.4 What influences the way we practice science?
- 1.5 Why do we learn science?



1.1 What is Science?

Success Criteria: I am able to	UR				
☐ state examples of where science appears in our lives	1	2	3	4	5
☐ state that science is the study of natural phenomena in the world	1	2	3	4	5
☐ appreciate that Science is a human endeavour, with scientific knowledge contributed by different civilisations over time	1	2	3	4	5

- Science is the study of natural phenomena in the world.
- Science is everywhere!
- Being curious and asking questions will enable us to learn and understand more about the world around us.



History of Diabetes

TB Pg. 4-5

An example is the study of diabetes, a condition in which the human body cannot regulate its blood sugar level. From the discovery of diabetes to its treatment, our knowledge of diabetes is still subject to change in light of new evidence (Figure 1.1).

▼ **Figure 1.1** Contributions of different individuals towards understanding diabetes

1500 BC to 8th century

The symptoms of diabetes were observed and recorded in ancient Egyptian, Indian, Chinese and Arabic civilisations. These symptoms included frequent urination, fatigue and excessive thirst.



◀ **Figure 1.1b** Aretaeus



▲ **Figure 1.1a**
Fatigue and
excessive thirst are
some symptoms of
diabetes that have
been recorded
across civilisations.

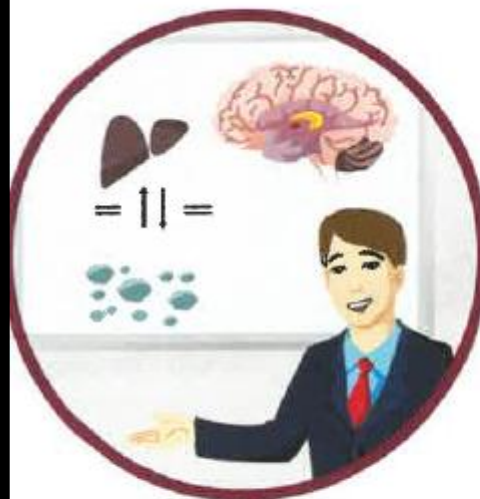


150 AD

The Greek physician Aretaeus coined the term "diabetes", which means "siphon" or "passing through", to describe the excessive urine passed by diabetic patients.

18th century

An English physician demonstrated the presence of sugar in the urine of diabetic patients by heating the urine. He noticed that the crystalline substance left behind had the taste of brown sugar.¹



20th century

German researchers discovered that the pancreas releases a chemical substance to regulate the blood sugar level.

Building on this discovery, a team of Canadian biochemists and physicians extracted the substance from pancreases. After being proven effective in some tests, this substance was injected into a patient and his blood sugar level decreased.²

▲ **Figure 1.1c** French physician
showing how the liver and
brain affect blood sugar level

19th century

A French physician discovered that the liver stores sugar and breaks it down into a simplified form of sugar to be released into the blood. He also demonstrated that a part of the brain affects the blood sugar level.¹

► **Figure 1.1d** Chemical substance injected into a diabetic patient to regulate his blood sugar level



▲ **Figure 1.1e**
Portable device
used by diabetic
patients



Present day

Portable devices are developed to enable diabetic patients to self-inject medications that regulate their blood sugar level.

Besides the treatment of diabetes, advancements have been made in the detection of diabetes. For example, a study has shown that the presence of severe gum diseases may indicate the onset of diabetes.³



CONNECT THE DOTS

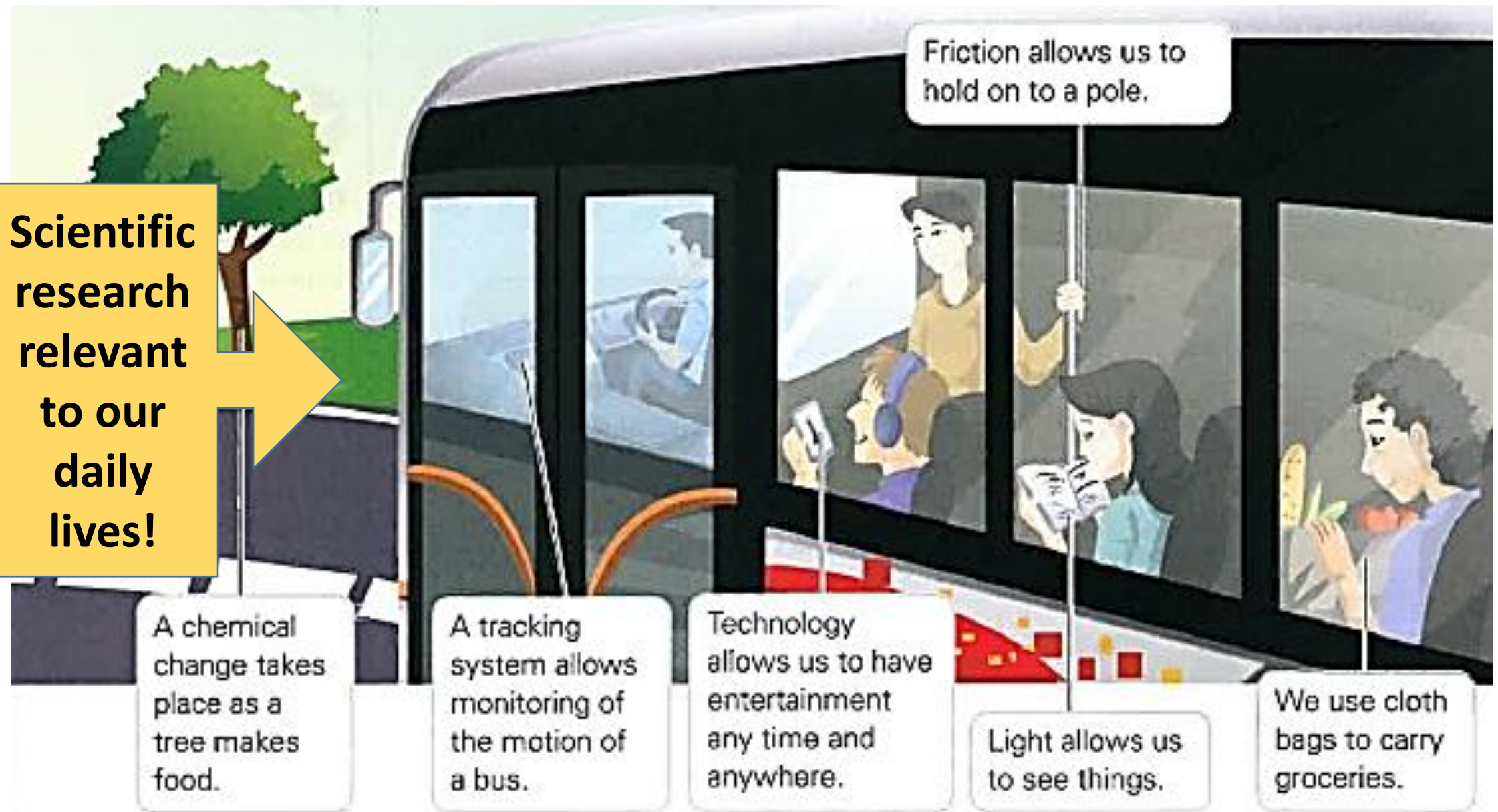
Activity Book 1A:
1.1.2 Eureka!
pages 3–8



FUN FACT

In the past, people known as water tasters tasted the urine of people suspected to have diabetes. If the urine tasted sweet, diabetes was diagnosed. To refer to the sweet taste of the urine, the word “mellitus”, which means “honey”, was added to the name “diabetes”. It was not until the 1800s that scientists developed chemical tests to detect the presence of sugar in urine.

**Scientific
research
relevant
to our
daily
lives!**



▲ **Figure 1.2** Examples of how science is relevant to our daily lives

NTU researchers develop method to tell if someone has Covid-19 or dengue in just 36 minutes



**Scientific
research can
be done in
the
laboratory**

A team of researchers consisting of (from left) Associate Professor Eric Yap, PhD candidate Mr Wee Soon Keong and senior research fellow Dr Sivalingam Paramalingam Suppiah have demonstrated a way to improve the speed, handling time and cost of COVID-19 laboratory tests.
PHOTO: NTU LKCMEDICINE

Scientific research can also be done outside a laboratory. For example, the conditions of natural habitats may be hard to recreate in a laboratory. In this case, real-time data and specimens are collected in the natural habitats of living things (Figures 1.5 and 1.6).



▲ **Figure 1.5** Scientist using a data logger to collect real-time data of a water body



▲ **Figure 1.6** Scientist tagging a sea turtle with a device that uses the Global Positioning System (GPS) to study its behaviour



SCIENCE@WORK

Marine Biologist

Marine biologists are scientists who study marine organisms, from small organisms such as microorganisms to large organisms such as whales. Marine biologists can work in a laboratory or at sea (Figure 1.7). They harness technology to collect samples that are difficult to reach. They also use computer programmes to study more delicate marine organisms virtually, without physically disturbing or harming the organisms. Sometimes, they work together with other scientists on expeditions to study marine organisms or discover new ones.

▼ **Figure 1.7** Marine biologists collecting samples at sea



1.2 What is the nature of Scientific Knowledge?

Success Criteria: I am able to ...	UR				
☐ state the difference between quantitative and qualitative data	1	2	3	4	5
☐ give examples of quantitative and qualitative data	1	2	3	4	5
☐ state that the scientific evidence can be obtained by collecting data using my five senses and/or scientific instruments	1	2	3	4	5
☐ understand that scientific knowledge is built on the systematic collection and analysis of evidence and rigorous reasoning based on the evidence	1	2	3	4	5
☐ explain that scientific conclusions and interpretations are based on observations and inferences, which may differ among people	1	2	3	4	5
☐ understand that scientific conclusions and interpretations can change as new evidence is found	1	2	3	4	5

1.2 What is the nature of Scientific Knowledge?

- Science is evidence-based.
- Evidence can be obtained by observing natural phenomena or conducting experiments.
- To make observations and collect data, we use our senses (sight, hearing, touch, taste and smell) and scientific instruments.



- Two types of data
 - qualitative data
 - quantitative data

science is evidence-based

evidence can be obtained by

observing natural phenomena and
conducting experiments.

Data collection

Use our senses and scientific
instruments.

Senses: sight, hearing, touch,
taste, smell.

Types of data:

qualitative data

quantitative data.

Difference between qualitative and quantitative data

Remember!

Qualitative Data

1. Descriptive
2. Involves senses

Quantitative Data

1. Numerical
2. Involves senses and measurements using specific instruments



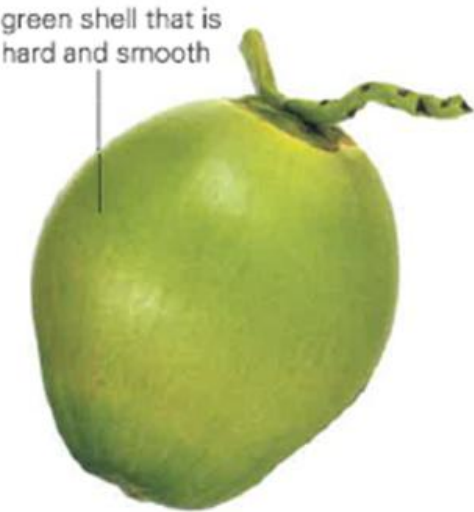
When designing experiments, consider

- type of data to be collected
- how to collect data

Qualitative Data

Table 1.1 How our senses help us to make observations about a coconut

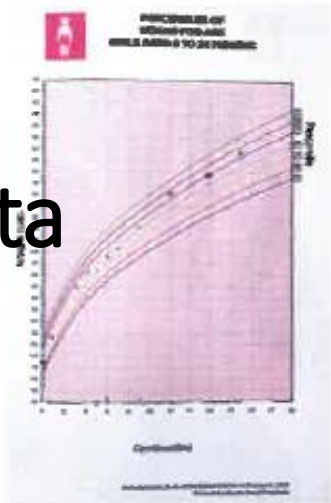
Sense	Qualitative Data Collected	Observation
sight	colour	green shell
hearing	sound	slush of liquid when the fruit is shaken
touch	texture	hard and smooth
smell	odour	no smell but has a slight fragrance when opened
taste	taste	the liquid and flesh in the fruit taste sweet



▲ Figure 1.8 We use our senses of sight and touch to study the shell of a coconut.

Quantitative Data

- Using specific instruments



▲ Figure 1.9 Change in the height of a child shown in a health booklet



▲ Figure 1.10 Time taken by a runner shown on a timing display



▲ Figure 1.11 Number of steps taken by a person shown on a pedometer



LEARNING POINT



Short Answer



State whether the following types of data are qualitative and/or quantitative.

- A chair has a greater height than a table.
- The height of a chair is 20 cm greater than the height of a table.
- Some students felt that the weather was too hot for them to concentrate in class.
- A room temperature of 36 °C is considered too high for students to concentrate in class.

Answer:

Reason:

- Qualitative.** ('greater' is **descriptive**)
- Quantitative** (Height 20 cm is a **numerical** data)
- Qualitative** ('hot' is **descriptive**)
- Quantitative** (Temperature 36 °C is a **numerical** data)

Activity Book Ex. 1.2.1 Where is the Evidence?

- Video for Activity 1.2.1 (Pasteurised milk). Click to play



1. Louis Pasteur, a scientist, experimented on milk and made observations that led him to explain the cause of milk spoilage (Figure 1.1). Subsequently, Pasteur explained the relationship between diseases and germs, which are disease-causing microorganisms.

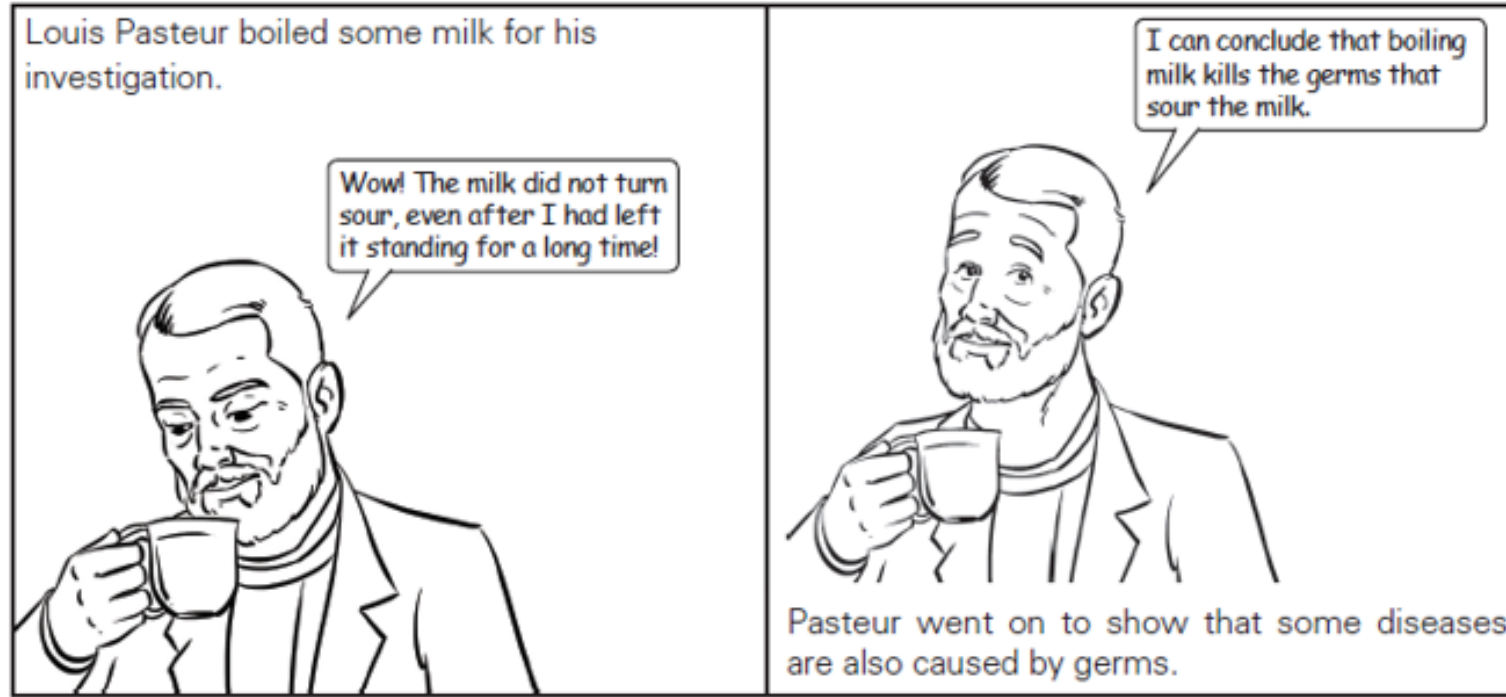


Figure 1.1

(a) When sniffing the milk, Pasteur used his sense of smell. State another sense that Pasteur could have used to make his observation.

Taste

(b) What type of data did Pasteur collect? Put a tick (✓) in the correct box in Table 1.2.

Table 1.2

Type of Data	Tick (✓)
quantitative data	
qualitative data	✓

- Explanation: 'Sour' taste is descriptive.

2. Long ago, doctors did not see the need to wash their hands before carrying out operations. This caused many patients to develop gangrene, a medical condition that often caused death.

In the early 1800s, some doctors blamed “bad air” for spreading gangrene and other diseases. Other doctors thought that diseases were caused by an imbalance in four basic substances called “humours”, which were believed to be found in the human body (Figure 1.2).

However, in the late 1800s, scientists found out that diseases are caused by germs, not “bad air” or an imbalance in “humours”. Hence, doctors were partly responsible for passing germs to patients and causing them to develop gangrene.

Joseph Lister, a doctor, introduced the idea of cleaning wounds and using disinfectants in hospitals. As a result, the number of patients who developed gangrene decreased.

(a) What is the **actual** cause of diseases? Put a tick (✓) in the correct box in Table 1.3.

My patients keep getting gangrene! It must be due to the “bad air”!



Figure 1.2

I think their four “humours” are not balanced.

Table 1.3

Cause	Tick (✓)
“bad air”	
imbalance in four “humours”	
germs	✓

(b) The concept of four “humours” was formed based on the observation of blood separating into four different layers when left to stand (Figure 1.3).



Figure 1.3

(i) State the sense that was used to make this observation. **Sight**

(ii) What type of data was collected during the observation? Put a tick ✓ in the correct box in Table 1.4.

Table 1.4

Type of Data	Tick (✓)
quantitative data	✓
qualitative data	

Explanation: A numerical value is given for the number of layers.

Construction of scientific knowledge

TB Pg. 9-11



Once data is collected,

- it is **analysed** for patterns and trends
- it is used to make **conclusions** and **inferences**
- Inferences and conclusions may **support** or **reject** a scientific idea.

◀ Figure 1.12 Earth was once believed to be at the centre of the universe.

Earth is at the centre of the universe.



▲ Figure 1.13 Ptolemy

Based on numerous observations of the sky, Ptolemy (Figure 1.13), a Greek astronomer, developed a model to predict the positions of the sun, the moon and planets in the night sky. In his model, Earth is at the centre of the universe. For over a thousand years, this model had been the primary explanation for the motion of planets in the night sky.

This illustrates how scientific knowledge is built on the systematic collection and analysis of evidence.

Scientific knowledge is subject to changes!



▲ Figure 1.14 The sun is at the centre of the solar system.

Nicolaus Copernicus (Figure 1.15), a European astronomer and mathematician, introduced the idea that the sun is at the centre of the solar system (Figure 1.14). His idea was based on his analysis of data collected over many years. While Copernicus gained support from a few scientists, he was unable to convince most of the scientific community.

Copernicus' experience shows that the scientific community may take time to accept an idea. This is partly because scientific evidence is interpreted based on a set of strongly held assumptions.

However, in light of new evidence, alternative explanations may be proposed. Hence, scientific knowledge is subject to change. This paves the way for further discoveries by other scientists later on.

The sun is at the centre of the solar system.



▲ Figure 1.15 Nicolaus Copernicus

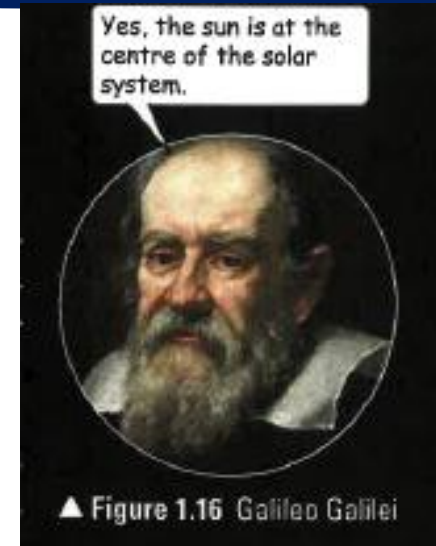
Scientific evidence – multiple interpretations, different inferences



Galileo Galilei (Figure 1.16), an Italian astronomer, physicist and engineer, improved and built a telescope (Figure 1.17) to observe distant objects. He was able to observe the movement and even the surfaces of some planets!

This provided observable evidence to support the idea that the sun is at the centre of the solar system, and that Earth and all other planets revolve around the sun.

Advancements in technology can help to shed light on new evidence that supports different conclusions or viewpoints. When more evidence is accumulated, assumptions will start to change. Over time, new understanding is formed.



This example demonstrates the shift in the understanding of Earth's position in the solar system. It illustrates how in science, there can be multiple interpretations of the same phenomena. Despite observing the same planetary system, Ptolemy, Copernicus and Galileo collected different data, which led them to make different inferences about Earth's position in the solar system.

Since scientific evidence can be interpreted in many ways, how do we know which interpretation should be accepted? The scientific community has to consider and analyse evidence thoroughly before accepting an interpretation. This shows the crucial role that the scientific community plays in building scientific knowledge.

Learning Points

1. Scientific knowledge must be based on evidence and not imagination or feelings. Is this true or false? **Ans: True**

2. Scientific knowledge should only be changed when _____.

A the majority of people say so

B a well-known scientist presents new evidence

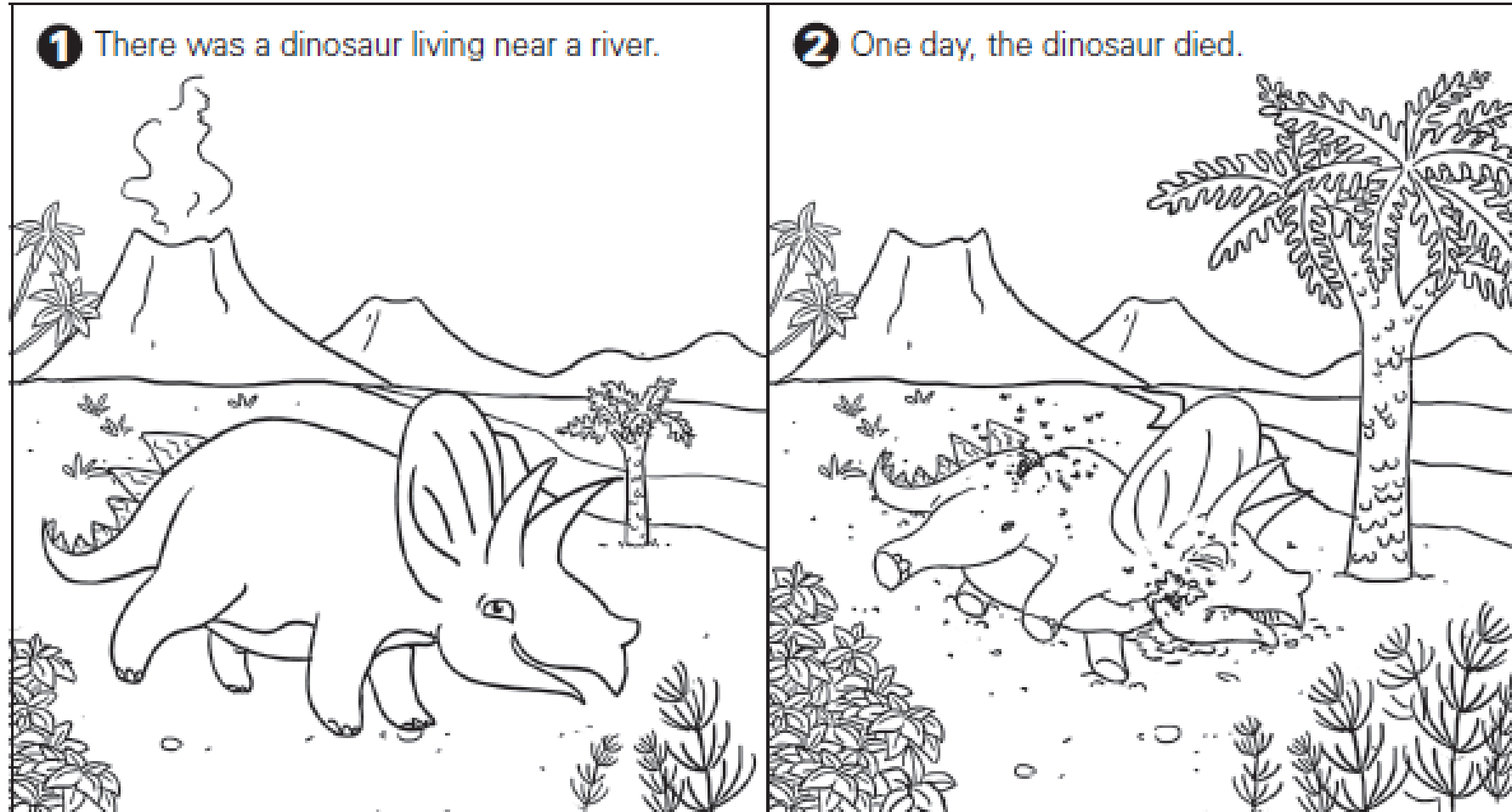
C the scientific community agrees to the claim after new evidence is found



Multiple Choice

Activity Book Ex. 1.2.2: Nature of Scientific Knowledge

Figure 1.4 shows a simplified interpretation of how dinosaurs are reconstructed. It conveys a message about the nature of scientific knowledge.



Activity Book Ex. 1.2.2: Nature of Scientific Knowledge



3 Millions of years later, archaeologists discovered the fossils of the dinosaur.



4 Based on the information provided by the fossils, the dinosaur was reconstructed and displayed in a museum.

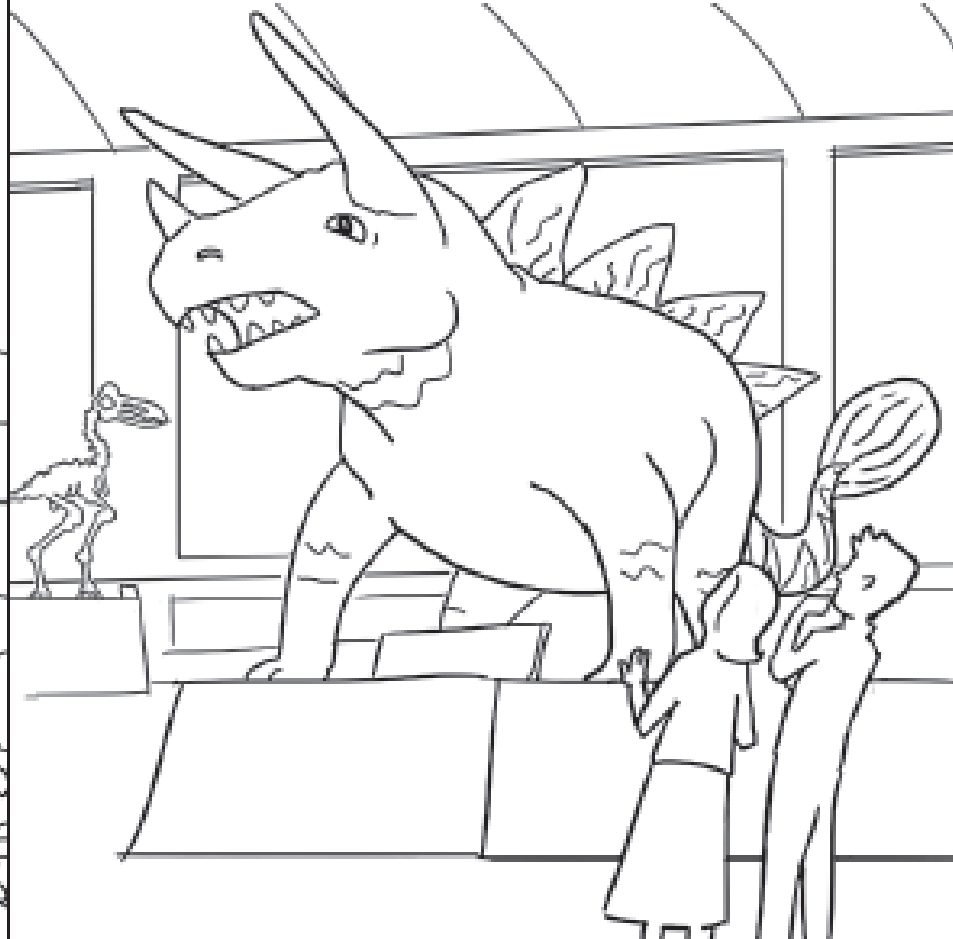


Figure 1.4

Discussion

Based on Figure 1.4, Nabil, Min Dee and Avani share their understanding of the nature of scientific knowledge (Figure 1.5).

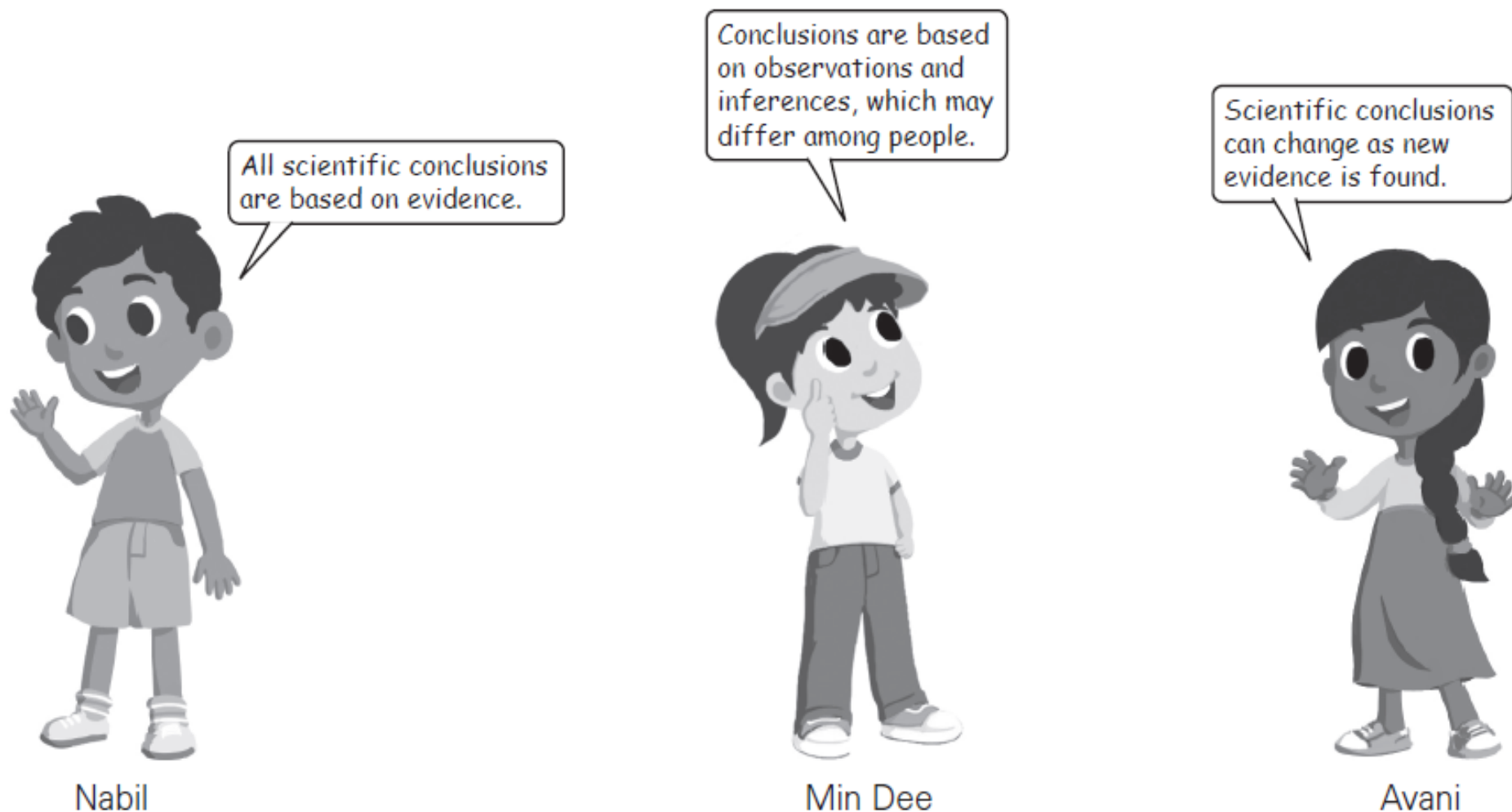


Figure 1.5

Table 1.5

Character	Points of Discussion on the Character's Statement
Nabil	All scientific conclusions are based on evidence, but scientists can differ in their interpretations of the data or evidence.
Min Dee	Interpretations may not always be correct and thus we need to reason and evaluate through discussions.
Avani	• New fossils may be unearthed. • Advancements in technology can provide new evidence that helps scientists learn more about the dinosaur.

1.3 How do we practice Science?

Success Criteria: I am able to	UR
☐ carry out scientific inquiry by asking questions, planning and carrying out simple experiments, evaluating experimental results and communicating findings	1 2 3 4 5
☐ state that a hypothesis is a proposed explanation for a natural phenomenon	1 2 3 4 5
☐ identify variable to be changed and variable to be measured when testing my hypothesis	1 2 3 4 5
☐ suggest variables to be kept constant for a fair experiment	1 2 3 4 5
☐ state the SI unit and commonly used units for volume, mass, time, length and temperature respectively (Will be further explored in subsequent chapters)	1 2 3 4 5
☐ draw scientific (2D) drawing of common laboratory apparatus such as beaker, boiling tube, test tube, conical flask, evaporating dish, retort stand, tripod stand, etc	1 2 3 4 5

1.3 How do we practice Science?

Success Criteria: I am able to	UR
☐ state that accuracy is the degree of agreement/closeness between a measured value and the true value of the quantity being measured	1 2 3 4 5
☐ state that precision is the degree of closeness between measured values obtained by repeated measurements	1 2 3 4 5
☐ describe that accuracy can be improved by • taking the average of multiple measurements of the same quantity being measured • ensuring that the scientific instrument is free from zero error • ensuring that there is no parallax error when taking measurements	1 2 3 4 5
☐ distinguish between zero error and parallax error and give examples of these errors	1 2 3 4 5
☐ state ways to eliminate or reduce zero error and parallax error	1 2 3 4 5
☐ [Optional for G2] classify and identify errors in measurements as consistent or unpredictable	1 2 3 4 5



Investigate
natural
phenomena



Make
observations to
develop possible
explanations and
solutions

**How do we
practise
science?**

Engage the
scientific
community through
discussions



1.3 How do we practice Science?

Demonstrating ways of thinking and doing in Science



Posing Questions and Defining Problems

- Pose / Ask questions (what, when, where, why, which and how)



Designing Scientific Investigations – Hypothesis and Variables

[MEMORISE] A hypothesis is a proposed explanation for an observation or natural phenomenon or solution to a problem.



Testing a hypothesis

- observations to be made from repeated experiments
- even if *results of experiment does not support hypothesis, the process is valuable.*



Variables in science experiments

Independent
variable

- Variable to **change**.

Dependent
variable

- Variable that is **measured**.

Constant variables

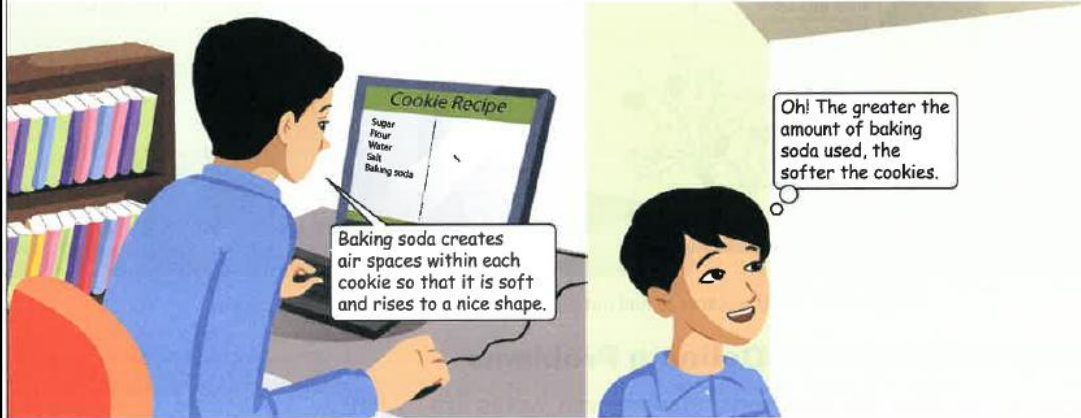
- Variables to be kept **constant**.
- In Pri 6, “location” is a constant variable.
- In lower sec, avoid stating “location”.
- Need to be more specific about the variable.

- ❓ In a science experiment, **all** variables should be **measurable**.

Read Zhi Bin's attempt to bake soft cookies

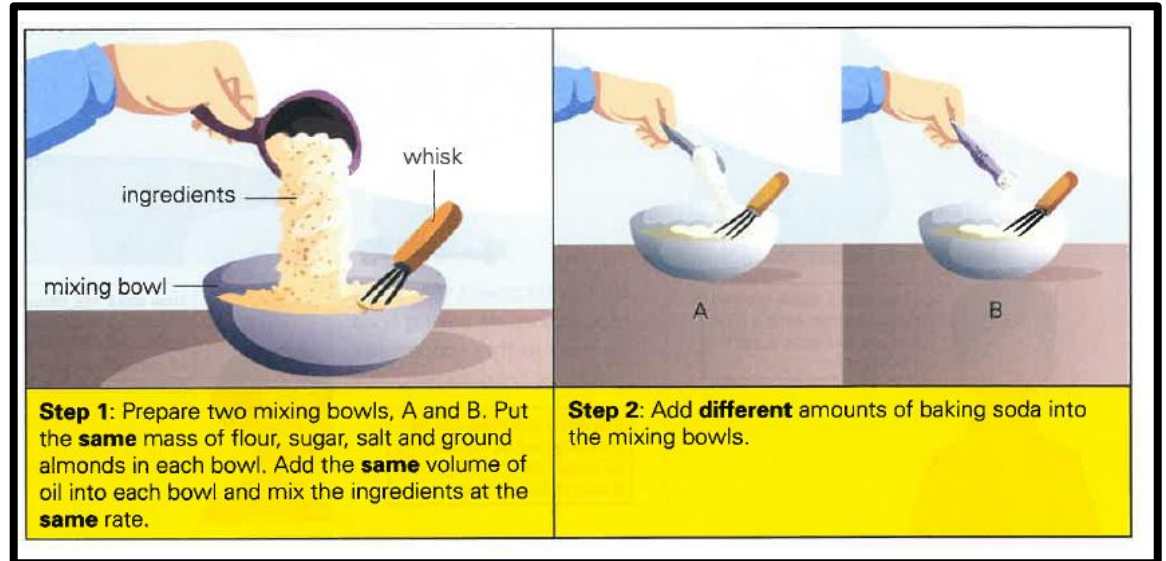
TB Pg. 14-15

Zhi Bin proposes a hypothesis before planning an experiment to find out how to bake soft cookies with a nice shape (Figure 1.23). A hypothesis may also be proposed based on observations made during an experiment.



▲ Figure 1.23 Zhi Bin proposes a hypothesis to solve a problem.

Zhi Bin's experiment



▲ Figure 1.24 Steps in Zhi Bin's experiment

Read Zhi Bin's attempt to bake soft cookies on TB Pg. 14 -15.

Q1) What are the **types** of **variables** considered in Zhi Bin's experiment?

Q2) Why is there only one variable to measure?



Short Answer

Table 1.3 Variables in Zhi Bin's experiment

Type of Variable	Variable(s) in Experiment
changed in an experiment	amount of baking soda
observed or measured	texture of almond cookies
kept constant to ensure a fair experiment	• mass of flour • mass of sugar • mass of salt • mass of ground almonds • volume of oil • rate of mixing • temperature in oven • mass, size and shape of dough to be baked • duration of baking

In every experiment, only **ONE** variable should be **changed**!

Table 1.3 Variables in Zhi Bin's experiment

Type of Variable	Variable(s) in Experiment
changed in an experiment	amount of baking soda
observed or measured	texture of almond cookies
kept constant to ensure a fair experiment	• mass of flour • mass of sugar • mass of salt • mass of ground almonds • volume of oil • rate of mixing • temperature in oven • mass, size and shape of dough to be baked • duration of baking



Only **one** variable should be **measured** (e.g. texture of almond cookies).

Helps to determine **if any change in the "measured variable" is directly caused by the "variable that is changed"**.

Table 1.3 Variables in Zhi Bin's experiment



All other variables kept constant.

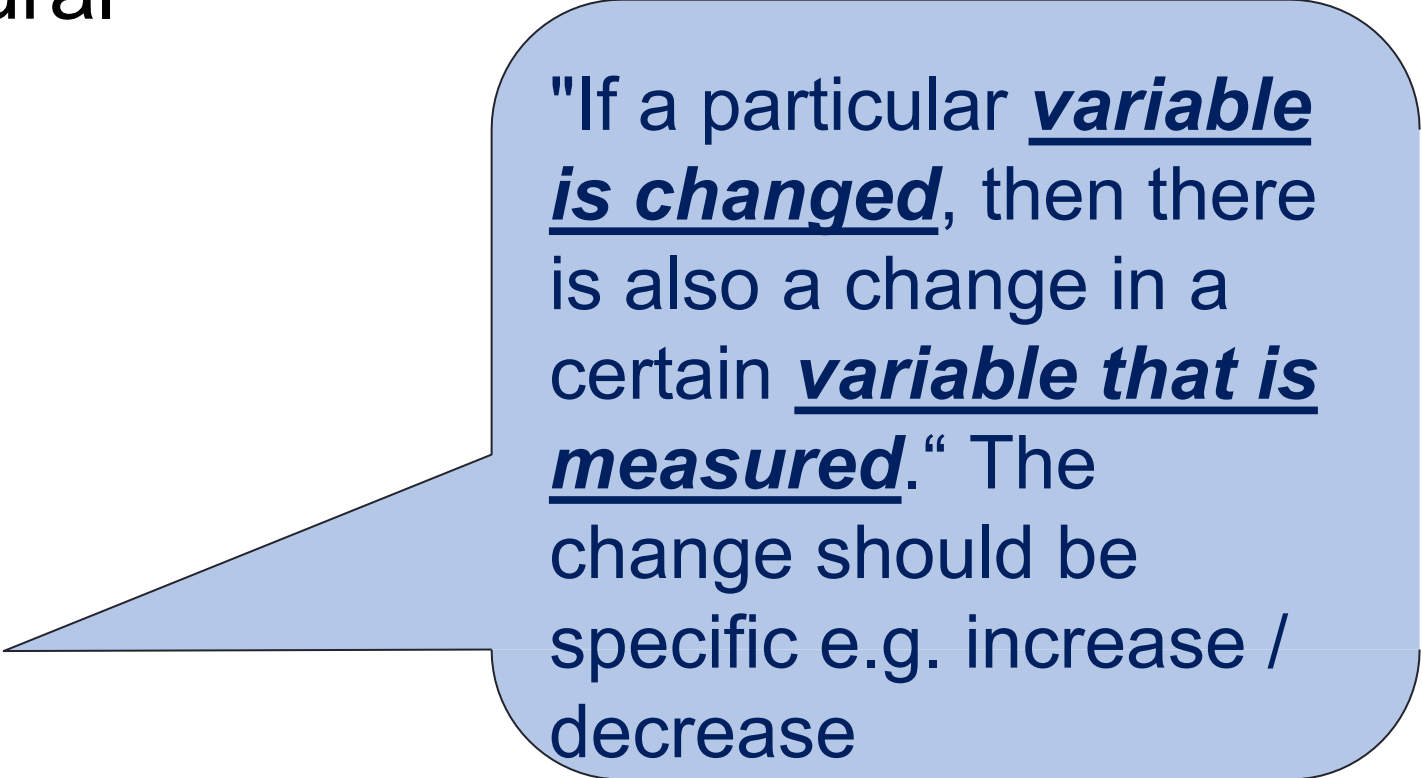
Reason: If not kept constant, these variables may affect the texture of the cookies (measured variable).

So it cannot be concluded fairly whether the amount of the baking soda (variable to change) affects the texture of the cookies (measured variable).

Type of Variable	Variable(s) in Experiment
changed in an experiment	amount of baking soda
observed or measured	texture of almond cookies
kept constant to ensure a fair experiment	• mass of flour • mass of sugar • mass of salt • mass of ground almonds • volume of oil • rate of mixing • temperature in oven • mass, size and shape of dough to be baked • duration of baking

Crafting a hypothesis

- A hypothesis is **proposed** **explanation** for a natural phenomenon or a proposed solution to a scientific problem.
- Many hypotheses are commonly stated something like this:



"If a particular **variable is changed**, then there is also a change in a certain **variable that is measured**." The change should be specific e.g. increase / decrease

Examples of hypotheses

For each hypothesis, identify the

(a) variable to change

(b) variable to measure

- ❑ When the temperature of a cup of water increases, the mass of sugar that dissolves in the water increases.
- ❑ If the intensity of light received by the plant increases, then the rate of photosynthesis by the plant increases.

Activity Bk Ex. 1.3.1 and 1.3.2



- 1.3.1 Investigation into the Pest problem
 - Avani and the egg shells
- 1.3.2 Let Us Investigate!

Questions

1. What is the aim of Avani's investigation?

- To find out if egg shells keep ants away

2. Is the data collected by Avani and her family quantitative or qualitative? Explain your answer.

- Quantitative.
- A numerical value was collected when counting number of ants.

There were many ants in Avani's house. They made the food in her kitchen inedible. Figure 1.6 shows how Avani practised science to solve the problem.

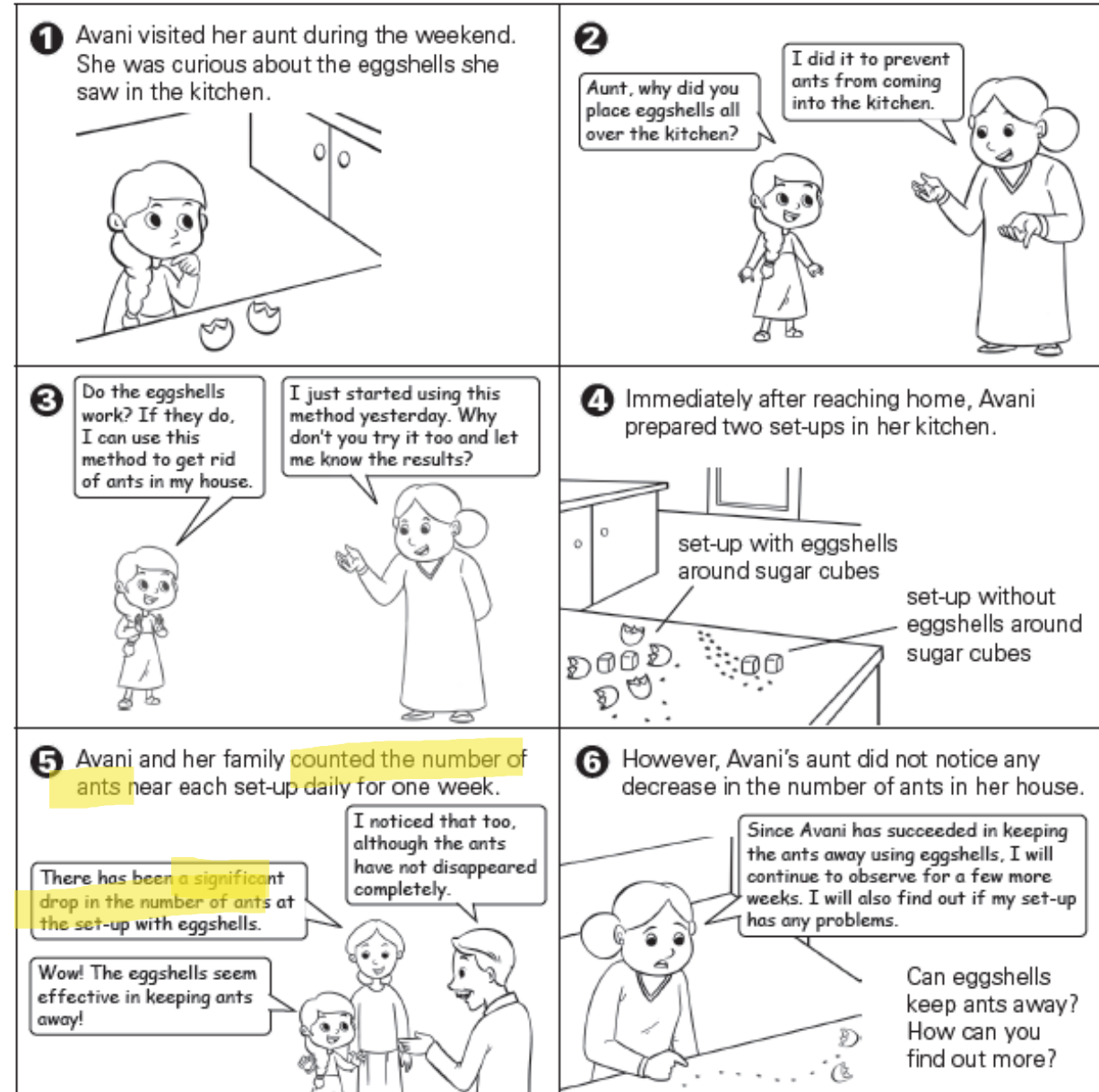


Figure 1.6

3. How did Avani and her aunt demonstrate the practices of scientists in their investigations?

Practice	How Avani and/or Her Aunt Demonstrated the Practice
investigating	Ans:
evaluating	Ans:
developing explanations and solutions	Ans:

3. How did Avani and her aunt demonstrate the practices of scientists in their investigations?

Practice	How Avani and/or Her Aunt Demonstrated the Practice
investigating	• Avani posed questions on what she observed. • Carried out investigations to test their hypothesis by having two set up including a control • Collected quantitative data - no. of ants
evaluating	• Avani concluded that the egg shells were effective, based on the evidence that the ants decreased in numbers. • Avani’s father agreed with her, but also cautioned that the conclusion may not be accurate as not all the ants disappeared. • Avani’s Aunt result is different from her. Decided to continue the experiment and also investigate if there is any problem with her set-up..
developing explanations and solutions	• Avani attempted to solve the problem of having ants in the kitchen by using eggshells and tested the effectiveness of this method.

1.3.2 Let Us Investigate

1. Kumar noticed that the clothes hung indoors took longer to dry compared to those hung outdoors.

(a) Suggest a **reason** for Kumar's observation.

Clothes hung outdoors dried faster due to faster evaporation caused by the heat from the Sun. (or any other suitable hypothesis)

(b) The reason stated in Question 1(a) is your hypothesis for the experiment. Pose a **question** to test your hypothesis.

How much time would it take for a shirt to dry with and without sunlight?

c) (i) State the variable that should be changed during the experiment.

- **Amount of sunlight exposed to the shirt
(This variable must match 1(b).)**

(ii) State one variable that should be kept constant for a fair experiment.

- **Exposed surface area of shirt / volume of water in the shirt / material of the shirt / time duration that the shirt is kept under the sunlight or without sunlight**

(iii) Suggest how the result may be affected if the variable stated in Question 1(c)(ii) is not kept constant.

- **The variable may affect the rate of evaporation.**
- **Thus, it cannot be concluded whether exposing the shirt to sunlight or without sunlight affects the rate of evaporation.**

Q2. Ahmad got two similar pots of balsam plants from his parents. He placed one in the garden with direct sunlight and the other inside his bedroom with little sunlight. After two weeks, he observed that the plant in the garden was taller than the one in his bedroom.

(a) Suggest a reason for Ahmad's observation.

There is more sunlight outdoors for the plant to make food and grow taller. (or any other suitable hypothesis).

(b) The reason stated in Question 2(a) is your hypothesis for the experiment. Pose a question to test your hypothesis.

How does the amount of sunlight affect the height of plants?

(c) (i) State the variable that should be changed during the experiment.

- **The amount of sunlight each plant receives. (This variable must match 2(b).)**

(c) (ii) State one variable that should be kept constant for a fair experiment.

Type of soil; Type of plant; Size of the pots; Amount of water given to each plant

(iii) Suggest how the result may be affected if the variable stated in Question 2(c)(ii) is not kept constant.

- **The variable in (c)(ii) may affect the plant growth.**
- **Thus, it cannot be concluded whether amount of sunlight affects plant growth.**

3. Wei Ming and Wei Ling woke up late for school one day. In their rush, Wei Ming left his slice of bread in the oven, while Wei Ling shoved her slice of bread into the refrigerator.

Three days later, Wei Ming noticed that some parts of his bread had turned greyish green, while Wei Ling's had not.

(a) Suggest what happened to the bread left in the oven.

- **The bread turned bad; there is mould on the bread; bread turned mouldy (or any other suitable hypothesis)**

(b) The reason stated in Question 3(a) is your hypothesis for the experiment. Pose a question to test your hypothesis.

- **How long would it take for the bread to turn mouldy inside the fridge compared to at room temperature?**
- **Other reasonable answer**

(c) (i) State the variable that should be changed during the experiment.

- **The place where I put the bread has to change: one inside the fridge, another in the oven**
- **Other reasonable answer. (This variable must match 3(b).)**

(ii) State one variable that should be kept constant for the experiment.

- **Thickness of bread / Type of bread / size of bread**

(iii) Suggest how the result may be affected if the variable stated in Question 3(c)(ii) is not kept constant.

- **The variable may affect the condition of the bread.**
- **So it cannot be concluded whether the condition of the bread is affected by the place/surrounding temperature where the bread is kept.**

Conducting experiments and testing solutions – measuring with scientific instruments

- Scientific instruments measure physical quantities.
- A physical quantity is a quantity that can be measured. E.g. length, time, volume, mass, temperature, etc.

Conducting experiments and testing solutions – measuring with scientific instruments



◀ **Figure 1.25**
Measuring cylinder



▲ **Figure 1.26** Electronic balance



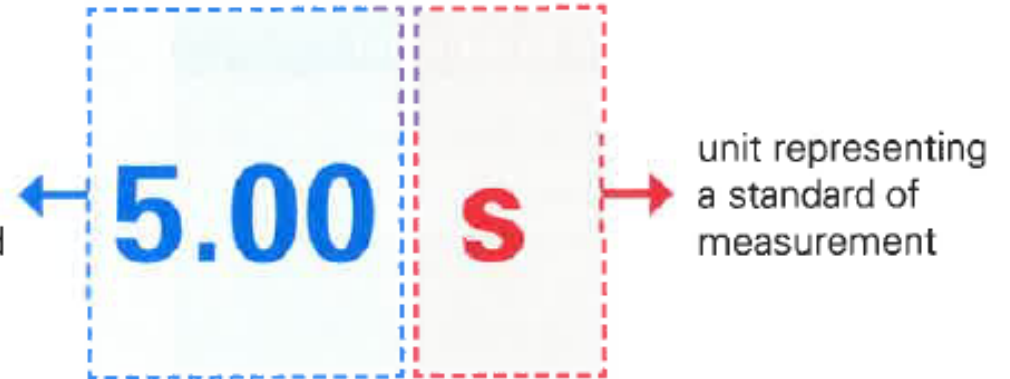
▲ **Figure 1.27** Digital calipers



▲ **Figure 1.28** Digital stopwatch

The readings taken from the instruments are expressed as a **numerical value** with a **unit**. For example, a stopwatch measures a time interval to be 5.00 seconds (Figure 1.30).

numerical value
representing the
quantity measured

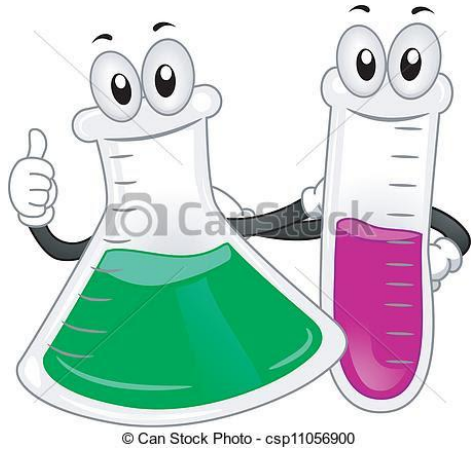


▲ **Figure 1.30** Value and unit of a time interval

Within the scientific community, a system of standardised units called International Systems of Units, or **SI units** , is widely used to ensure a common standard when making measurements.



Physical quantity	SI unit (symbol)	Other commonly used units	Measuring instrument(s)
volume	cubic metre (m ³)	cm ³ , ml, l	measuring cylinder
mass	kilogram (kg)	mg, g	electronic balance
time	second (s)	ms, min, h	digital stopwatch
length	metre (m)	mm, cm, km	ruler metre rule measuring tape digital calipers (sec 3) micrometer screw gauge (sec 3)
temperature	kelvin (K)	°C, °F	thermometer



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Tips on drawing apparatus



- Draw 2-dimensional diagrams.
- Ensure diagrams are proportional in size.
- Draw solid lines
- Using a pencil (and a ruler if drawing straight lines).
- Do NOT shade, unless specifically stated.

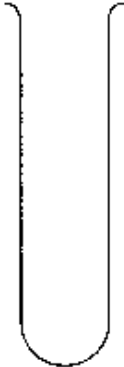
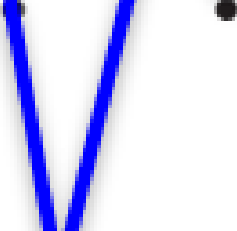
Activity Book 1.3.3: Measuring instruments and apparatus (with scientific drawing)



Table 1.7

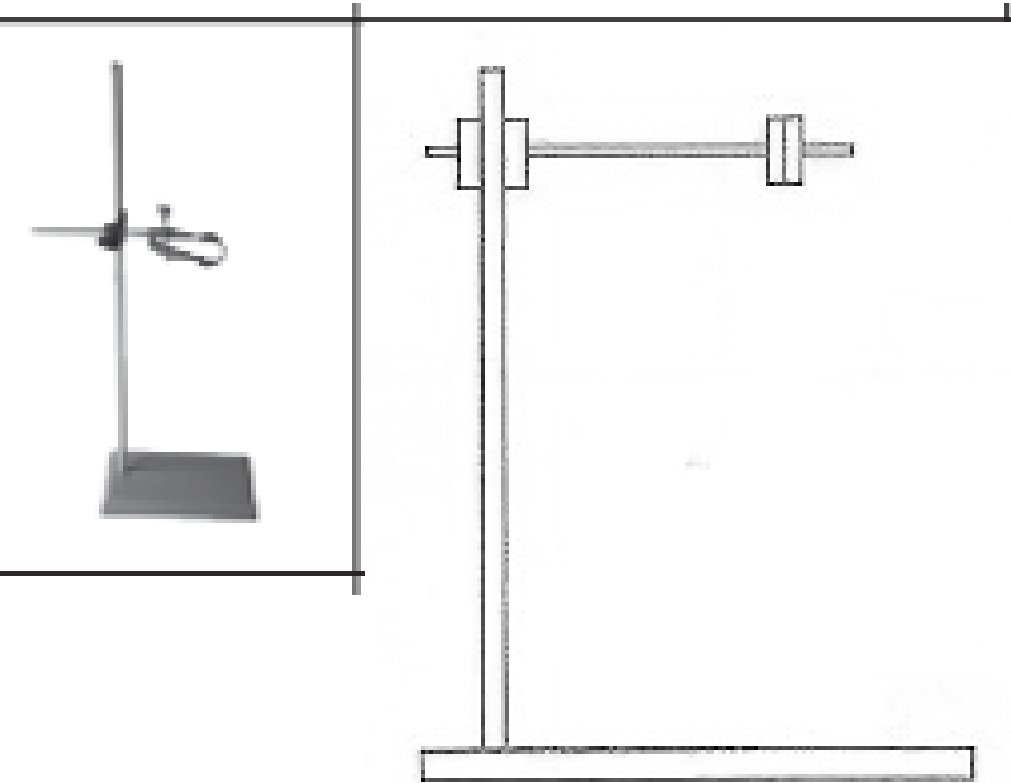
Quantity	Measuring Instrument(s)	Unit(s) of Measurement
time	digital stopwatch	• second (s) • minutes (min) • hours (h)
temperature	thermometer	• degree celsius ($^{\circ}\text{C}$) • fahrenheit ($^{\circ}\text{F}$) • kelvin (K)
mass	electronic balance	• kilogram (kg) • gram (g) • milligram (mg)

length	metre rule measuring tape digital calipers (sec 3) micrometer screw gauge (sec 3)	• metre (m) • kilometre (km) • centimetre (cm) • millimetre (mm)
volume	measuring cylinder For liquid volume, burette (sec 3) and pipette (sec 3)	• cubic metre (m³) • cubic centimetre (cm³) • litre (l) • millilitre (ml)

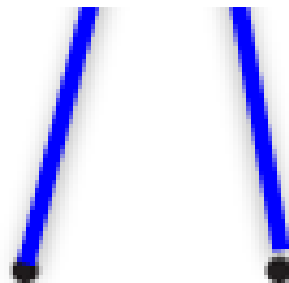
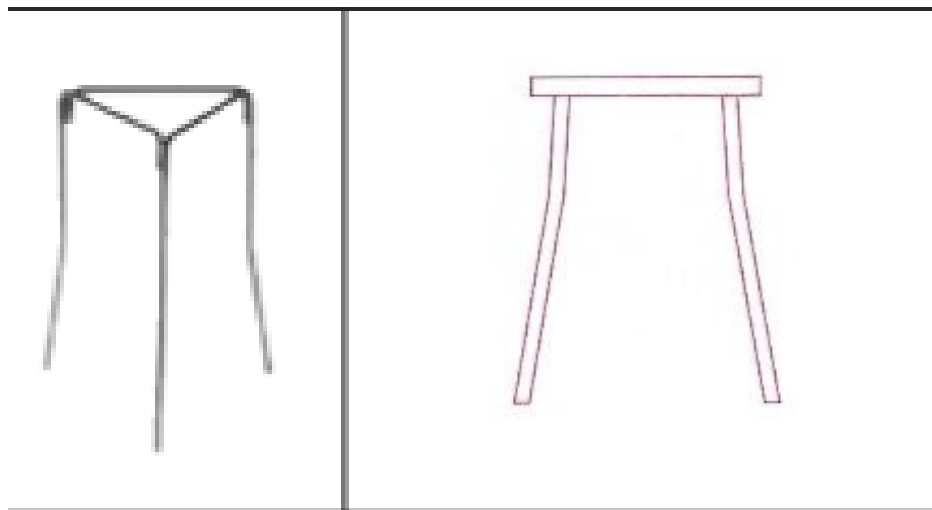
Apparatus	Scientific Drawing		Description
			A boiling tube is glassware used to contain chemicals for strong heating. Its transparent body allows for easy observation.
			An evaporating dish is a small porcelain container with a spout. It is commonly used to evaporate a liquid.
			A test tube is glassware commonly used to hold chemicals. Its curved base allows for even heating and reduces the amount of chemicals left behind after pouring them out. Its transparent body allows for easy observation.



A tripod stand is usually used with a wire gauze on it. It supports the apparatus that is being heated by a Bunsen burner.



A retort stand has a clamp that holds other apparatus.



A conical flask is glassware with a flat bottom and a conical body that tapers upwards to a short vertical neck. Its narrow mouth allows a stopper or filter funnel to fit into it. Its conical body allows for easy mixing of liquids without spillage.



Other acceptable drawings

Apparatus	Scientific Drawing		Description
			A boiling tube is glassware used to contain chemicals for strong heating. Its transparent body allows for easy observation.
			An evaporating dish is a small porcelain container with a spout. It is commonly used to evaporate a liquid.
			A test tube is glassware commonly used to hold chemicals. Its curved base allows for even heating and reduces the amount of chemicals left behind after pouring them out. Its transparent body allows for easy observation.
			A tripod stand is usually used with a wire gauze on it. It supports the apparatus that is being heated by a Bunsen burner.
			A retort stand has a clamp that holds other apparatus.
			A conical flask is glassware with a flat bottom and a conical body that tapers upwards to a short vertical neck. Its narrow mouth allows a stopper or filter funnel to fit into it. Its conical body allows for easy mixing of liquids without spillage.

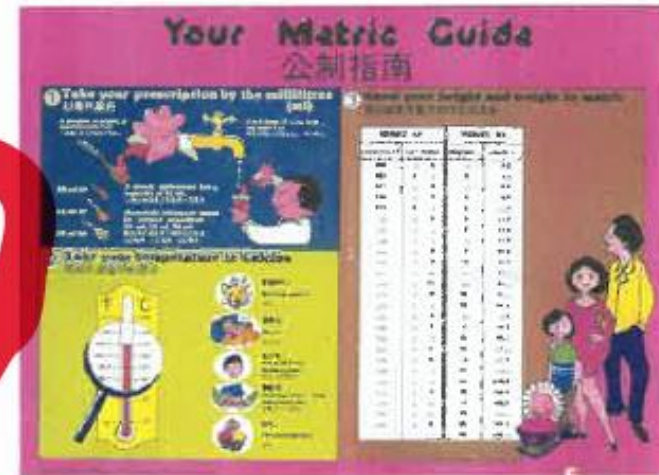
Singapore's story on measurement!

(Read on your own)

The definitions of SI units are continually reviewed to reflect advancements in science and technology, and the latest developments in society. For example, Singapore adopted the SI units to align with the units used by its major trading partners. The adoption made trading more convenient.

The adoption of SI units affected the people in Singapore as they adjusted to using SI units to express speed limits and weigh groceries (Figure 1.31). The use of other units such as the hour, minute and inch has been deeply ingrained in Singapore's history and culture. For practical reasons, these units continue to be used alongside SI units today.

► **Figure 1.31** In the 1970s, a series of publicity campaigns were carried out in Singapore to educate the general public and industries about SI units.



Textbook: Fun Fact on the kilogram (read on your own)



FUN FACT

The kilogram (kg) was defined based on the mass of a platinum-iridium cylinder manufactured in 1889 and conserved in Paris, France.

Known as the International Prototype of the Kilogram (IPK), the cylinder has been the standard for a mass of 1.0 kg for more than a hundred years. Copies of the IPK were made and sent to different countries. Singapore has the official copy number 83 (Figure 1.32), which is maintained by the National Metrology Centre (NMC) of the Agency for Science, Technology and Research (A*STAR).

Through very careful measurements over many years, scientists discovered that these official copies do not have the same mass. They have become heavier than the IPK over time.

After a historic vote by representatives from around 60 countries in November 2018, the IPK was retired on 20 May 2019. In its place was an improved definition of the kilogram. This was made possible with better understanding and applications of science and technology.



▲ Figure 1.32 Copy of the IPK



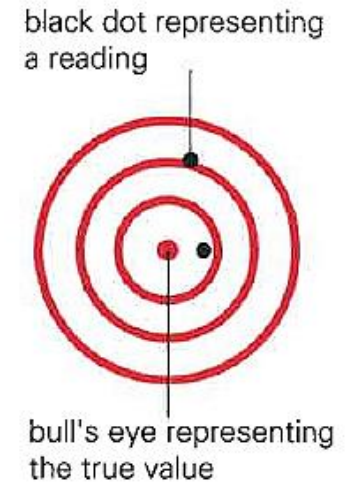
Supporting video (optional) 10 mins:

<https://youtu.be/ZMByl4s-D-Y?si=ryJuVMlpgXoSg30e>

Conducting experiments and testing solutions

– accuracy, precision and errors

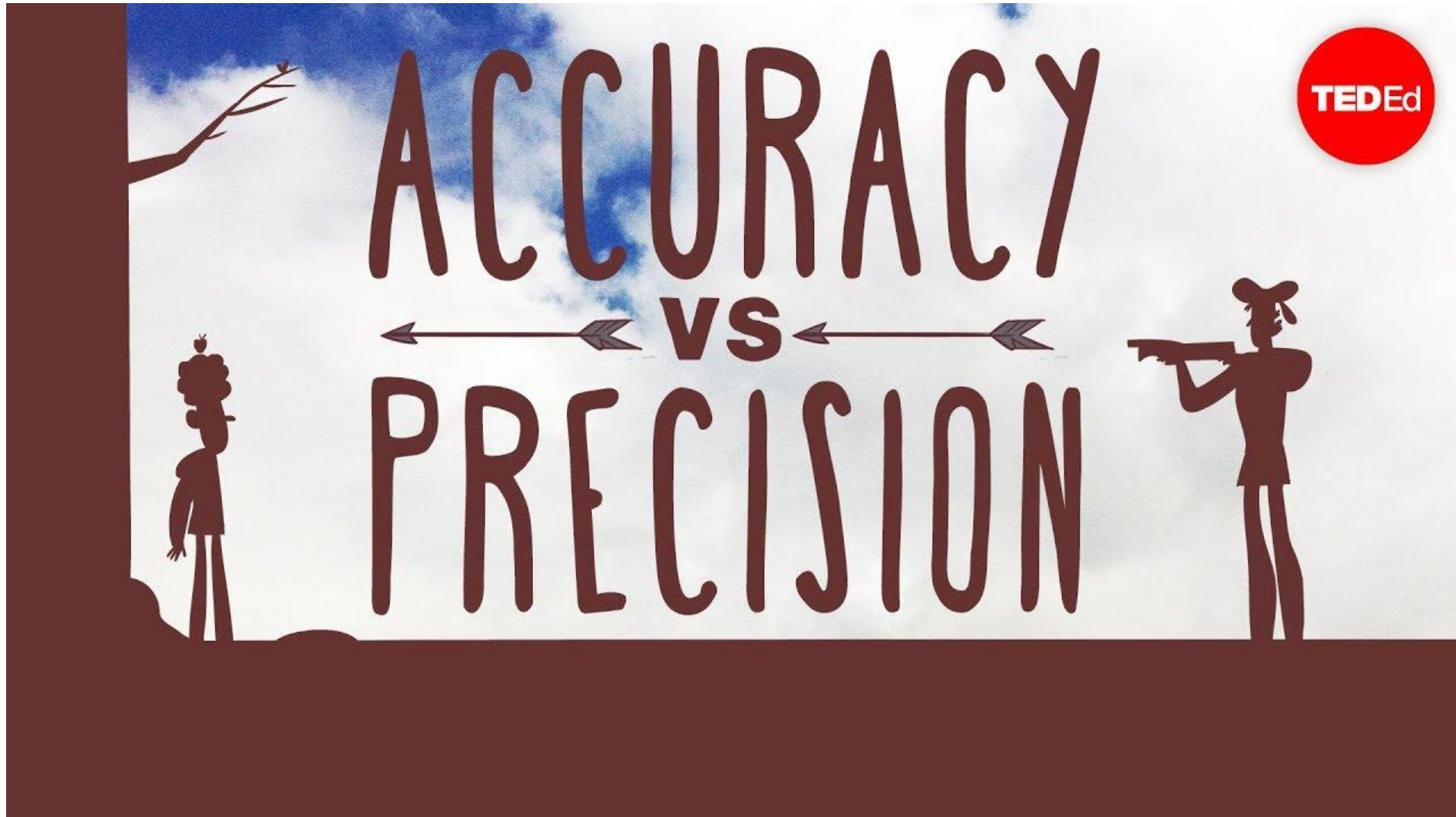
- When taking and recording measurements, the best measurement is one that is *both* **accurate** and **precise**.



▲ **Figure 1.33** Dartboard for illustrating accuracy

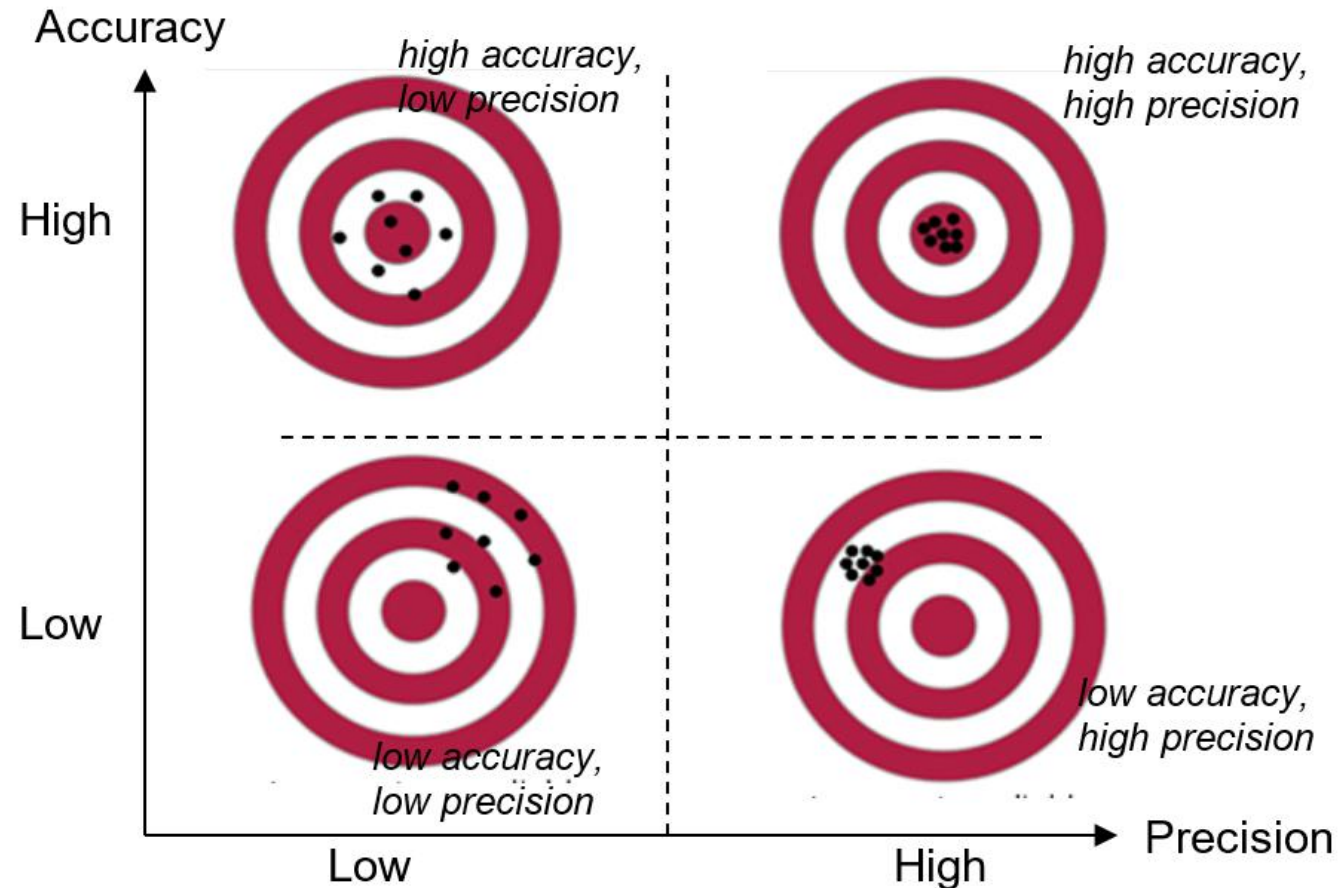
Accuracy	Precision
How <u>close</u> a <u>measured</u> value is to the <u>true</u> value.	How <u>close repeated measured</u> values are to <u>one another</u> .
Can be improved by ensuring - scientific instruments do <u>not</u> have <u>zero error</u> <u>no parallax error</u> when taking measurements.	Can be improved by - paying close attention to procedures - using apparatus properly - increasing number of repeated measurements taken

Accuracy vs Precision [Video] [Click to play](#)



Accuracy vs Precision

Accuracy	Precision
How close a measured value is to the true value.	How close repeated measured values are to one another .

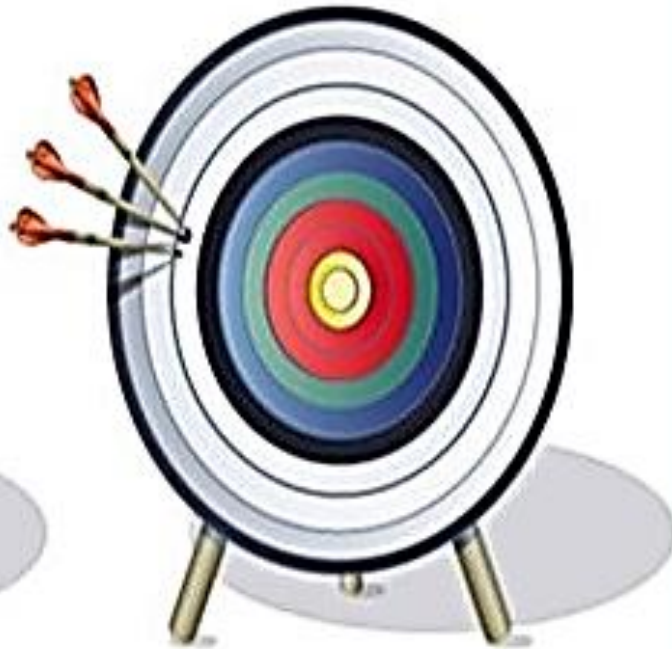


Accuracy vs Precision



Arrow in the center

=



Arrows far from center

=

Arrows close together

=



Arrows in center

=

Arrows close together

=



Arrows far from center

=

Arrows far apart

=

Example Question: Accuracy and Precision

True volume of a liquid is 25.0 cm^3 .

Three students each measured the volume of the liquid four times and took the average volume.

	Volume / cm^3				
Student	V_1	V_2	V_3	V_4	V_{average}
Andrew	27.2	27.1	26.9	27.0	27.1
Ben	23.6	22.8	24.6	22.2	23.3
Caleb	25.2	25.4	25.3	25.1	25.3

Whose measurements is

- (a) most precise, but not accurate
- (b) both accurate and precise?

(a) Whose measurements is most precise, but not accurate?

True volume of a liquid is 25.0 cm^3 .

	Volume / cm^3				
Student	V_1	V_2	V_3	V_4	V_{average}
Andrew	27.2	27.1	26.9	27.0	27.1
Ben	23.6	22.8	24.6	22.2	23.3
Caleb	25.2	25.4	25.3	25.1	25.3

- **Answer: Andrew**

Difference between Andrew's highest measured value and lowest measured value = $27.2 - 26.9 = 0.3 \text{ cm}^3$

Andrew's volume measurements are close to one another → precise.

However, average volume is 27.1 cm^3 , which is 2.1 cm^3 away from the actual volume of 25.0 cm^3 .

Andrew's volume measurements are **not** accurate.

(b) Whose measurements is both accurate and precise?

True volume of a liquid is 25.0 cm^3 .

	Volume / cm^3				
Student	V_1	V_2	V_3	V_4	V_{average}
Andrew	27.2	27.1	26.9	27.0	27.1
Ben	23.6	22.8	24.6	22.2	23.3
Caleb	25.2	25.4	25.3	25.1	25.3

• Answer: Caleb

Difference between Caleb's highest measured value and lowest measured value

$$= 25.4 - 25.1 = 0.3 \text{ cm}^3$$

Caleb's volume measurements are close to one another → **Precise**.

Each of Caleb's volume measurements is also close to the true volume of 25.0 cm^3 → **Accurate**.



LEARNING POINTS

At a hawker centre, a group of students observed that the tea became cooler after it was “pulled” (poured from one mug into another) a few times by a stallholder (Figure 1.49).

The students invited the stallholder to carry out an experiment. He “pulled” the tea ten times with the two mugs held about 30 cm apart. They then measured the final temperature of the tea. These steps were carried out thrice.

The experiment was repeated with different distances between the mugs, using tea of the same initial temperature. The students recorded their results in Table 1.5.

Further Example: Textbook page 24



Table 1.5 Results of the experiment

Distance Between the Mugs / cm	Final Temperature of the Tea / °C			Average Final Temperature / °C
	Reading 1	Reading 2	Reading 3	
30	98.3	98.5	98.2	98.3
40	95.8	95.6	95.2	95.5
50	93.5	93.2	93.0	93.2

- Which of the following statements can be concluded from the results?
 - The final temperature of the tea depended on the distance between the mugs.
 - The final temperature of the tea would reach 91 °C after the tea was “pulled” ten times with the mugs held 60 cm apart.
 - The greater the distance between the mugs, the lower the final temperature of the tea.
 - The distance between the mugs was the only factor that affected the final temperature of the tea.

Ans: C

Example: Textbook page 24 (cont'd)

Table 1.5 Results of the experiment

Distance Between the Mugs / cm	Final Temperature of the Tea / °C			Average Final Temperature / °C
	Reading 1	Reading 2	Reading 3	
30	98.3	98.5	98.2	98.3
40	95.8	95.6	95.2	95.5
50	93.5	93.2	93.0	93.2

2. How can the students modify the presentation of their results so that it is easier to identify any trends or patterns in the results?

Ans: Plot a graph of average final temperature against the distance between the mugs.

Example: Textbook page 24 (cont'd)

Table 1.5 Results of the experiment

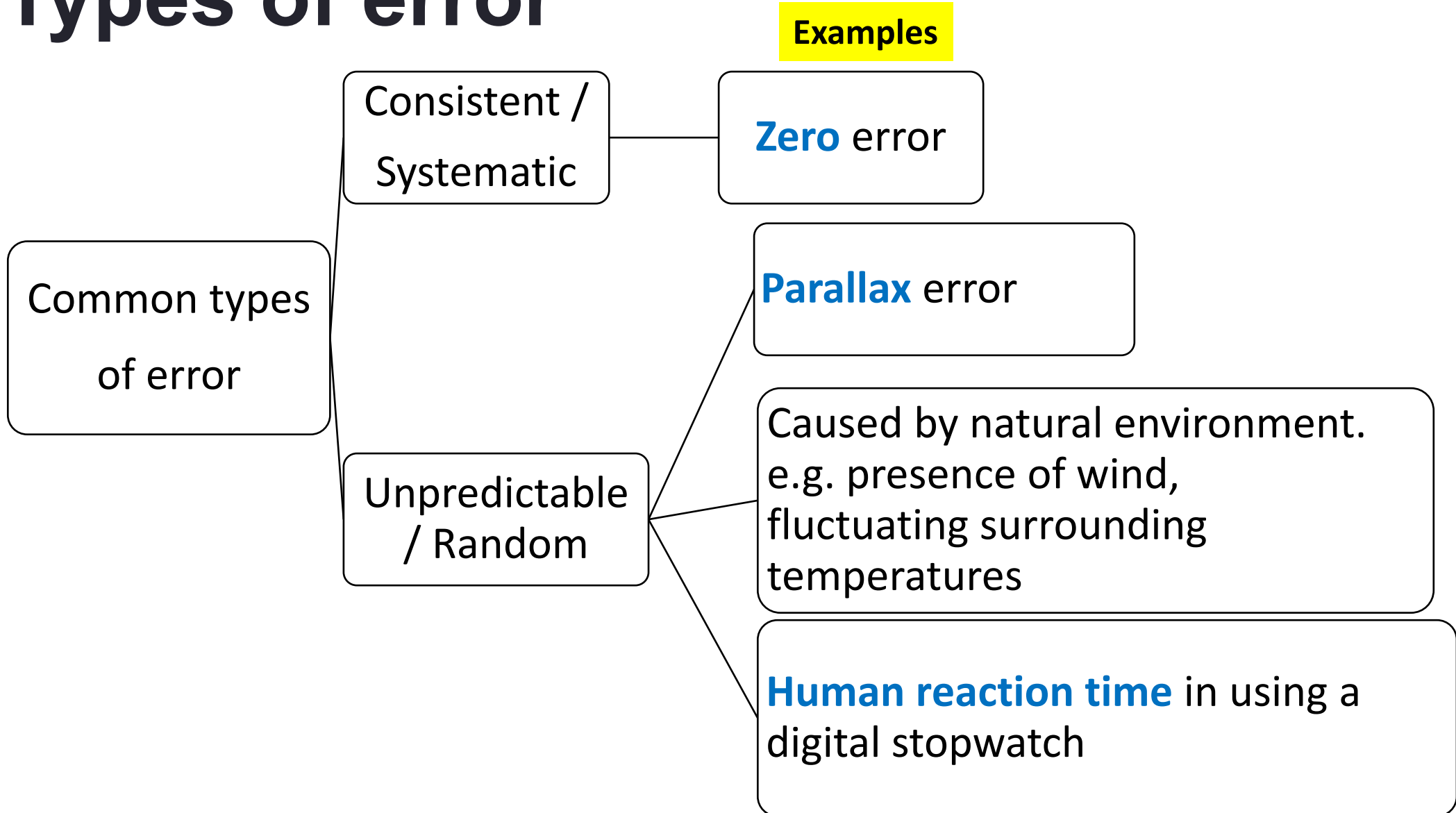
Distance Between the Mugs / cm	Final Temperature of the Tea / °C			Average Final Temperature / °C
	Reading 1	Reading 2	Reading 3	
30	98.3	98.5	98.2	98.3
40	95.8	95.6	95.2	95.5
50	93.5	93.2	93.0	93.2

3. Instead of taking one reading for each distance between the mugs, the students took three readings. Can they infer from their readings whether the results are accurate or precise?

Ans: The three repeated readings are close to one another, so they are precise.

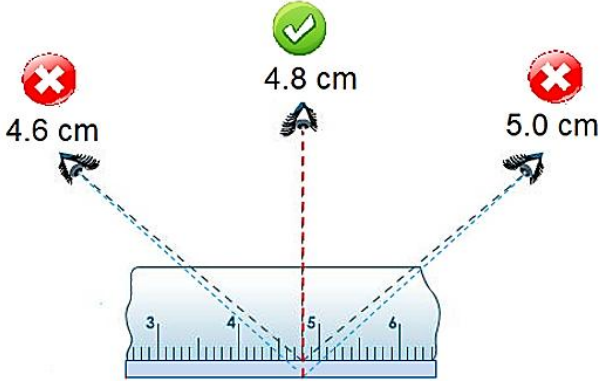
- If each reading is close to the true value, then it is accurate.
But the true value is not given in the question.
- So we do not know if the readings are accurate or not.

Types of error





Parallax error vs Zero error

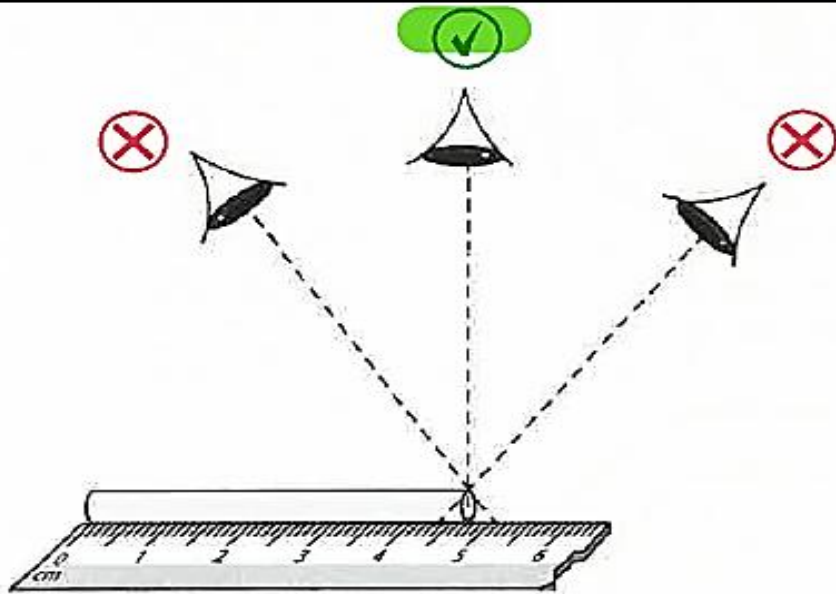
	Definition	Way(s) to reduce the error
Parallax error	Error in measurement when the <u>marking</u> on the instrument is viewed from the <u>wrong angle</u>.  The diagram shows a ruler with markings from 3 to 6. A vertical dashed line with a green checkmark icon at the top indicates the correct viewing angle, resulting in a reading of 4.8 cm. Two other viewing angles, indicated by dashed lines and red 'X' icons, show parallax error: one from the left results in a reading of 4.6 cm, and one from the right results in a reading of 5.0 cm.	• The line of sight of the eye should be perpendicular to the marking on the scale of a ruler. • Eye should be at the bottom of the meniscus of the liquid when taking volume measurements (chapter 2) (refer to next few slides for more examples)
Zero error	Error in measurement when an instrument gives a <u>non-zero reading</u> when the measured quantity <u>should be zero</u>.	• Replace the instrument with one without zero error. • If it is a digital instrument, reset it by pressing the '<u>tare</u>' button.  The image shows a close-up of a button on a digital scale. The button is rectangular with rounded corners and has a power symbol (a circle with a vertical line) followed by the text "/TARE" in a bold, sans-serif font.

When instruments are used incorrectly, the measurements made can be less accurate or precise.

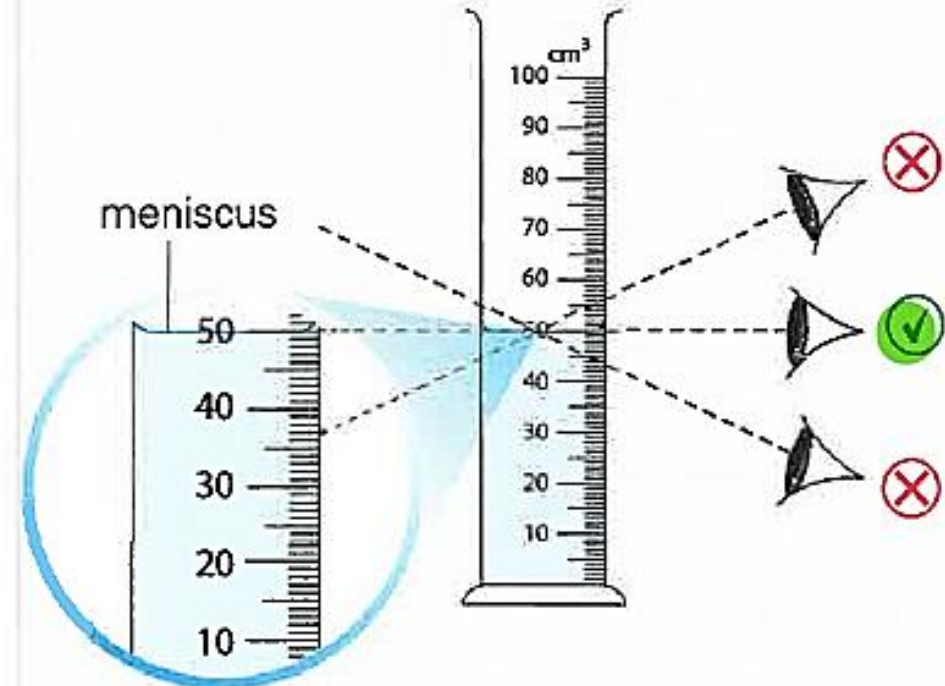
Parallax error takes place during measurement when the marking on an instrument is viewed from the wrong angle.

How to avoid parallax error?

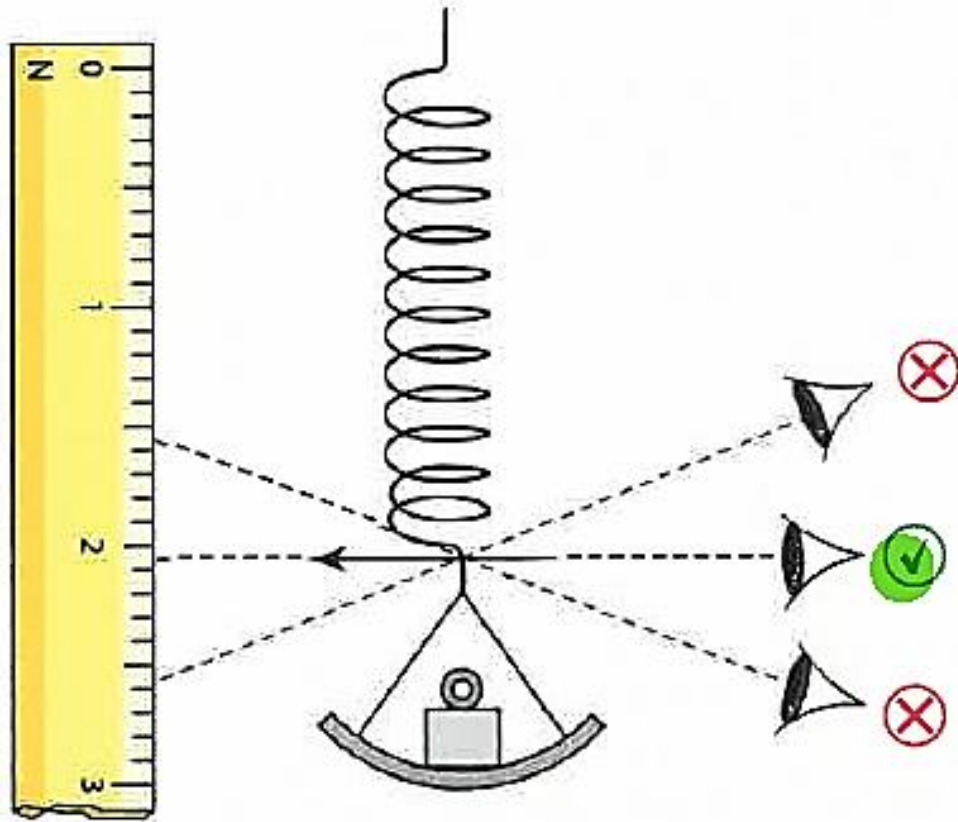
When using a ruler, position the eye so that the line of sight is perpendicular to the marking on the ruler.



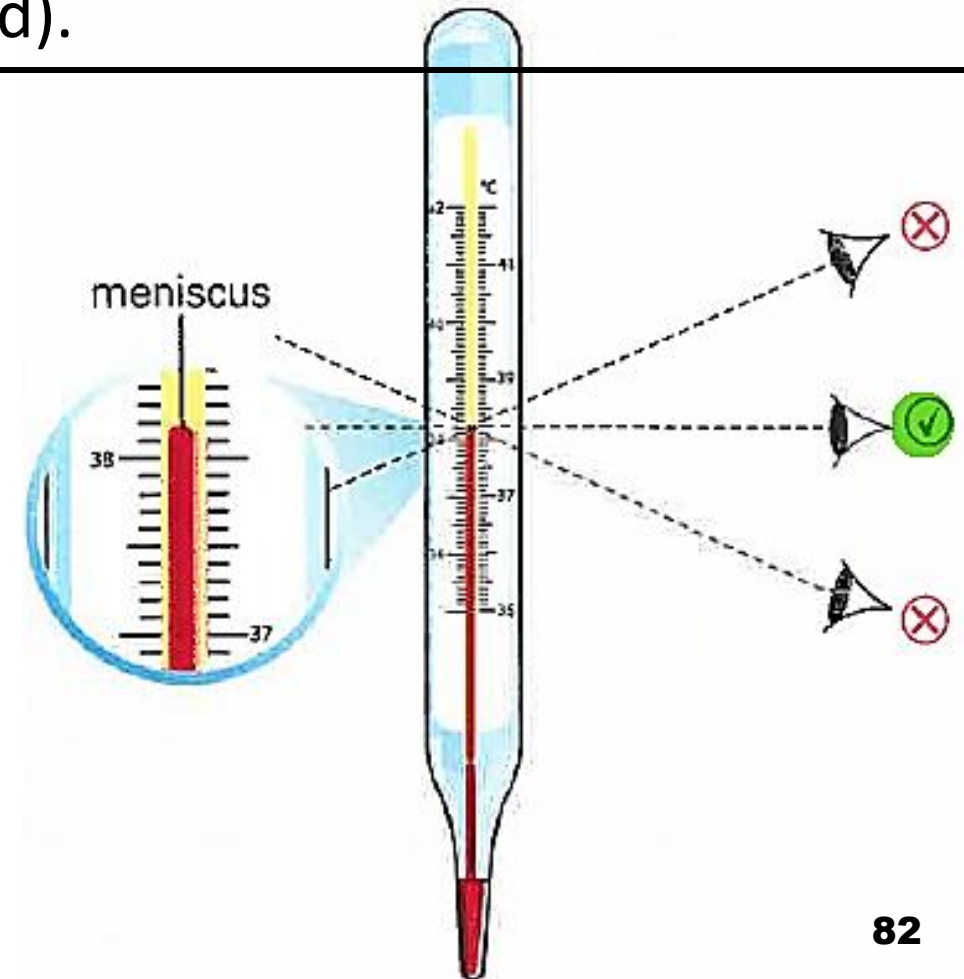
When using a measuring cylinder, position the eye so that the line of sight is level with the bottom of the meniscus (curved surface of the liquid).



When using a spring balance, position the eye so that the line of sight is perpendicular to the marking on the scale.



When using a mercury-in-glass thermometer, position the eye so that the line of sight is level with the top of the meniscus (curved surface of the liquid).



Example: Zero Error

See the diagram below on different weighing scales.
Which of them will most likely give an accurate reading?

Answer: B.
Why?

Positive zero error:
All measurements
will be larger than
true value.



weighing scale A



weighing scale B



weighing scale C

▲ Figure 1.34 Weighing scales showing different readings when nothing is placed on them

Negative zero
error: All
measurements
will be smaller
than true value.

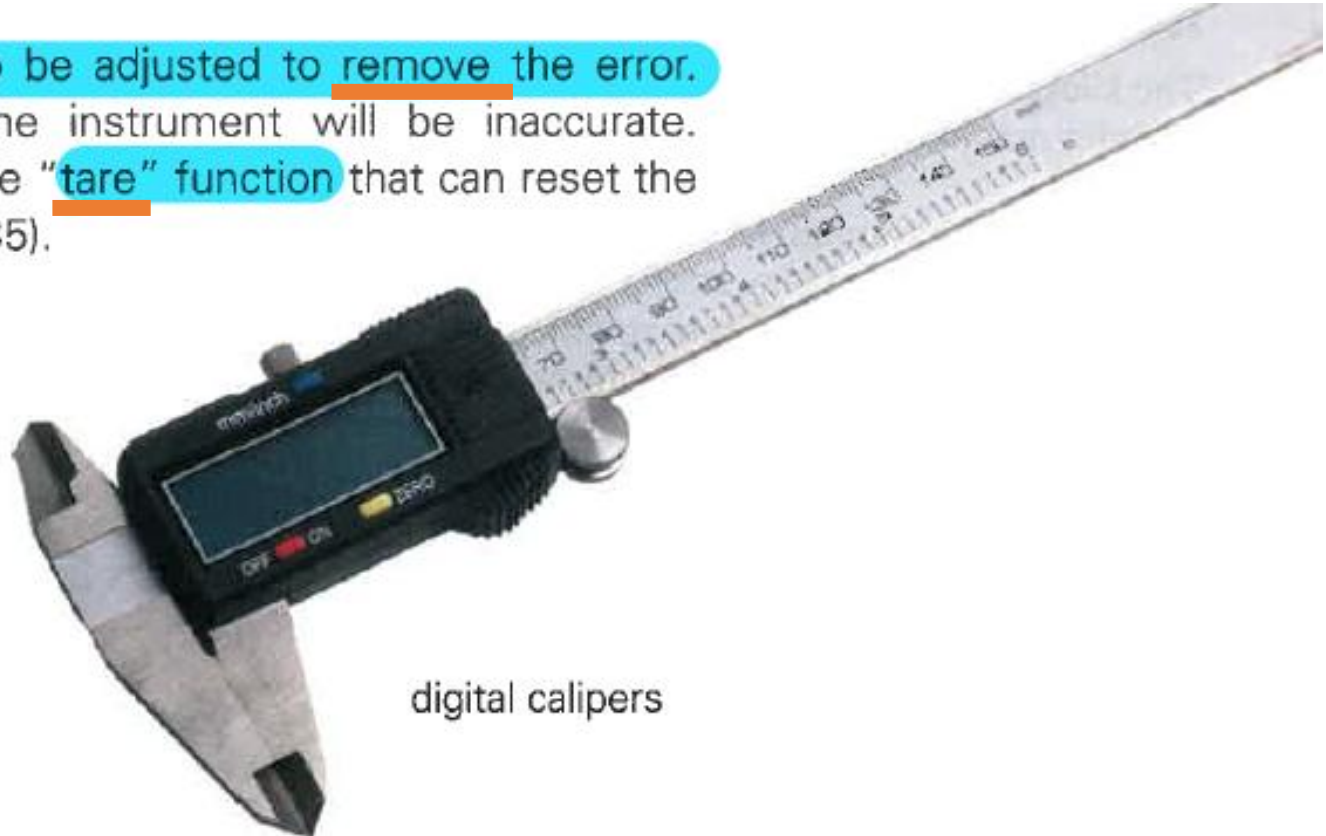
Types of Errors

The readings on weighing scales A and C should be zero as nothing is placed on them. However, their arrows point to a non-zero value. The weight measured by weighing scales A and C would be more than or less than the true value respectively, causing an inaccurate measurement. Weighing scales A and C exhibit zero error. Zero error is a type of error in which an instrument gives a non-zero reading when the measured quantity should be zero.

Instruments with zero error have to be adjusted to remove the error. If not, any readings taken with the instrument will be inaccurate. Some electronic instruments have the "tare" function that can reset the scale to remove zero error (Figure 1.35).



electronic balance



digital calipers



LEARNING POINTS

Complete the sentences.

1. A _____ is a proposed explanation for an observation that can be tested scientifically.
2. The _____ of a measurement refers to how close a reading is to the true value of the quantity.
3. The _____ of repeated measurements refers to how close the readings are to one another.
4. _____ errors are introduced when the eye is positioned wrongly when making measurements.
5. If an instrument gives a non-zero reading when the true value should be zero, it has _____ error.

OPTIONAL FOR N(A) SCIENCE

Errors That are **Consistent**

Taking readings using an instrument with zero error causes consistent error, so the readings are consistently inaccurate (Figure 1.38).



Nothing is placed.
The reading is -200 g.

A 200 g apple is placed.
The reading is 0 g.

A 300 g bunch of
grapes is placed.
The reading is 100 g.

▲ **Figure 1.38** Errors are consistent when the weighing scale has a zero error of -200 g.

Errors That are **Unpredictable**

Unpredictable errors may arise and cause imprecise measurements. Factors that contribute to unpredictable errors include unpredictable environmental conditions and human reaction time in operating a stopwatch.

An experiment was carried out to investigate how the rate of evaporation of water is affected by outdoor temperature. One beaker of water was left in the shade, while another similar beaker of water was left in the sun. Although the outdoor temperature was the same, the final amounts of water in the beakers were different. The difference could be due to an unpredictable error such as the presence of wind, which caused water to evaporate faster (Figure 1.39).

Activity Book 1.3.4: To Err is Human



Jon and Jia Li each took a 100.0 g mass and weighed it using a different electronic balance. Their results are shown in Table 1.8.

Table 1.8

Student	Mass / g			
	Reading 1	Reading 2	Reading 3	Average Reading
Jon	99.6	100.1	99.8	99.8
Jia Li	103.1	103.1	103.2	103.1

1. (a) Who had more accurate results? Circle the name and explain your answer.

- **Ans: Jon**
- **Reason: Jon's average reading is closer to the true mass of 100.0 g.**

(b) Who had more precise results? Circle the name and explain your answer.

- **Ans: Jia Li**
- **Reason: Jia Li's individual readings are closer to one another.**

2. One of the students realised that his electronic balance gave a reading of 3.0 g when there was nothing on it.

(a) What type of error was introduced? Put a tick (✓) in the correct box in Table 1.9.

Table 1.9

Type of Error	Tick (✓)
parallax error	
zero error	

(b) Do you think the error in Question 2(a) can be corrected? If so, briefly describe how it can be corrected.

Yes.

[1] Pressing the “tare” button on the electronic balance before placing the 100 g mass on it; OR

[2] Subtract 3.0 g from the reading shown by the electronic balance (if there is no tare button)

Is the error in **Question 2(a)** unpredictable or consistent? Put a tick (✓) in the correct box in Table 1.10.

Table 1.10

Description	Tick (✓)
unpredictable	
consistent	

(d) State a reason for your answer in Question 2(c).

- This error will continue as long as the value of 3.0 is not subtracted from each measurement.
- So, the measured reading will always be 3.0 g more than the actual reading.

Jon measured 50 ml of water using a 100 ml measuring cylinder. He read the measuring cylinder from three different positions, **A**, **B** and **C** (Figure 1.7).

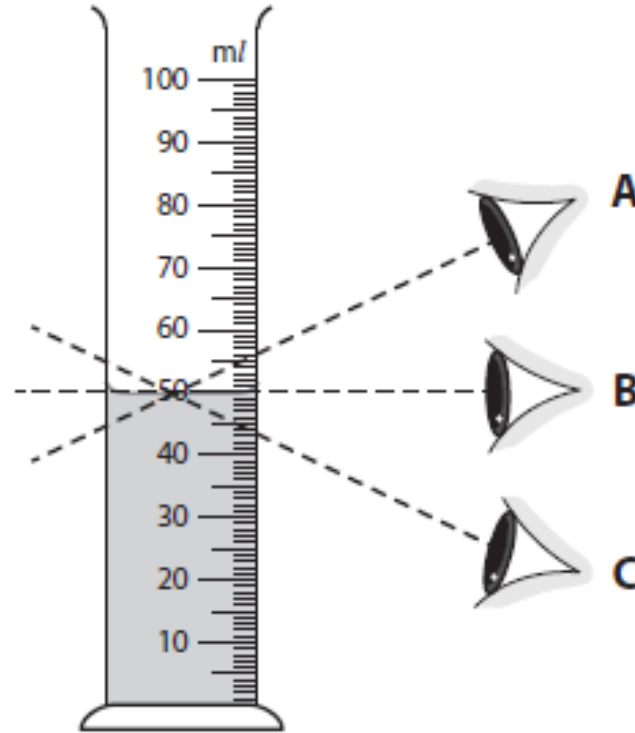


Figure 1.7

ANS: B

No parallax error at B,
because **the eye is at the
same level with the bottom
of the meniscus.**

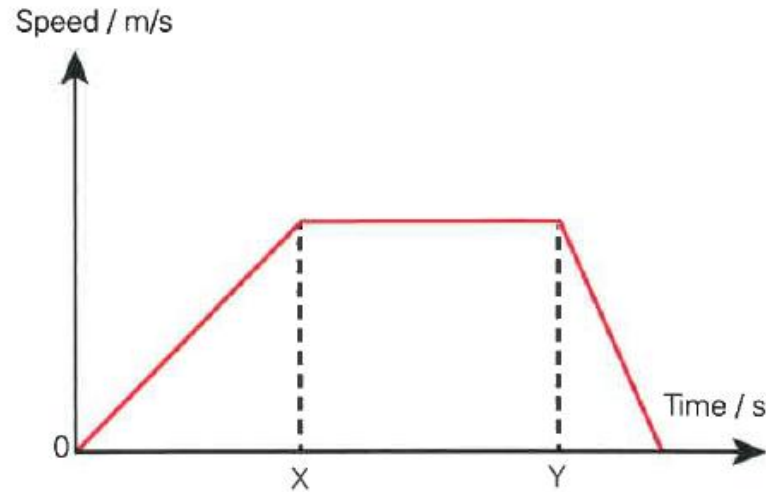
From which position should Jon take the reading to ensure an accurate measurement?

Developing Explanations and Solutions

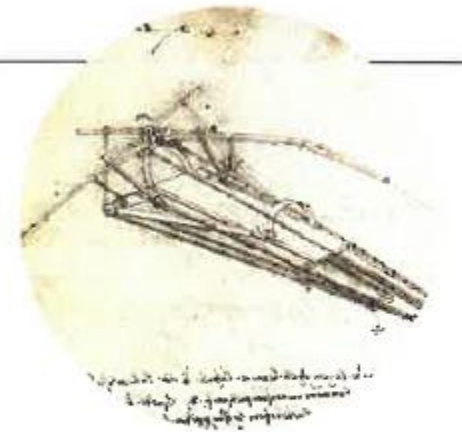
- Data collected is used to **identify** patterns or trends
- By studying these patterns or trends, **possible** explanations are made from observations.
- Data collected can be presented in different ways to help identify and communicate patterns and trends more easily.
- If any explanation or conclusion is unable to be made, we **think of other ways** to modify the investigation to obtain more useful data.



▲ **Figure 1.41** Some observations can be recorded in the form of audio recordings, videos and photographs.



▲ **Figure 1.42** Trends and relationships can be shown using charts, tables and graphs.



▲ **Figure 1.40** Specimens can be shown using diagrams and drawings.

Evaluating, Reasoning and Communicating

- In an investigation, it is good to **record** the processes, observations and findings.
- Records are useful when scientific findings are to be presented.
- Scientists use different **means** to present their findings.

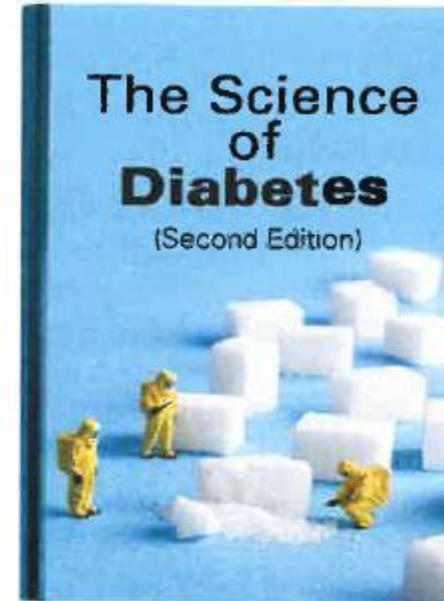
Scientists use different means to present their findings to the scientific community (Figures 1.44 to 1.46).



▲ Figure 1.44 Scientific journals



▲ Figure 1.45 Conference



▲ Figure 1.46 Scientific book

1.4 What influences the way we practise Science?

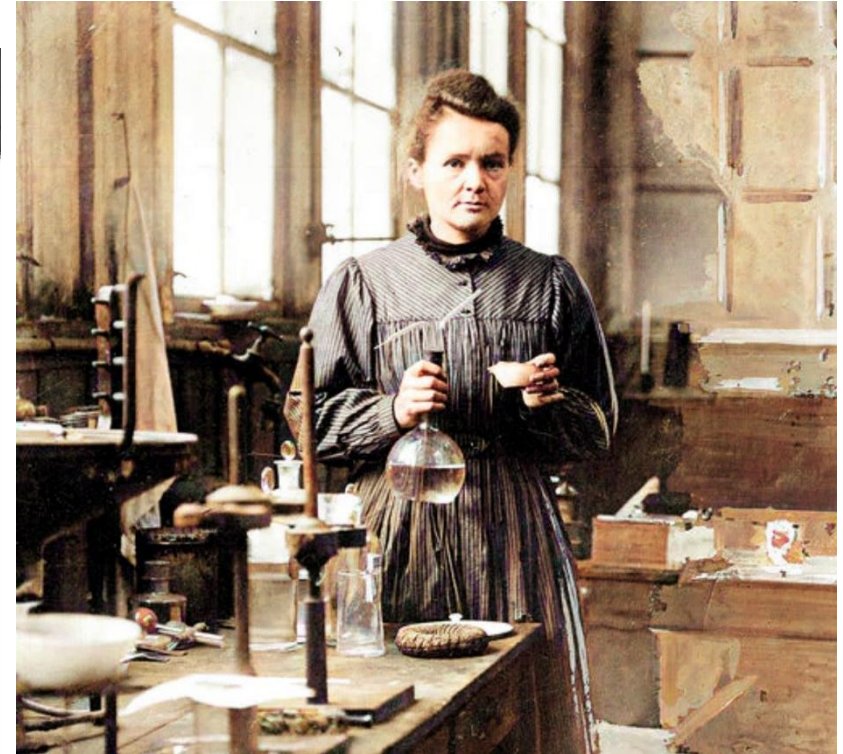
Success Criteria: I am able to	UR
☐ understand that attitudes such as creativity, objectivity, integrity, open-mindedness and perseverance are important in carrying out scientific inquiry.	1 2 3 4 5
☐ understand the importance and follow safety rules when conducting experiments in the laboratory.	1 2 3 4 5
☐ match hazards to their respective symbols: corrosive, irritant/harmful, environment toxicity, oxidising substance, gases under pressure, acute toxicity, explosive, flammable, carcinogenicity. (Drawing of symbols <u>not</u> required.)	1 2 3 4 5
☐ suggest safety precaution(s) corresponding to identified hazard(s)	1 2 3 4 5
☐ identify and label parts of the Bunsen burner	1 2 3 4 5
☐ distinguish between luminous flame and non-luminous flame and how to obtain these flames.	1 2 3 4 5

1.4 What influences the way we practise Science?

Values, Ethics, Attitude!

Contributions and legacies of Marie Curie

- She did intensive research on radioactivity.
- Her scientific findings helped to overturn established ideas in various fields of science. They also provided the means for other scientists to make further scientific discoveries.
- Radium Institutes in France and Poland were founded in her honour. These institutes remain major centres of medical research today.
- She is the first female Nobel Prize winner. She and her husband were awarded a Nobel Prize for their work on radioactivity. She was later awarded another Nobel Prize.



Perseverance

Marie Curie was unable to attend a university as women were not accepted by universities in Poland then. However, she did not give up learning while she was working. She eventually had enough money to pursue higher education in France. After her graduation, she continued to work in France. She and her husband persisted for many years before they successfully isolated the metal radium and proved its existence.

Creativity and Responsibility

Besides investigating natural phenomena, Marie Curie also tried to solve **real-life problems** by applying her scientific knowledge.

During World War I, Marie Curie **invented a way of sterilising infected wounds using radioactive gas**. She also developed and **provided mobile X-ray services for field hospitals to help doctors diagnose and provide better treatment to injured soldiers** (Figure 1.52).



◀ Figure 1.52 Truck that transported X-ray machines to field hospitals



CONNECT THE DOTS

Activity Book 1A:
1.4.1 Avani's
Investigation Into Her

Curiosity, Open-mindedness and Objectivity

Marie Curie exhibited curiosity and willingness to think of new ways to solve scientific problems. Being curious and open-minded about the earlier discoveries of other scientists, she decided to investigate uranium samples. She did this by measuring electric charge with an instrument invented by her husband (Figure 1.51).

Integrity

Marie Curie was provided with one gram of radium by a group of donors. However, she donated the metal to a university in Poland instead.

Ethics

Marie Curie and her husband **deliberately decided not to copyright the technique of isolating radium**. Doing so would have granted them exclusive rights to the technique. However, **it would have been harder for other scientists to apply the technique and develop new solutions**.

The decision to copyright scientific research or not is an example that highlights how decisions related to ethics are often not straightforward. Ethical decisions involve **careful consideration of one's duties, rights and values**.



CONNECT THE DOTS

Activity Book 1A:
1.4.1 Avani's
Investigation Into Her
Pest Problem (Part 2)
page 23

Safe Practices in Science

- Look at the advertisement on the right.
- Can you list down what are the unsafe practices?



Safe Practices in Science



Safety rules when handling and disposing glassware and sharp objects!



Safety rules for the use of electrical devices!



Activity Book 1.4.2: Safety in the Science Laboratory



- Do only Part B: Safe practices in the Science Laboratory

B Safe Practices in the Science Laboratory

Figure 1.9 shows some students in a science laboratory.

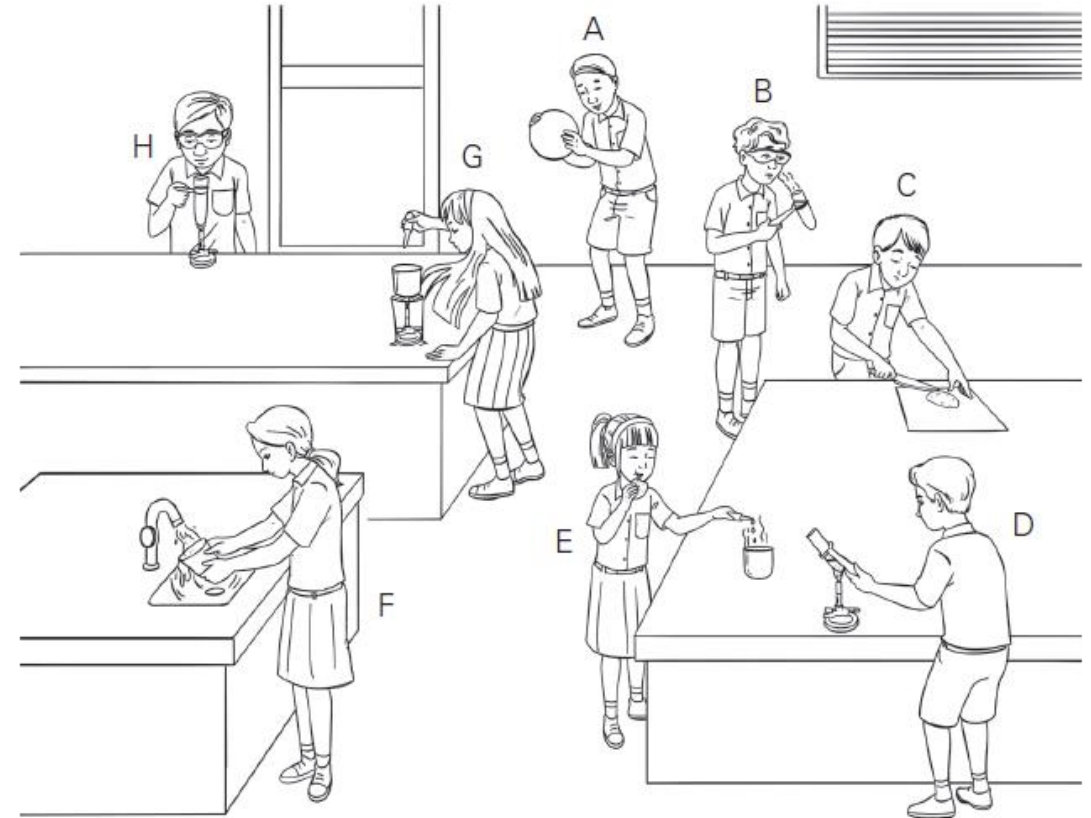


Figure 1.9

Q1) Which students in Figure 1.9 are not adopting safe practices?

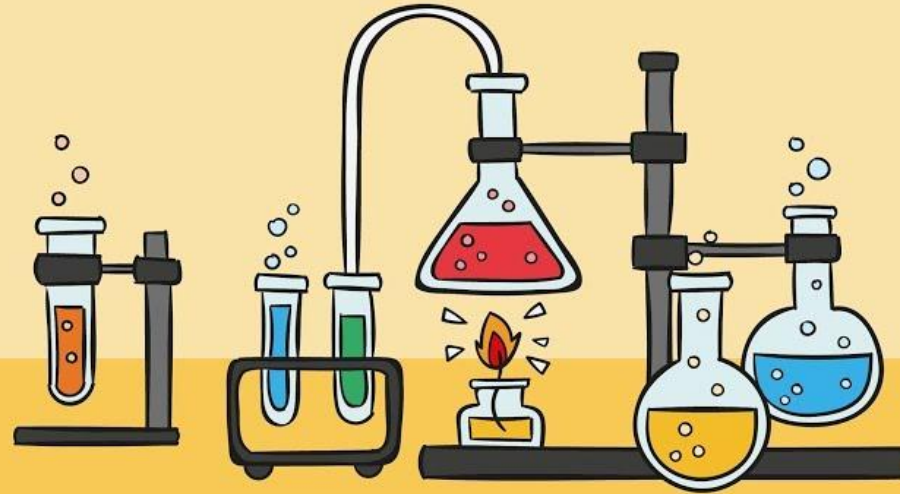
- A, B, C, D, E, G, H.

[C should wear goggles when cutting specimen to protect her eyes]

Safe Practice	Student	Importance of the Practice
Refraining from playing in the laboratory	A	Might knock apparatus over or cause accidents
Using the fume cupboard when handling chemicals that give out fumes	B	To prevent inhalation of toxic fumes
Wearing safety goggles when heating	D, G	To prevent chemicals from getting into your eyes
Pointing the mouth of a test tube away from others when heating	D	To prevent chemicals from spurting towards others and scalding them
Refraining from eating in a science laboratory	E	To prevent contamination of the reagents, apparatus and food
Tying up one's long hair before entering the laboratory	G	To prevent her hair from being burnt by the naked flame
Pointing the mouth of a test tube away from oneself when heating	H	Prevent chemicals that spurt out of the test tube from falling on her and scalding her

Activity Book 1.4.3: Safety Precautions when using a Bunsen Burner

[Click to play video](#)



THE BUNSEN BURNER

Differences between Luminous and Non-luminous flames

Name of flame	Luminous	Non-luminous
Colour	Yellow or orange	Pale / light blue
Steady/unsteady	Unsteady	Steady
Visibility	Easily visible	Not easily visible
Hotness	Hot	Very hot
Produces soot?	Yes (due to incomplete combustion of gas)	No
Air-hole of Bunsen burner after the flame is lit.	Closed	Open

Differences between Luminous and Non-luminous flames



Activity Book 1.4.3: Safety Precautions when using a Bunsen Burner

Procedure and Observations

1. Identify and label the parts of the Bunsen burner in Figure 1.10.

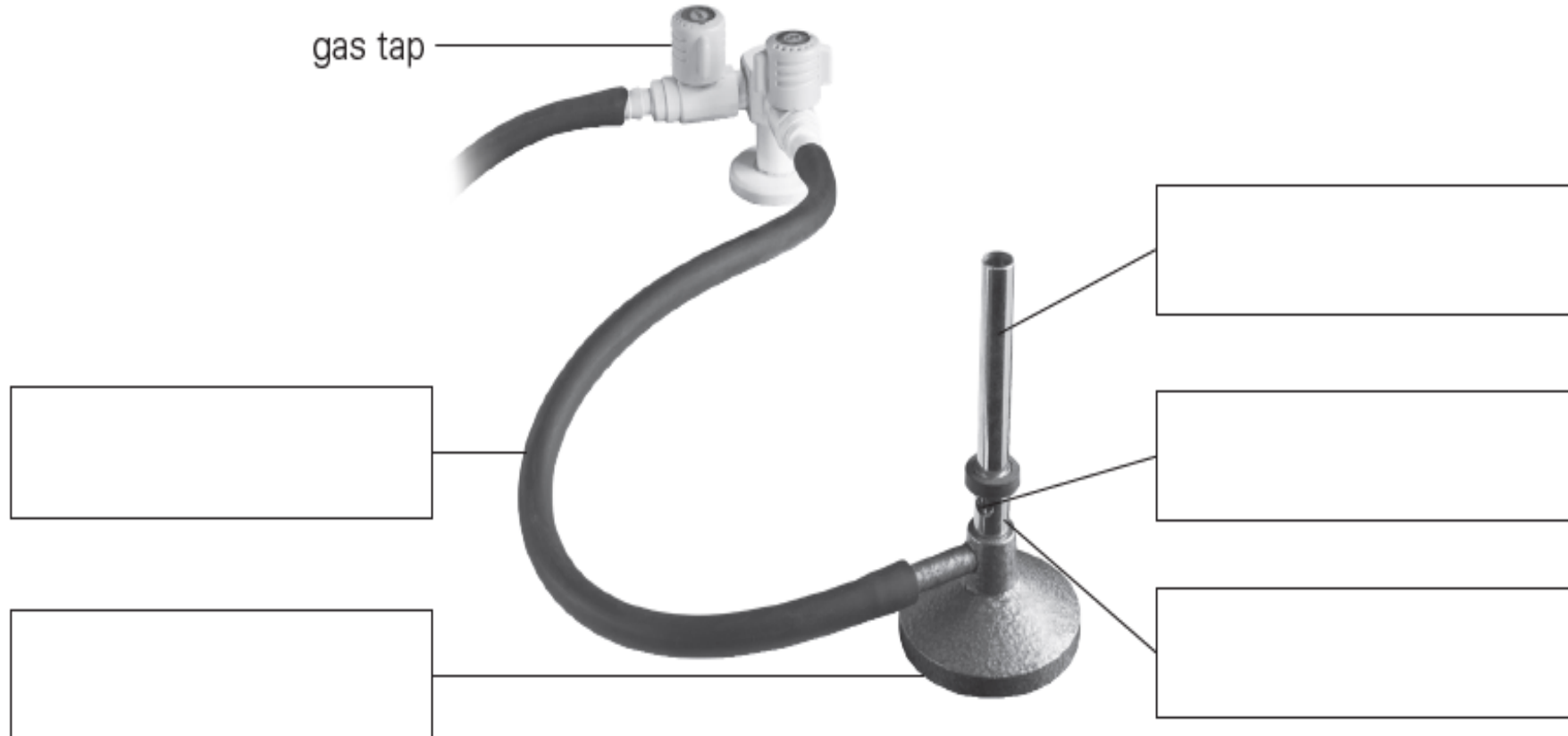


Figure 1.10



Figure 1.10

5)(a)

orange/ yellowish orange

blue



Figure 1.11

5)(b)

Unsteady

6)(a)

pale blue

dark blue



Figure 1.12

6)(b)

Steady

7)

Close the air-hole again

Questions

1. Which flame, luminous or non-luminous, is more visible to the eye?

Luminous flame

2. Which flame, luminous or non-luminous, should be used for heating?
Explain your answer.

Non-luminous flame. It is hotter than the luminous one.

3. If the Bunsen burner was to be left unattended for a short while, which type of flame should be used? Explain your answer.

Luminous flame. It is more visible than the non-luminous one.

ACTUAL: Switch off gas tap when Bunsen burner is not in use.

Hazard symbols (Figure 1.56) are developed by the United Nations as part of standardised communication on chemical hazards. Knowledge of these symbols helps people to protect themselves and the environment from hazardous chemicals. It also facilitates international chemical trading.

Most equipment and chemicals in a science laboratory are labelled with hazard symbols. We should look out for these symbols when carrying out investigations. We should also be aware of the potential dangers to health and safety that these equipment and chemicals may cause.

Some commonly used chemicals may be hazardous. They are diluted (made less concentrated) so that they can be used safely in the laboratory.



▲ Figure 1.56 Hazard symbols and what they mean

Activity Book 1.4.4: Hazard Symbols



		Catches fire easily	Keep the chemical away from an open flame or flammable sources.
		Causes toxic or harmful effects to the body when breathed in, swallowed or in contact with skin	Wear gloves and eye protection when using the chemical.
		May cause cancer or damage to organs over time	Wear appropriate protective clothing to prevent body parts (e.g., eyes, skin and lungs) from coming into contact with the chemical.
		May explode when heated, or cause breathing difficulties when leaked in an enclosed space	Avoid tampering with or damaging the cylinder that contains the chemical.
		May cause damage to body parts in contact	Wear gloves and eye protection when using the chemical.
		Releases oxygen easily and aids burning	Keep the chemical away from open flames.
		Explodes easily when heated	Avoid tampering with or damaging the container that contains the chemical.
		Causes irritation to the body	Wear appropriate protective clothing to prevent body parts (e.g., eyes, skin and lungs) from coming into contact with the chemical.
		Causes harm to aquatic life	Replace the chemical with another chemical that does not harm aquatic life. Dispose of the chemical responsibly.

2. Many cleaning agents contain chemicals. Look around your home for a cleaning agent that carries a hazard symbol.

- (free response from student)

(a) The cleaning agent that I have found is _____.
Its packaging carries the hazard symbol of _____.

- **Possible answer: bleach ; corrosive, etc**

(b) State one safety precaution you should take when handling this chemical.

- **E.g. wear gloves; use the agent in a well-ventilated area; OR**
- **avoid using the agent near open flames**
- **Other reasonable answer.**

1.5 Why do we learn Science?

Success Criteria: I am able to	UR
☐ discuss the benefits and harmful effects of science and technology to society	1 2 3 4 5
☐ relate applications of science to some social and ethical issues.	1 2 3 4 5
☐ identify some current limitations of science and technology in solving societal problems.	1 2 3 4 5
☐ understand the need to use technology and scientific knowledge responsibly	1 2 3 4 5

Scientific applications have improved our lives but has also harmed the environment and society.

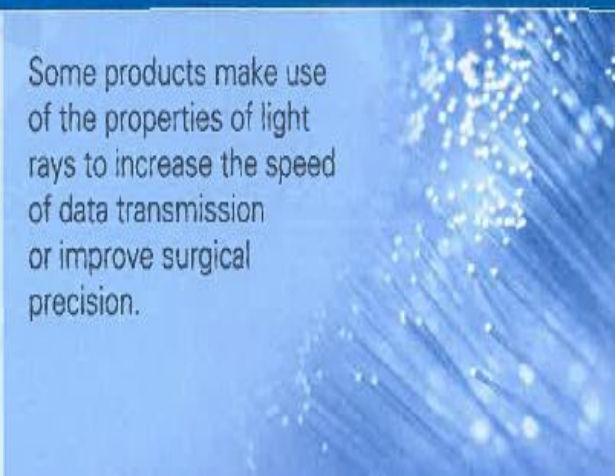
Benefits

Plastics are used to make numerous lightweight and waterproof products.



▲ **Figure 1.57a** Plastic bottles that are lightweight and waterproof are used as containers.

Some products make use of the properties of light rays to increase the speed of data transmission or improve surgical precision.



▲ **Figure 1.57c** The increased speed of data transmission is brought about by properties of light rays.

Harmful effects

Plastics are non-biodegradable and can cause land and water pollution.

▼ **Figure 1.57b** Pollution caused by improper disposal of plastic products



Urbanisation and the presence of light at night can affect the lives of animals.



▲ **Figure 1.57d** Article showing how turtles are affected by light

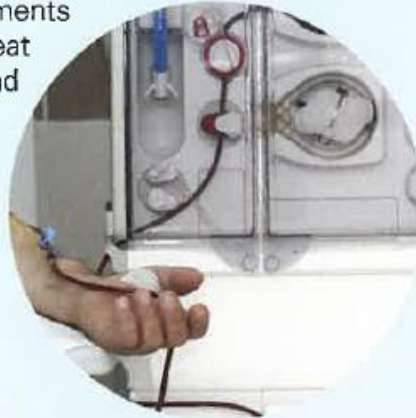
Benefits

The invention of paper products has changed the way we print, write and communicate.



▲ **Figure 1.57e** Paper products such as books and magazines are commonly used.

Medical advancements have helped to treat many diseases and ease the pain suffered by patients.



▲ **Figure 1.57g** Medical advancements improve the lives of patients.

Harmful effects

Excessive logging leads to deforestation, which in turn contributes to global warming and climate change.



▲ **Figure 1.57f** Deforestation is caused by excessive logging.

Medical and chemical knowledge is used to produce biological and chemical weapons, which can cause casualties and damage.



▲ **Figure 1.57h** Chemical weapons such as tear gas can cause harm.

Scientific applications have its limitations.
Science cannot answer all questions.
Science cannot solve all problems.

To solve any problem,
we need to consider
these!

“

*Science in everyday
life has many
applications and is
still in the process to
develop more
innovative solutions
for our biggest
problems.*

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CONNECT THE DOTS

Activity Book 1A:
1.5.1 Genetically
Modified Fish – Impact
and Implications
pages 31–32

Video on GM
food – SLS 1.5

Ethical considerations	Social considerations	Environmental considerations	Economic considerations
Characteristics • Consider the moral values of individuals or groups • Consider personal duties, rights and beliefs	Characteristic • Consider what is commonly accepted in society	Characteristic • Consider the possible effects on living things and the environment	Characteristic • Consider the cost and benefits of an issue
Example • Should the use of plastic bags be banned nationwide?	Examples • How often are plastic products used in daily life? • Is there a growing trend in the use of disposable plastic products in Singapore?	Example • How does the production of plastics affect living things and the environment?	Examples • How much does it cost to produce disposable plastic utensils? • How much is earned from the sale of plastic products? • How much does it cost to produce alternatives that are not harmful to the environment?