Science 7–8

Chapter 3 — Planning and conducting

Aboriginal and Torres Strait Islander content has been excluded as accuracy cannot be guaranteed, and it is better to be respectful than cover the entire curriculum inaccurately.

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Contents

Planning a reproducible investigation: independent, dependent and controlled variables, and stating the assumptions you are making

What we teach here — `VC2S8I02` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"reproducible investigations to answer questions and test hypotheses can be planned and conducted, including identifying independent, dependent and controlled variables where applicable, stating assumptions, recognising and managing risks, considering ethical issues and following protocols when accessing cultural sites and artefacts on Country and Place"* **This subtopic owns the planning clause only**: planning reproducible investigations — what a reproducible plan looks like, independent, dependent and controlled variables, and stating the assumptions a plan leans on. The rest of the CD — recognising and managing risks, considering ethical issues, and following protocols when accessing cultural sites and artefacts on Country and Place — belongs to the partner subtopic **3B** († split delivery, D6). **In our words:** a test is only as good as its plan. If a plan leaves things to guesswork, nobody can tell whether the answer came from the one thing you changed or from something you forgot to hold still — and nobody else can repeat what you did. So a good plan names the one thing you change, the one thing you measure, and everything you keep the same, and it says out loud the things it takes as given without checking. That last habit — stating your assumptions — is the quiet skill underneath all the others. **Achievement-standard extract served here (D13):** *"They plan a range of reproducible scientific investigations, document procedures and identify potential ethical issues and intercultural considerations required for fieldwork or use of secondary data."* 3A is the owner of `VC2S8I02`, so the extract appears here in full; the partner subtopic 3B cites it by reference to this header. 3A serves the first half of that sentence — planning reproducible investigations and writing procedures down; the ethical-issues and intercultural-considerations half is served by 3B. **Elaborations drawn on:** `VC2S8I02.E01` (identifying assumptions relating to variables that are assumed to be constant, such as ambient temperature, properties of materials used and purity of substances), `VC2S8I02.E02` (identifying assumptions related to testing a hypothesis using analogous models, such as using dialysis tubing to model the properties of plant cell walls) and `VC2S8I02.E04` (discussing why it is important to identify variables and assumptions when planning an investigation, and designing reproducible investigations that specifically test variables of a causal relationship and control the remaining variables). **Authored from the CD text and the elaboration contexts (D12):** the CD names reproducible investigations, the three kinds of variable, and stated assumptions as the things a plan must carry; E01 and E02 supply the two families of assumption practised here — assumptions about what stays constant, and assumptions about models that stand in for the real thing — and E04 supplies the reason it all matters: a plan that tests the variable of a causal relationship and controls everything else. Scope is capped by D9: risks, ethical issues and protocols are 3B's and do not appear here at all. **No Aboriginal or Torres Strait Islander content is delivered here (D10):** the CD's Country-and-Place clause is delivered, from named published sources, by the partner subtopic 3B.

Word watch — *reproducible*, *variable*, *hypothesis*, *assumption*, *analogous model*. The Victorian Curriculum uses all five terms and does not define them. This subtopic therefore treats them as follows, and every question here is answerable on these definitions alone. A **variable** is anything in a test that could take different values: the **independent variable** is the one you change on purpose, the **dependent variable** is the one you measure as the outcome, and a **controlled variable** is one you keep the same so it cannot affect the outcome. A **hypothesis** is a testable idea about the answer to a question — a claim a plan can support or knock down. An investigation is **reproducible** when another group can follow your written plan and compare their results with yours. An **assumption** is something the plan takes as given without checking. An **analogous model** is a stand-in you can handle and watch, used because the real thing is too small, too fast or too hard to test directly — it is *analogous* because it behaves like the real thing in the one way you are testing.

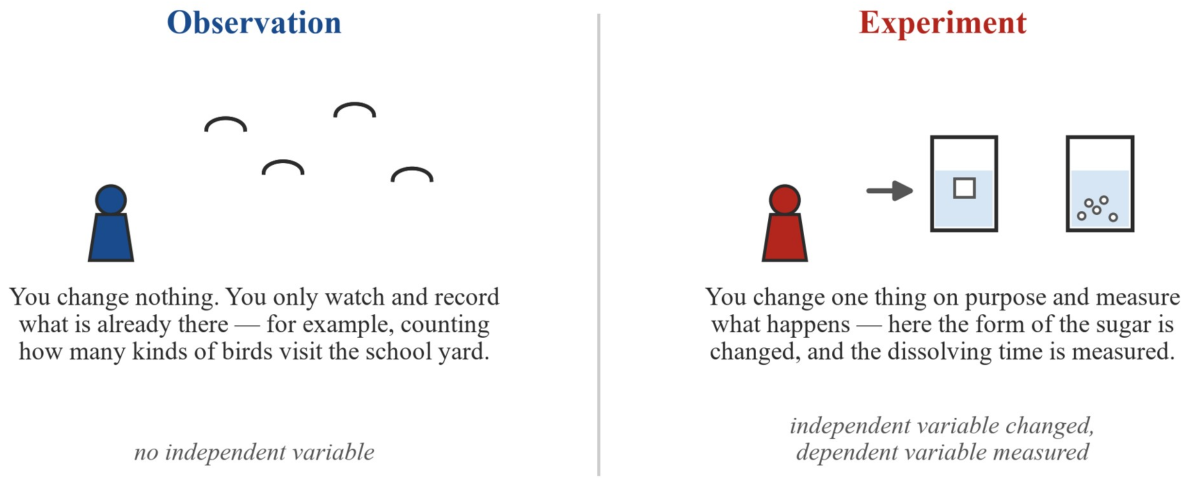
Theory

A question, and two ways to answer it

Science starts with a question, and there are two ways to answer one.

In an **observation**, you change nothing. You watch and record what is already there — counting how many kinds of birds visit the school yard at lunchtime, for example. Nothing is changed on purpose, so there is no independent variable.

In an **experiment**, you change one thing on purpose and measure what happens. Put a whole sugar cube in one beaker and a crushed cube in another, and time how long each takes to dissolve: the form of the sugar is changed on purpose, and the dissolving time is measured.



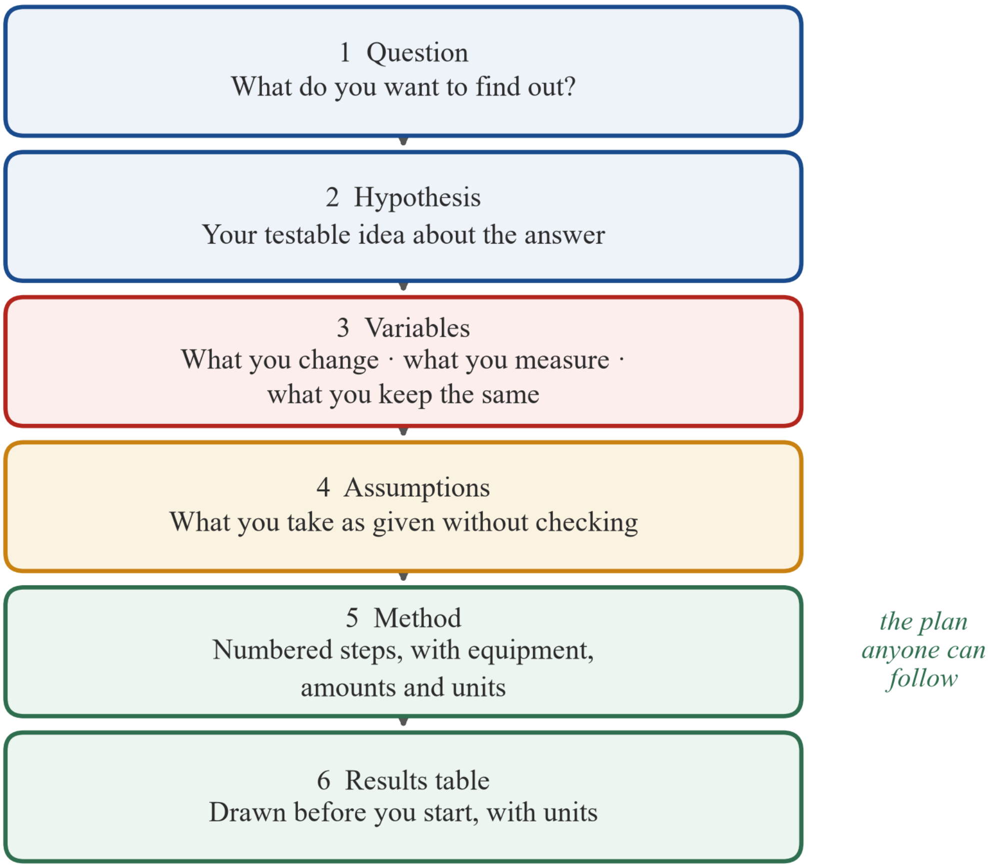
Two side-by-side panels, one showing a person watching and counting birds with the label "Observation — no independent variable", the other showing a person with two beakers, one holding a whole cube and one holding crushed sugar, with the label "Experiment — independent variable changed, dependent variable measured"

Naming experiment and observation as the two ways to collect data is a step science shares with maths: planning investigations with experiments and observations also appears in the maths interlock `VC2M7ST03` and `VC2M8ST01` (D11). This subtopic is about the experiment side — the kind of investigation where a plan must say what changes, what is measured, and what is held still.

The plan anyone can follow

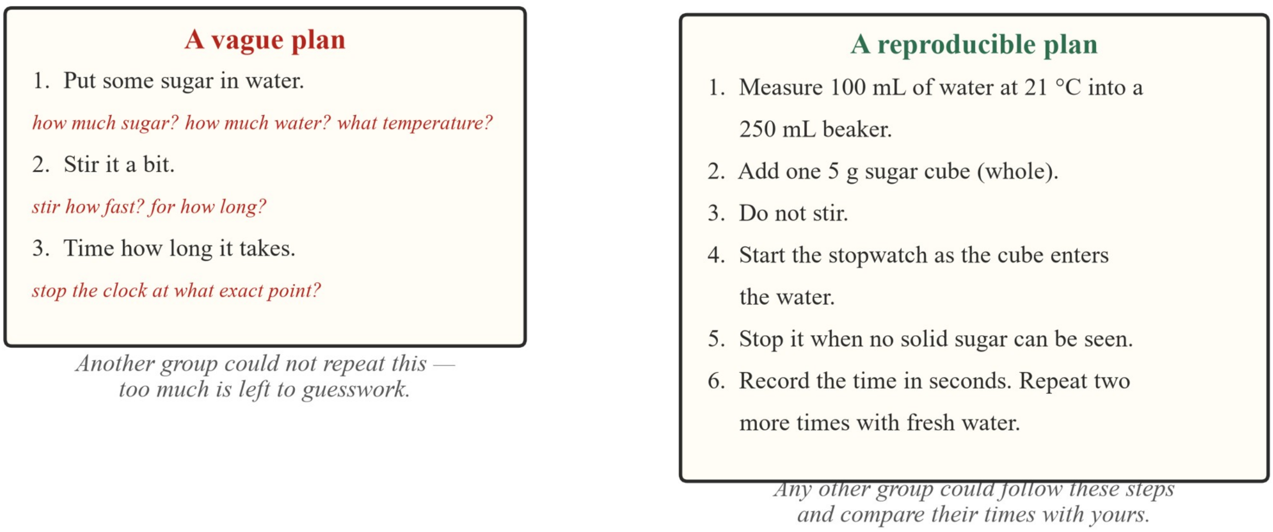
An investigation is **reproducible** when another group can follow your written plan and compare their results with yours. Reproducible is the word for the biggest promise science makes: a result is not a private story, it is something anyone can check.

A reproducible plan has six parts, in order.



Flow diagram of six planning steps joined by arrows, top to bottom: 1 Question — what do you want to find out?; 2 Hypothesis — your testable idea about the answer; 3 Variables — what you change, what you measure, what you keep the same; 4 Assumptions — what you take as given without checking; 5 Method — numbered steps with equipment, amounts and units; 6 Results table — drawn before you start, with units

The difference between a vague plan and a reproducible one is not effort — it is detail. Compare the two plans below. They describe the same test. Only one of them could be followed by a group in the next room.



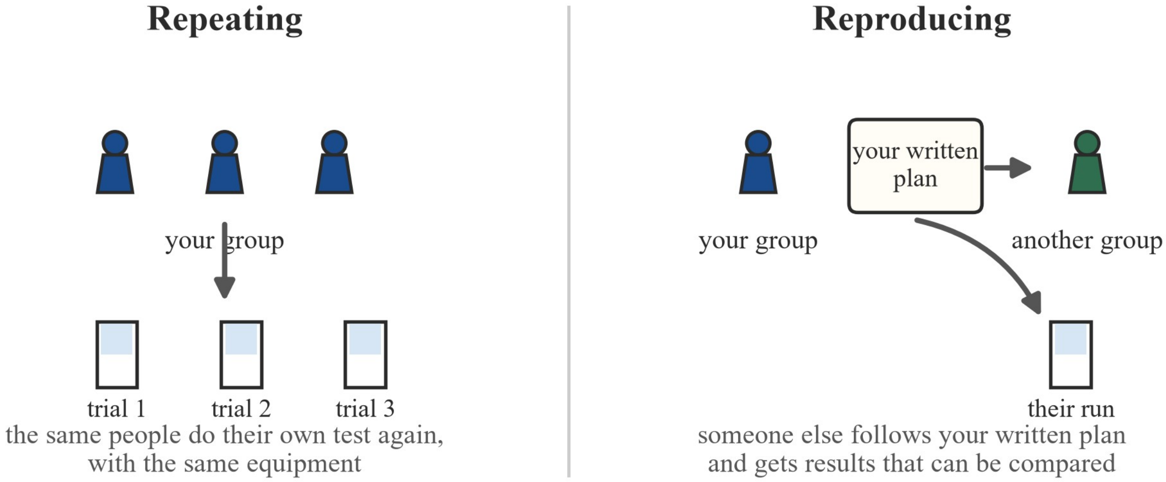
Two plan cards side by side. Left, "A vague plan": 1. Put some sugar in water. 2. Stir it a bit. 3. Time how long it takes — with red questions under each step: how much sugar? how much water? what temperature? stir how fast? for how long? stop the clock at what exact point? Right, "A reproducible plan": 1. Measure 100 mL of water at 21 °C into a 250 mL beaker. 2. Add one 5 g sugar cube (whole). 3. Do not stir. 4. Start the stopwatch as the cube enters the water. 5. Stop it when no solid sugar can be seen. 6. Record the time in seconds, and repeat two more times with fresh water

Every red question on the vague plan is a place where another group would have to guess — and guesses differ, so their results could not be compared with yours. The reproducible plan answers all of them before anyone touches a beaker: amounts with units (100 mL, 5 g), a temperature (21 °C), a start rule (as the cube enters the water), a stop rule (when no solid sugar can be seen), and a unit for the result (seconds).

Repeats, and another group

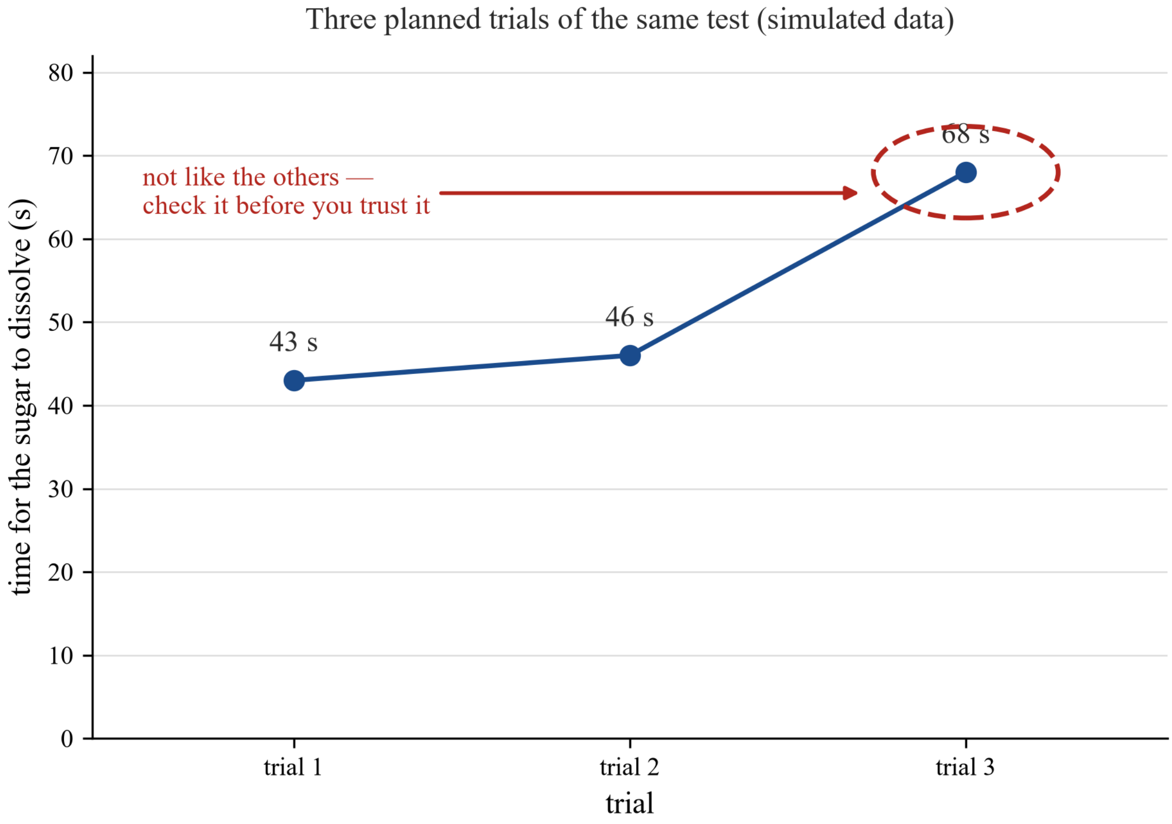
One run of a test can be unlucky — a late thumb on the stopwatch, a cube a little bigger than the next. So a reproducible plan says, before the test starts, how many **trials** there will be.

Repeating is doing your own test again: the same people, the same equipment, more trials. **Reproducing** is someone else following your *written* plan and getting results that can be compared with yours. Repeating checks your own luck; reproducing checks your plan.



Two side-by-side panels. Left, "Repeating": one group of three people above three beakers labelled trial 1, trial 2, trial 3 — the same people do their own test again with the same equipment. Right, "Reproducing": one group handing over a card labelled "your written plan" to another group, who run their own beaker — someone else follows your written plan and gets results that can be compared

Here are three planned trials of the sugar test (*simulated data — made-up values to think with, not measured results*).



Line graph of three planned trials of the same test with simulated data: trial 1 at 43 s, trial 2 at 46 s, trial 3 at 68 s, with the third point circled in red dashes and an arrow reading "not like the others — check it before you trust it"

Trials 1 and 2 sit close together; trial 3 is not like the others. The rule for a result like that is: **check it before you trust it**. Do not quietly cross it out, and do not quietly keep it — look for what was different about that run (a late start? a bigger cube? water from a different tap?), and run the trial again. The plan said three trials *before* the test began, so checking a strange result is part of the plan, not a fix-up afterwards.

Variables: one change, one measure, everything else held still

Take the question: *does the form of a sugar cube change how fast it dissolves in water?* Every thing in the test that could take a different value is a **variable**, and the variables fall into three jobs.

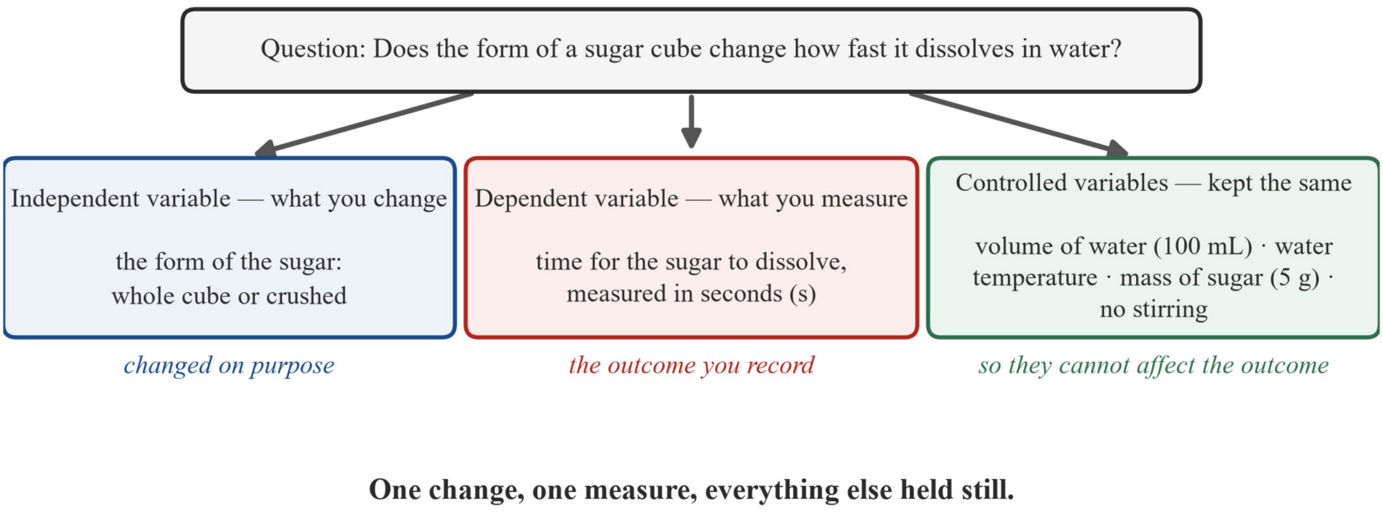
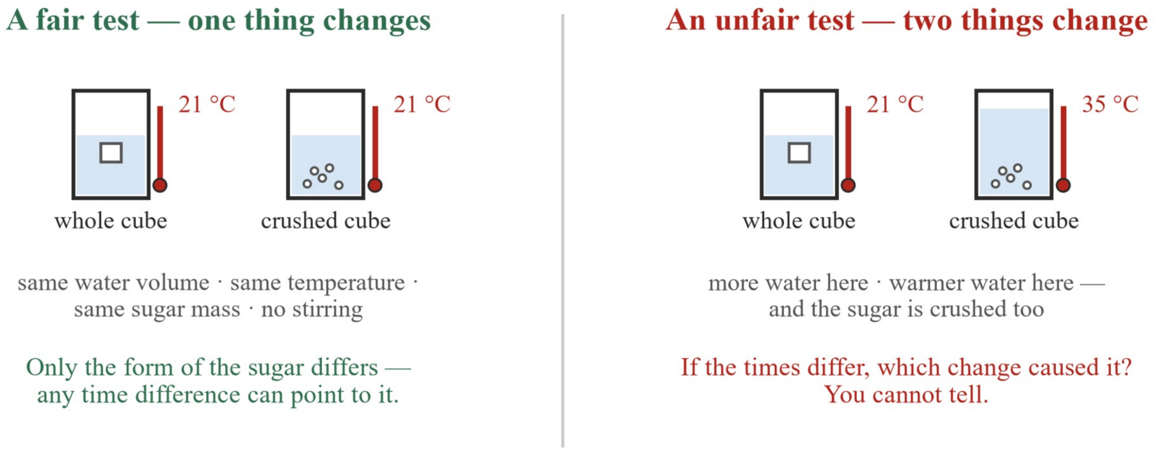


Diagram with the question "Does the form of a sugar cube change how fast it dissolves in water?" at the top and three boxes below it: Independent variable — what you change (the form of the sugar: whole cube or crushed), Dependent variable — what you measure (time for the sugar to dissolve, measured in seconds), Controlled variables

— kept the same (volume of water 100 mL, water temperature, mass of sugar 5 g, no stirring), with the caption "One change, one measure, everything else held still."

- The **independent variable** is what you change on purpose: the form of the sugar — whole cube or crushed.
- The **dependent variable** is what you measure: the time for the sugar to dissolve, in seconds, on a stopwatch.
- The **controlled variables** are everything you keep the same so they cannot affect the outcome: the volume of water (100 mL), the water temperature, the mass of sugar (5 g), and no stirring.

A test built like that is called a **fair test** in primary school, and the name still fits: only one thing differs between the two beakers, so any difference in the times can point at it.

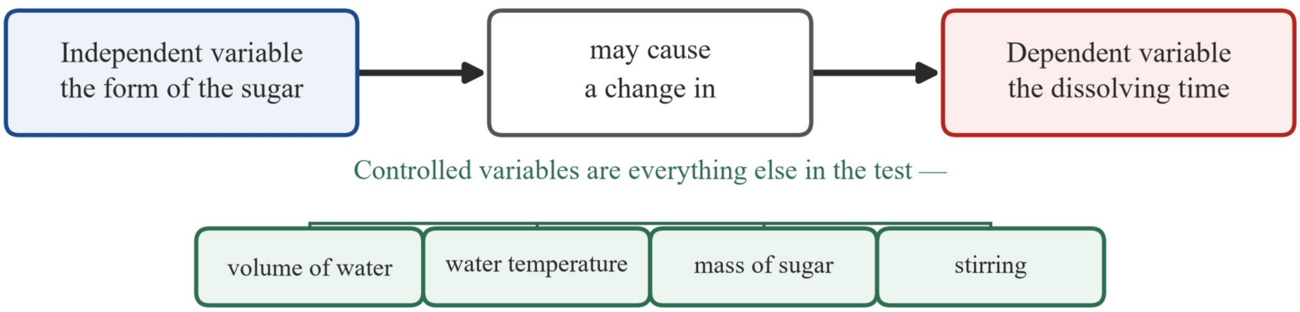


Two side-by-side panels of beakers. Left, "A fair test — one thing changes": a whole cube and a crushed cube in the same volume of water at the same 21 °C. Right, "An unfair test — two things change": a whole cube in less, cooler water and a crushed cube in more, warmer water at 35 °C, with the caption "If the times differ, which change caused it? You cannot tell."

In the unfair panel, the crushed cube also has more water and warmer water. If its time is different, which of the three changes caused it? There is no way to tell — the test has three answers and no way to choose between them.

Why name the variables? Causal claims (`VC2S8I02.E04`)

The reason variables matter is that an experiment like this one is testing a **causal relationship** — the claim that one thing *makes* another thing happen. The independent variable is the cause you are testing; the dependent variable is the effect you measure.



If two things change at once, the chain breaks — you cannot say which one mattered.

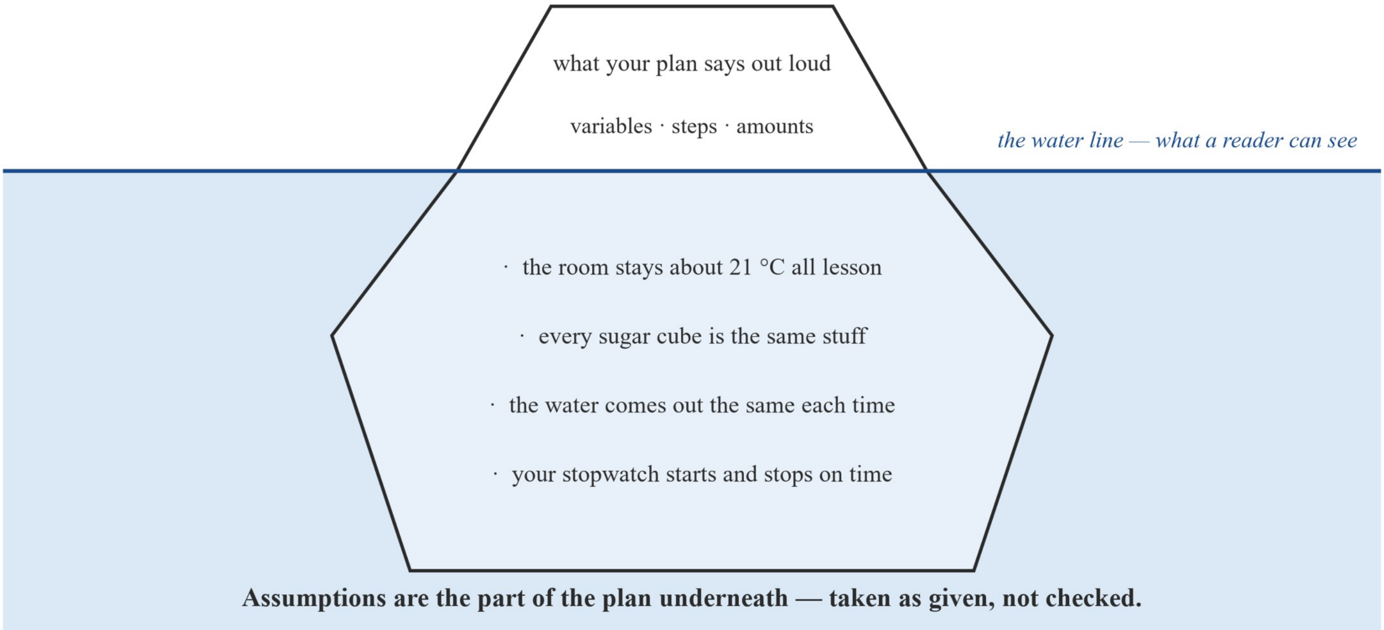
Cause-chain diagram: "Independent variable — the form of the sugar" with an arrow to "may cause a change in", then an arrow to "Dependent variable — the dissolving time"; below, a green bracket holding four boxes — volume of water, water temperature, mass of sugar, stirring — labelled "Controlled variables are everything else in the test", with the caption "If two things change at once, the chain breaks — you cannot say which one mattered."

The chain only holds if everything else in the test is controlled. If two things change at once, the chain breaks — a difference in the times could come from either change, and the plan has no answer to the question *which one mattered?* That is why a reproducible design changes the one variable of the causal relationship and controls the remaining variables: not as a ritual, but so the result can point at a cause.

It is just as important to say *why* the naming matters. A plan that does not name its variables has not said what it is testing; a plan that does not state its assumptions has not said what it leans on. Naming both is what turns "we did a test" into "here is a claim, here is what could have broken it, and here is why the result still points where it points".

Assumptions: the part of the plan you don't say

An **assumption** is something the plan takes as given without checking. Every plan has them — the skill is not to avoid assumptions but to *state* them, because an assumption you have not written down is a hole in the plan nobody can see.



Iceberg diagram: above the water line, the tip labelled "what your plan says out loud — variables, steps, amounts"; below the water line, the much larger body holding four lines: the room stays about 21 °C all lesson; every sugar cube is the same stuff; the water comes out the same each time; your stopwatch starts and stops on time — with the caption "Assumptions are the part of the plan underneath — taken as given, not checked."

In a school investigation, assumptions usually fall into three families (`VC2S8I02.E01`).

Three common families of assumptions in a school investigation

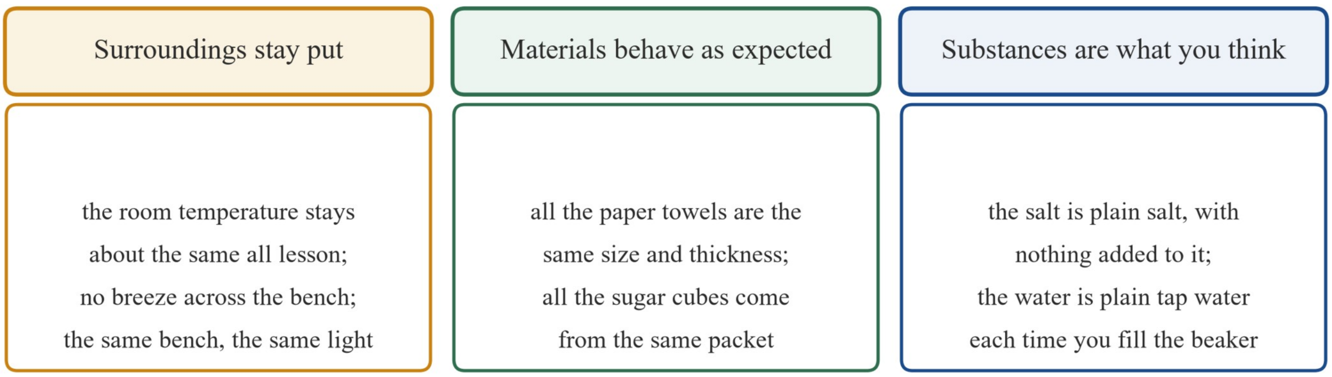
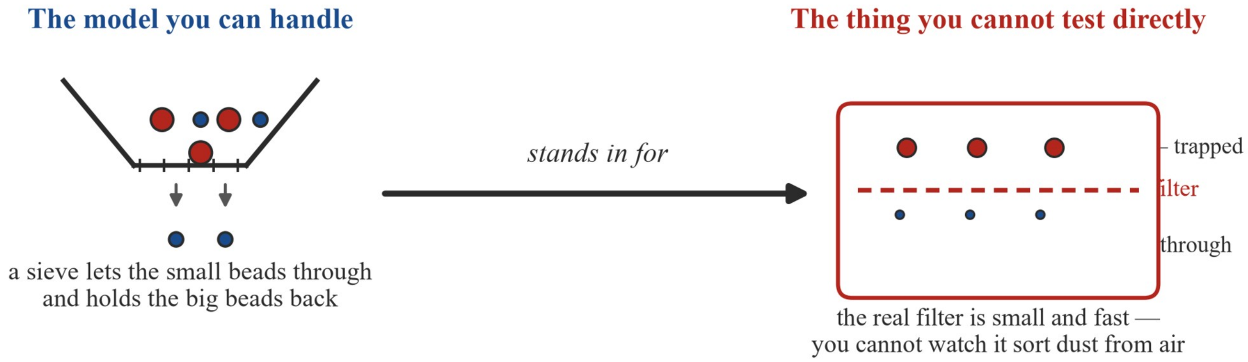


Diagram of three labelled columns. "Surroundings stay put": the room temperature stays about the same all lesson; no breeze across the bench; the same bench, the same light. "Materials behave as expected": all the paper towels are *the same size and thickness; all the sugar cubes come from the same packet. "Substances are what you think": the salt is plain salt with nothing added to it; the water is plain tap water each time you fill the beaker*

The curriculum's own list names these families directly: **ambient** temperature — the temperature of the room around the test — is assumed to stay about the same; the **properties of materials used** are assumed to behave as expected; and the **purity of substances** is assumed — that the salt is plain salt, the water plain water. None of these is checked during the test. Each one is taken as given — and each one *could* be false, which is exactly why it gets written down.

Assumptions about models that stand in for the real thing (`VC2S8I02.E02`)

Some things cannot be tested directly. You cannot watch a vacuum-cleaner filter sort dust from air — it is too small and too fast. So you test a **analogous model**: a sieve and two sizes of bead, which you *can* handle and watch, standing in for the filter.



The assumption you must state: the model sorts like the real thing does — in the one way you are testing, and only in that way.

Two-panel diagram joined by a long arrow labelled "stands in for". Left, "The model you can handle": a sieve holding back big red beads while small blue beads fall through. Right, "The thing you cannot test directly": a box with a dashed filter line, red dust trapped above it and blue air passing through below. Caption: "The assumption you must state: the model sorts like the real thing does — in the one way you are testing, and only in that way."

The model earns its place through one assumption, and the assumption must be stated out loud: **the sieve sorts the beads the way the filter sorts dust — by size, and only by size.** If the sieve also sorted by weight, or if the real filter clogged in a way the sieve never does, the model would be telling you about the sieve, not about the filter.

The curriculum's own example of this family is **dialysis tubing standing in for a plant cell wall**: the tubing lets small particles through and holds big ones back, the way a cell wall is taken to do. The assumption is the same shape as the sieve's — that the model lets things through *the way the real wall does, in the way being tested*. This subtopic borrows the logic of that example, not the cell biology; what matters here is the habit: whenever a model stands in for the real thing, write down the one way it must match — and notice that "only in that way" is part of the assumption too.

Try it — plan the dissolving race (`VC2S8I02.E04`)

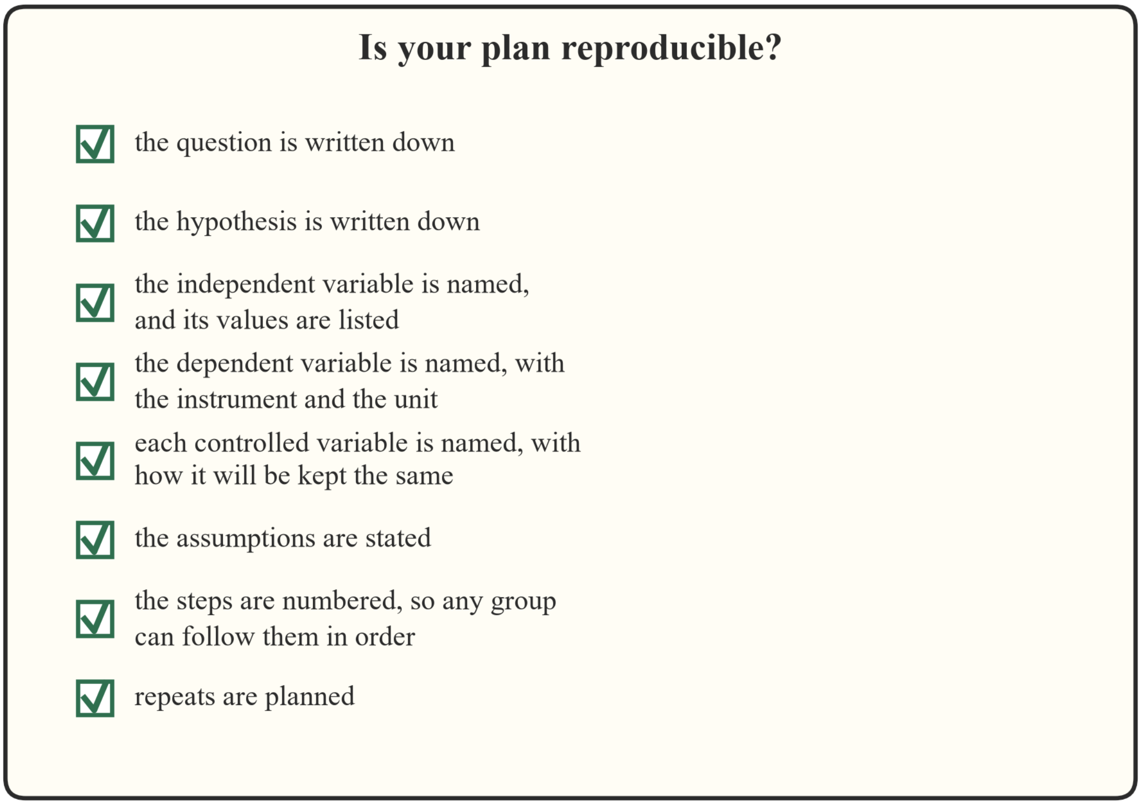
This one is on paper — no equipment needed. You will need a pen and the checklist below.

1. Write the question: *does the form of a sugar cube change how fast it dissolves in water?*
2. Write a hypothesis — one testable sentence, e.g. "the crushed cube will dissolve faster than the whole cube".
3. Fill in the three variable jobs: name the independent variable and list its two values; name the dependent variable with the tool and the unit; list at least three controlled variables, each with *how* you will keep it the same.
4. List two assumptions your plan makes — one about the surroundings, one about the substances.

5. Write the method as numbered steps, with amounts and units, a start rule and a stop rule.
6. Draw the results table *before* any test could start — a column for the trial number and a column for the time in seconds, with three rows for three planned trials.

Safety: if you ever run this plan for real, it uses only sugar and tap water at room temperature — wipe up any spills so the bench is not slippery.

Then check your plan against the list a reproducible plan must pass.



Checklist card titled "Is your plan reproducible?" with eight ticked boxes: the question is written down; the hypothesis is written down; the independent variable is named and its values are listed; the dependent variable is named with the instrument and the unit; each controlled variable is named with how it will be kept the same; the assumptions are stated; the steps are numbered so any group can follow them in order; repeats are planned

Ask yourself:

- Which box on the checklist was hardest to tick in your first draft? What did you add to tick it?
- A classmate swaps plans with you and follows yours exactly, without asking you anything. Where in your plan could they have guessed? Fix those spots.
- Your plan assumes the room stays about the same temperature. How would you *check* that assumption instead of assuming it — and does checking it change the plan?

Try it — the sieve and the filter (`VC2S8I02.E02`)

You will need: a kitchen sieve, a bowl, a mix of large beads (or dried peas) and small beads (or coarse sand), and a vacuum cleaner with a visible filter, or a picture of one.

1. Pour the mix into the sieve over the bowl and shake gently. Watch what the sieve does: the small beads pass, the large beads stay.
2. Now look at the filter. It traps dust and lets air through — too small and too fast to watch.
3. Write the assumption that lets the sieve stand in for the filter, in one sentence, including the words "in the one way you are testing".

4. Write one way the sieve is *not* like the filter — a way that does not matter for the question "does it sort by size?", and (harder) one way that *could* matter.

What you did	What it models	What it stands for in nature
Sieve holds the big beads back	A barrier that sorts by size	The vacuum-cleaner filter trapping dust
Small beads pass through the sieve	The same barrier letting smaller things through	Air passing through the filter
Stating the assumption in step 3	Naming the one way the model must match the real thing	The assumption every analogous model carries

Ask yourself:

- The sieve sorts in the open, slowly, where you can watch. The filter sorts hidden and fast. Does that difference matter for the claim "it sorts by size"? Why or why not?
- Dialysis tubing standing in for a plant cell wall is the curriculum's example of the same move. Write the assumption that example leans on, in the same sentence shape as your sieve assumption.

The whole story in four sentences

A reproducible investigation is one another group can follow from your written plan and compare results with yours, and reproducibility is built in at the planning stage — not added afterwards. The plan names one independent variable (the cause being tested), one dependent variable (the effect being measured, with a tool and a unit), and controls every other variable so a difference in the outcome can point at the cause. It states its assumptions — about what stays constant and about any model standing in for the real thing — because an assumption not written down is a hole nobody can see. And it plans repeats before the test begins, so a result that is not like the others gets checked, not quietly kept or crossed out. That is the whole craft: one change, one measure, everything else held still — and everything taken as said out loud.

Worked examples

Example 1 — scaffolded

A group writes this plan. *(All values are the plan's own; no test has been run yet.)*

1. Measure 100 mL of tap water at 21 °C into a 250 mL beaker.
2. Add one 5 g sugar cube, whole.
3. Do not stir.
4. Start the stopwatch as the cube enters the water; stop it when no solid sugar can be seen.
5. Record the time in seconds. Repeat with a crushed 5 g cube, then repeat each two more times with fresh water.

(a) Name the independent variable and its two values.
(b) Name the dependent variable, the tool that measures it, and the unit.
(c) Name three controlled variables.

Working	Comment
(a) The independent variable is the form of the sugar; its values are whole cube and crushed cube.	The independent variable is the one thing changed on purpose — step 5 swaps whole for crushed.
(b) The dependent variable is the time for the sugar to dissolve, measured with a stopwatch, in seconds (s).	A dependent variable is not fully named until the tool and the unit are with it.
(c) Any three of: volume of water (100 mL); water temperature (21 °C); mass of sugar (5 g); no stirring; fresh water each trial.	A controlled variable is anything kept the same so it cannot affect the outcome.

Example 2 — scaffolded

The same plan makes assumptions, like every plan. State one assumption about the **surroundings** and one about the **substances**, and for each say what could go wrong if it were false.

Working	Comment
Surroundings: the room stays about 21 °C for the whole test. If it were false — a heatwave through the lesson — the later trials would run in a warmer room and could dissolve faster, so the times would differ for a reason the plan never named.	This is the "ambient temperature" family from `VC2S8I02.E01`.
Substances: every 5 g cube is the same stuff (same purity). If it were false — one cube had an additive that slows dissolving — the whole-vs-crushed comparison would also be a comparison of two different substances, and the form of the sugar would not be the only difference.	This is the "purity of substances" family from `VC2S8I02.E01`.

Example 3 — unscaffolded

A student tests whether the form of the sugar changes the dissolving time with this plan: beaker A holds a whole cube in 100 mL of water at 21 °C; beaker B holds a crushed cube in 150 mL of water at 35 °C. The crushed cube dissolves faster, and the student writes: "the form of the sugar changes the dissolving time." Evaluate this conclusion.

The conclusion does not follow from the test, because the plan changed three things at once: the form of the sugar, the volume of water (100 mL against 150 mL), and the water temperature (21 °C against 35 °C). The cause chain runs from the independent variable to the dependent variable only if everything else is controlled; here it is not, so the chain is broken. Warmer water alone would be expected to speed up dissolving, and the faster time in beaker B could come from the temperature as much as from the form. ∴ the test shows that *something* in beaker B made the sugar dissolve faster, but it cannot point at the form of the sugar as the cause — the conclusion names a cause the plan never isolated.

Example 4 — unscaffolded

A student shakes a sieve over a bowl, watches it hold back large beads and pass small ones, and writes: "this shows a vacuum-cleaner filter traps dust because the dust is bigger than the gaps in the filter." State the assumption this conclusion leans on, and one way the model could mislead.

The conclusion leans on the analogous model assumption: that the sieve sorts the beads the way the real filter sorts dust from air — by size, and only by size. That assumption is the whole bridge from the model to the filter; without it, the student has only shown what sieves do. One way the model could mislead: the real filter can clog as dust builds up, changing how it sorts over time, while a sieve shaken over a bowl does not — so the model says nothing about how the filter behaves after a month of use. A second way: the beads are hard and round, while dust is flaky and sticky, so a real filter might sort by stickiness in a way the sieve never shows. ∴ the model supports the size-sorting idea only as far as the stated assumption holds, and the assumption says where the model's story stops being the filter's story.

Practice questions

Scaffolded

Q1. Answer the following about the three kinds of variable. (a) Which variable is the one you change on purpose? (b) Which variable is the one you measure as the outcome? (c) Which variables are kept the same so they cannot affect the outcome?

Q2. Answer the following about the sugar plan in the variable map diagram. (a) Name the independent variable and its two values. (b) Name the dependent variable, the tool that measures it, and the unit. (c) Name two controlled variables from the plan.

Q3. Answer the following about reproducible plans. (a) In our words, what does *reproducible* mean for an investigation? (b) Give one thing the vague plan leaves to guesswork. (c) Why does that guesswork stop another group from comparing their results with yours?

Q4. Answer the following about repeats and reproducing. (a) Your group runs its own test three times with the same equipment. What is that called? (b) Another group follows your written plan and runs the test themselves. What is that called? (c) What must the other group have from you before they can do that?

Q5. Answer the following about assumptions. (a) What is an assumption in a plan, in one sentence? (b) Give one assumption about the surroundings in the sugar test. (c) Why should a plan state its assumptions instead of keeping them quiet?

Q6. Answer the following about observation and experiment. (a) Counting the kinds of birds that visit the school yard — observation or experiment? (b) Which of the two ways of answering a question has an independent variable? (c) The sugar dissolving test is which one, and why?

Unscaffolded

Q7. A group plans this test of whether the form of the sugar changes the dissolving time: beaker A holds a whole cube in 100 mL of water at 21 °C; beaker B holds a crushed cube in 150 mL of water at 35 °C. Evaluate the plan as a test of that question. *(2 marks)*

Q8. Discuss why it is important to identify the variables *and* state the assumptions when planning an investigation. In your answer, use the idea of a causal relationship. *(2 marks)*

Q9. Three planned trials of the sugar test give 43 s, 46 s and 68 s (*simulated data*). Identify the trial to look at again and say what a good planner does with it — and name one thing they must not do. *(2 marks)*

Q10. A sieve that holds back large beads and passes small ones is used as an analogous model of a vacuum-cleaner filter. State the assumption that lets the sieve stand in for the filter, and one way the sieve is not like the real filter. *(2 marks)*

Q11. "Put some sugar in water and time how long it takes." Name two details this plan is missing, and for each say why the detail matters for reproducibility. *(2 marks)*

Q12. A group plans to find which brand of paper towel soaks up more water: soak one towel from each brand for 30 s, lift it out, and weigh it. State two assumptions this plan takes as given — one about the materials, one about the substances or the surroundings. *(2 marks)*

Q13. Design a plan's variables for the question: *does the number of layers of paper towel change how much water it soaks up?* Name the independent variable with three values, the dependent variable with the tool and the unit, and two controlled variables. *(3 marks)*

Q14. Explain why a reproducible plan needs *both* planned repeats and a written plan another group can follow. In your answer, say what each one checks that the other cannot. *(3 marks)*

Answers

Q1. (a) The independent variable. (b) The dependent variable. (c) The controlled variables. **Q2.** (a) The form of the sugar; whole cube or crushed. (b) The time for the sugar to dissolve; stopwatch; seconds (s). (c) Any two of: volume of water (100 mL); water temperature; mass of sugar (5 g); no stirring. **Q3.** (a) Another group can follow your written plan and compare their results with yours. (b) Any one of: how much sugar; how much water; the water temperature; how fast or how long to stir; when to stop the clock. (c) Another group would make different guesses, so their test would not be the same test — and a difference in the times could come from the guesses instead of the thing you changed. **Q4.** (a) Repeating (trials). (b) Reproducing. (c) The written plan — numbered steps with equipment, amounts and units. **Q5.** (a) Something the plan takes as given without checking. (b) Any one of: the room stays about the same temperature all lesson; no breeze across the bench. (c) So a reader can see what the plan leans on — and judge what could go wrong if an assumption were false. **Q6.** (a) Observation. (b) The experiment. (c) Experiment — the form of the sugar is changed on purpose and the dissolving time is measured. **Q7.** The plan changes more than one thing (form, volume and temperature), so if the times differ it cannot say which change caused it; only the form should change, with everything else held the same. **Q8.** The independent variable is the cause being tested and the dependent variable the effect, so naming them says what causal relationship is on trial; controlling the rest means a difference can point at the cause. Stated assumptions show what the plan takes as given, so a reader can see the holes the plan leans over. **Q9.** Trial 3 (68 s) is not like the others; a good planner checks it — looks for what was different about that run and runs the trial again. They must not quietly cross it out (or quietly keep it). **Q10.** Assumption: the sieve sorts the beads the way the filter sorts dust from air — by size, and only by size. Difference (any one): the sieve sorts slowly in the open where you can watch, the filter hidden and fast; the beads are hard and round while dust is flaky and sticky; the real filter clogs over time and the sieve does not. **Q11.** Any two, each with a why: the mass of sugar and the volume and temperature of water (amounts with units) — without them another group guesses different amounts and runs a different test; a start and stop rule for the clock — without them "how long" is measured in different ways; whether to stir — stirring changes the time. **Q12.** Materials (any one): all the towels are the same size and thickness; each towel is new and unused. Substances or surroundings (any one): the water is the same tap water each time; the room temperature stays about the same; the scale reads true each weighing. **Q13.** Independent variable: the number of layers — e.g. 1, 2 and 3 layers. Dependent variable: the mass of water soaked up, found by weighing before and after soaking, on a scale, in grams (g). Controlled variables (any two): same size and brand of towel; same soaking time; same volume and temperature of water. **Q14.** Repeats check your own luck — one run can be unlucky, and three trials let you spot and check a result not like the others. A written plan checks the plan itself — reproducibility means another group can follow it and compare, which repeats alone cannot show. Together they make the result checkable from two directions: same people again, and different people from the same words.

Fully-worked solutions

Q1. (a) The **independent variable** — the one changed on purpose. (b) The **dependent variable** — the one measured as the outcome. (c) The **controlled variables** — kept the same so they cannot affect the outcome.

Q2. (a) The independent variable is **the form of the sugar**, with values **whole cube** and **crushed**. (b) The dependent variable is **the time for the sugar to dissolve**, measured with a **stopwatch** in **seconds (s)**. (c) Any two of: **volume of water (100 mL)**; **water temperature**; **mass of sugar (5 g)**; **no stirring**.

Q3. (a) An investigation is reproducible when **another group can follow your written plan and compare their results with yours**. (b) Any one of: **how much sugar or water**; **the water temperature**; **how fast or how long to stir**; **when to stop the clock**. (c) Another group would **make different guesses**, so they would run a **different test** — and any difference in the times could come from the guesses instead of the one thing you changed.

Q4. (a) **Repeating —** the same people doing their own test again. (b) **Reproducing —** someone else following the written plan. (c) The **written plan**: numbered steps with equipment, amounts and units — everything they need so they never have to ask or guess.

Q5. (a) An assumption is **something the plan takes as given without checking**. (b) Any one of: **the room stays about the same temperature all lesson**; **no breeze across the bench**. (c) Stating assumptions lets a reader **see what the plan leans on** and judge **what could go wrong if an assumption were false** — an assumption not written down is a hole nobody can see.

Q6. (a) **Observation** — nothing is changed; the birds are watched and counted. (b) The **experiment** — an observation has no independent variable. (c) **Experiment** — the form of the sugar is **changed on purpose** and the dissolving time is **measured**.

Q7. The plan fails as a fair test because it changes **three things at once** — the form of the sugar, the volume of water (100 mL against 150 mL) and the temperature (21 °C against 35 °C) *(1 mark)*. If the times differ, the broken cause chain cannot say which change caused it, so the plan should change **only the form** and hold the rest the same *(1 mark)*.

Q8. Naming the variables says what **causal relationship** is on trial — the independent variable is the cause being tested, the dependent variable the effect, and controlling the remaining variables means a difference in the outcome can point at the cause *(1 mark)*. Stating the assumptions says what the plan **takes as given**, so a reader can see whether the "everything else held still" claim really holds — an unchecked assumption is a hidden way for the outcome to change *(1 mark)*.

Q9. Trial 3 (68 s) is not like the others, so it is the one to look at again *(1 mark)*. A good planner **checks it before trusting it** — looks for what was different about that run and runs the trial again — and must **not quietly cross it out** (or quietly keep it) *(1 mark)*.

Q10. The assumption: **the sieve sorts the beads the way the filter sorts dust from air — by size, and only by size** *(1 mark)*. One way the sieve is not like the filter (any one): the sieve sorts **slowly in the open** where you can watch, the filter **hidden and fast**; the beads are **hard and round** while dust is flaky and sticky; the real filter **clogs over time** and the sieve does not *(1 mark)*.

Q11. One mark each for a missing detail with its why (any two): **the mass of sugar and the volume and temperature of the water**, with units — without them another group guesses different amounts and runs a different test; **a start rule and a stop rule for the clock** — without them two groups measure "how long" in different ways; **whether to stir, and how much** — stirring changes the dissolving time, so leaving it to guesswork changes the test.

Q12. One mark each family. Materials (any one): **all the towels are the same size and thickness**; each towel is new and unused. Substances or surroundings (any one): **the water is the same tap water each time**; the room temperature stays about the same; the scale reads true each weighing.

Q13. Independent variable: **the number of layers**, with three values listed (e.g. 1, 2 and 3 layers) *(1 mark)*. Dependent variable: **the mass of water soaked up**, found by weighing before and after, on a **scale**, in **grams (g)** *(1 mark)*. Controlled variables (any two): **same size and brand of towel; same soaking time; same volume and temperature of water** *(1 mark)*.

Q14. Repeats check your own luck — one run can be unlucky, and planned trials let you spot a result not like the others and check it before trusting it *(1 mark)*. **A written plan checks the plan** — reproducibility means another group can follow your words and compare their results with yours, which your own repeats can never show *(1 mark)*. Together the result is checkable from two directions — the same people again, and different people from the same words — and a result that survives both is one science can build on *(1 mark)*.

Sources

Web sources below were retrieved 2026-08-21.

- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8I02` and its elaborations, 2026. vcaa.vic.edu.au

All investigation plans and times in this subtopic — including the three trials of 43 s, 46 s and 68 s — are **simulated data for practice**: made-up values to plan against and argue about, not measured results.

Elaboration contexts used: `VC2S8I02.E01` (assumptions about variables taken as constant — ambient temperature, properties of materials, purity of substances), `VC2S8I02.E02` (assumptions carried by analogous models, including the curriculum's dialysis-tubing example, borrowed here for its logic rather than its cell biology) and

`VC2S8I02.E04` (why variables and assumptions matter, and designing reproducible investigations that test a causal relationship and control the remaining variables).

Teacher-facing note — E02 framing and the 3B reservation (not student text). E02's own example is dialysis tubing modelling a plant cell wall. 3A leads with an original analogous model sized for the band (sieve ↔ vacuum-cleaner filter) and names the dialysis example only to show the same assumption at work; the biology of cell walls is not taught here — it sits in another strand. The reserved elaborations `VC2S8I02.E03` (risks), `.E05` (ethical issues) and `.E06` (protocols for cultural sites and artefacts on Country and Place) belong to the partner subtopic 3B; nothing of them is taught or assessed here, and the D10 Aboriginal and Torres Strait Islander content of this CD is delivered by 3B from named published sources.

Risk, ethics and protocols: recognising and managing hazards in the laboratory and the field, ethical issues, and permissions for cultural sites and artefacts on Country and Place

What we teach here — `VC2S8I02` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"reproducible investigations to answer questions and test hypotheses can be planned and conducted, including identifying independent, dependent and controlled variables where applicable, stating assumptions, recognising and managing risks, considering ethical issues and following protocols when accessing cultural sites and artefacts on Country and Place"* **This subtopic carries the risk, ethics and protocols clauses**: recognising and managing risks, considering ethical issues, and following protocols when accessing cultural sites and artefacts on Country and Place. The CD is owned by the partner subtopic **3A** († split delivery, D6): 3A teaches the planning clause — variables, assumptions, reproducible plans — and 3B teaches this one. **In our words:** good science is safe science, and safe science is planned science. A hazard can hurt someone; a risk is that hazard with its chance of hurting someone added in — and risks are managed before the work starts, by working down a ranked list of controls from *remove the hazard* to *wear the protection*. Ethics asks who and what else the work touches — the living things at a field site, the people a survey asks about, the sources whose data a report borrows — and holds the work to what is right and fair. Protocols make permission part of the method: on Country and Place, some sites and artefacts are protected by law, and asking the right people before anything starts is not paperwork around the science — it is the science. **Achievement-standard extract served here (D13):** *"They plan a range of reproducible scientific investigations, document procedures and identify potential ethical issues and intercultural considerations required for fieldwork or use of secondary data."* The owner of `VC2S8I02` is 3A, so the extract appears in full in 3A's header; this subtopic cites it by reference. 3B serves the second half of that sentence — identifying potential ethical issues, and the intercultural considerations, required for fieldwork or the use of secondary data. **Elaborations drawn on:** `VC2S8I02.E03` (investigating the fire triangle to illustrate how heat, fuel and oxygen are required for a fire to burn, for example using a lit candle to represent fire, covering the candle with a glass jar to limit oxygen, then removing the jar to re-introduce oxygen, and then using their observations to discuss safe laboratory practices in the laboratory when working with heat or flames), `VC2S8I02.E05` (acknowledging and considering ethical principles when using or citing secondary data (such as acknowledging sources), and/or respecting cultural protocols (ethical principles that guide behaviour in particular situations when interacting with Aboriginal and/or Torres Strait Islander Peoples and that are designed to protect Aboriginal and Torres Strait Islander cultural and intellectual property rights) about sharing of particular information) and `VC2S8I02.E06` (recognising and acknowledging Aboriginal and/or Torres Strait Islander Peoples' artefacts and sites of cultural significance such as ceremonial grounds and traditional quarries, and ensuring permission is sought to enter and that no harm is caused to cultural sites and artefacts during any permitted fieldwork). **Maths interlock (D11):** `VC2M8ST04` — *"use ethical and fair methods to make inferences about the population"* — shares this ground. 3B teaches the science side of it: fair, honest, permission-first ways of collecting and using data, including data about people. **Authored from the CD text and the elaboration contexts (D12):** the CD's risk clause is taught as hazard → risk rating → controls, with E03's fire triangle as the worked demonstration; its ethical-issues clause is taught across fieldwork, people and secondary data, in E05's own words; its protocols clause is taught as process and law against named Victorian instruments, with E06's quarry example drawn from the sourced set in subtopic 13B. Scope is capped by D9: nothing of 3A's planning clause is taught here, and nothing above Levels 7–8 is pre-taught. **Aboriginal and Torres Strait Islander content is delivered here (D10):** the protocols clause is CD text and is mandatory. It is taught as method — process and law — against named published instruments and sources only: no invented communities, Peoples, ceremonies, sites, statutes or knowledge claims.

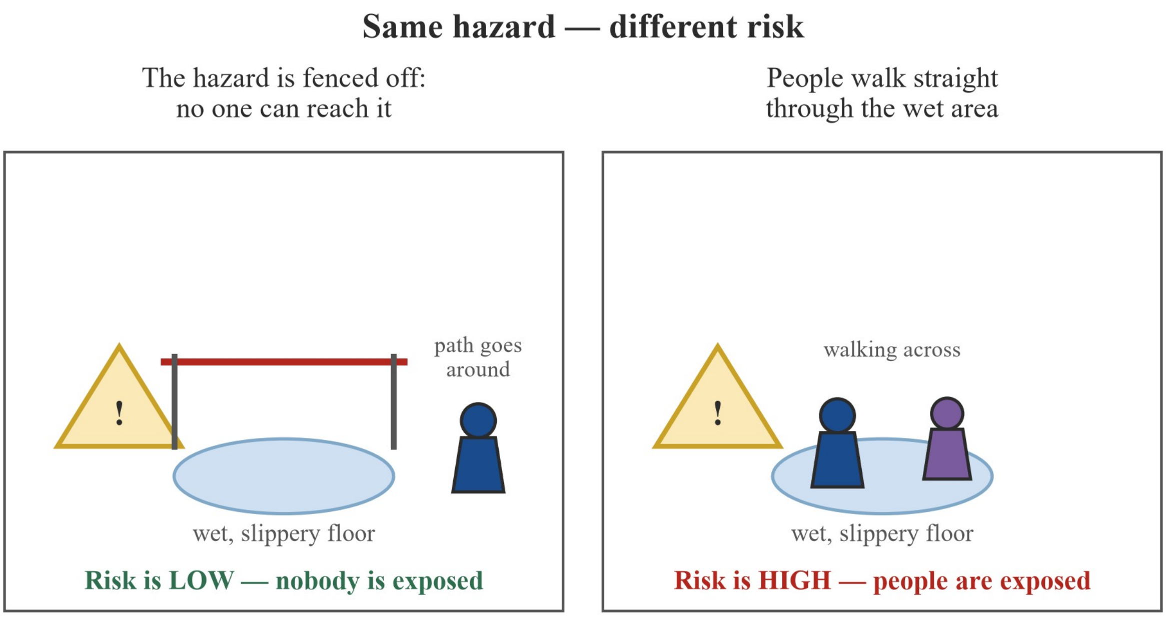
Word watch — *hazard*, *risk*, *control*, *hierarchy of controls*, *PPE*, *ethical*, *protocol*, *cultural protocols*, *artefact*, *permission*. The curriculum uses these terms and does not define all of them; this subtopic therefore treats them as follows, and every question here is answerable on these definitions alone. A **hazard** is anything with the potential to cause harm — a flame, a wet floor, a corrosive chemical. A **risk** is the chance that a hazard actually harms someone, together with how bad that harm would be: the same hazard can carry a low risk or a high risk depending on who and what is exposed to it. Safety guidance in Australian school science draws exactly this hazard/risk distinction [S2][S3], and so does this book. A **control** is anything done to lower a risk, and the **hierarchy of controls** ranks controls from the one that removes the hazard itself down to the one that only protects the person. **PPE** — personal protective equipment — is what you wear (safety glasses, a lab coat), and it sits last in that ranking. **Ethical** is a word people argue over; in this book it means acting in a way you could defend as right and fair to everyone and everything the work affects — a working sense in line with the AIATSIS Code of Ethics for research with Aboriginal and Torres Strait Islander peoples [S7]. An **ethical issue** is a point in the work where that question has to be answered. A **protocol** is a set of rules for how to behave in a particular situation. **Cultural protocols** are, in the curriculum's own words, *"ethical principles that guide behaviour in particular situations when interacting with Aboriginal and/or Torres Strait Islander Peoples and that are designed to protect Aboriginal and Torres Strait Islander cultural and intellectual property rights"* about sharing of particular information (`VC2S8I02.E05`). An **artefact** is an object made or changed by people in the past — in this subtopic, usually one of Aboriginal cultural heritage, such as a worked stone flake. **Permission** is agreement from the right person or body before the work starts.

Theory

Hazard and risk — not the same word

Science work happens in real places with real dangers, so this subtopic starts with two words that people mix up. A **hazard** is anything with the potential to cause harm. A **risk** is the chance that the hazard actually harms someone, together with how bad that harm would be.

The difference matters because you manage the two in different ways. The wet, slippery floor below is the same hazard in both panels. On the left it is fenced off and the path goes around it: nobody is exposed, so the risk is low. On the right, people walk straight through the wet area: the risk is high. Nothing about the floor changed — what changed was who was exposed to it.



A hazard can hurt someone. Risk is how likely that is, given who or what is exposed.

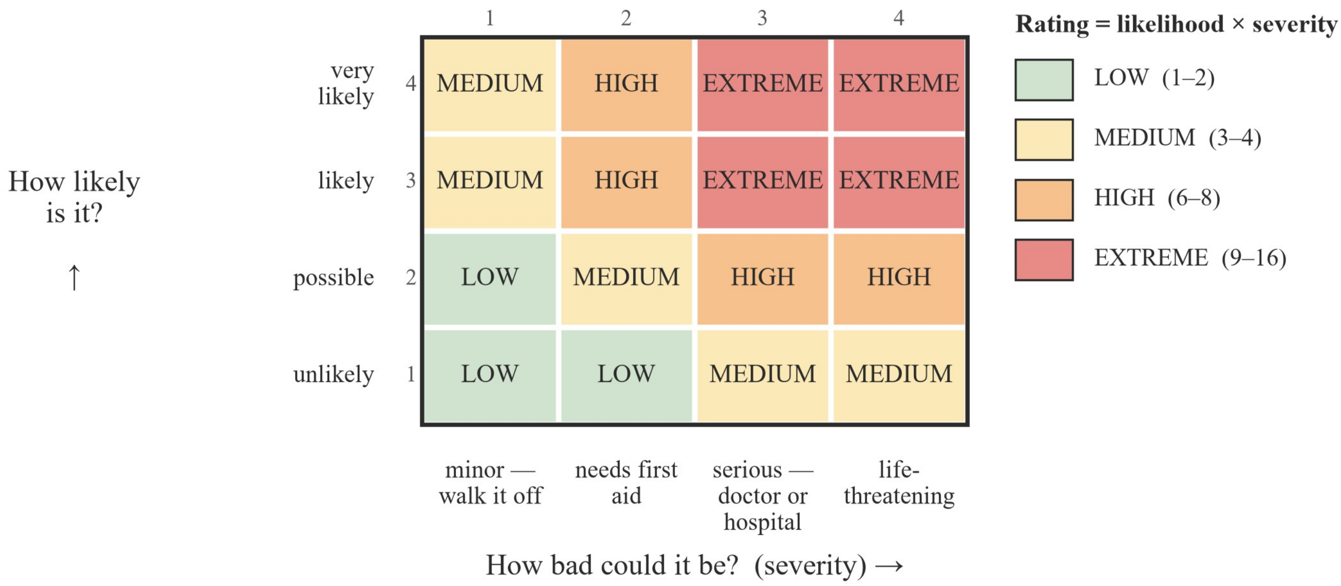
Two panels showing the same wet, slippery floor marked with a hazard sign. Left panel: the wet area is fenced off and the person's path goes around it, labelled "Risk is LOW — nobody is exposed". Right panel: two people walk straight through the wet area, labelled "Risk is HIGH — people are exposed". Caption: a hazard can hurt someone; risk is how likely that is, given who or what is exposed

That is the whole idea in one sentence: **a hazard can hurt someone; a risk is how likely that is, given who or what is exposed**. You cannot always remove a hazard — a Bunsen burner flame is a flame — but you can almost always lower the risk.

Rating a risk — the grid

To manage a risk, first rate it. The grid below asks two questions: *how likely is it?* and *how bad could it be?* Give each a score from 1 to 4 and multiply. The total puts the risk into a band: scores 1–2 rate **LOW**, 3–4 **MEDIUM**, 6–8 **HIGH** and 9–16 **EXTREME** [S2][S3].

Rating a risk before and after controls



Example: heating a liquid over a flame rates HIGH before controls, and MEDIUM or LOW once the controls in this subtopic are in place — the hazard is unchanged; the likelihood has fallen.

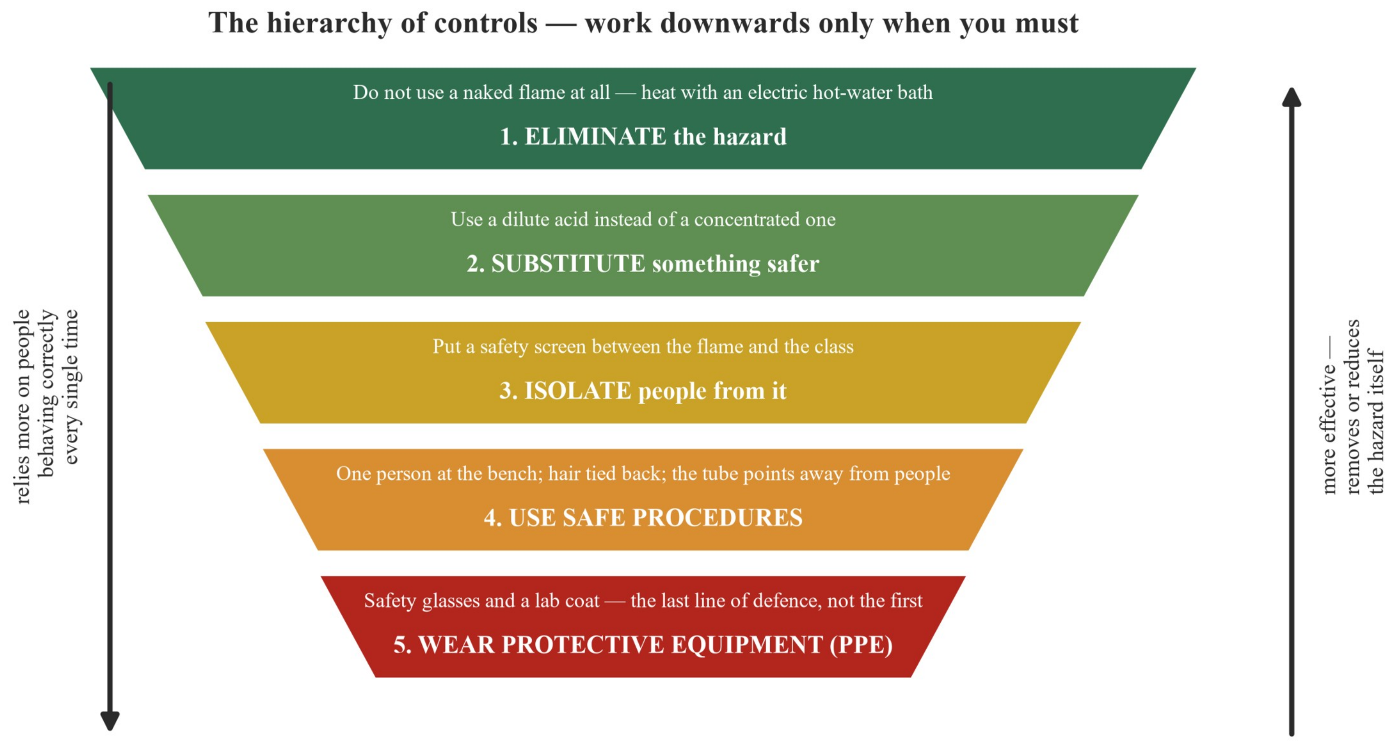
A four-by-four risk-rating grid. The rows ask "How likely is it?", from unlikely at the bottom to very likely at the top; the columns ask "How bad could it be?", from minor at the left to life-threatening at the right. Each cell is coloured by band — low, medium, high or extreme — with a legend reading: rating = likelihood × severity; LOW 1–2, MEDIUM 3–4, HIGH 6–8, EXTREME 9–16. A note underneath says that heating a liquid over a flame rates HIGH before controls and MEDIUM or LOW once the controls in this subtopic are in place

Worked rating: heating a liquid in a test tube over a Bunsen flame. Before any controls, a burn or a caught sleeve is possible (likelihood 2) and the harm could be serious (severity 3): 2 × 3 = 6, which rates **HIGH**. Put the controls from the next few sections in place — hair tied back, the tube pointed away from people, filled no more than one-third, safety glasses on — and the likelihood falls to 1: 1 × 3 = 3, **MEDIUM** or lower. Notice what moved: the hazard is unchanged — a flame is still a flame. The risk moved because the *likelihood* moved. That is what "managing risk" means.

The hierarchy of controls — from best to last resort

Controls are not all equally strong. Safety guidance ranks them in a **hierarchy of controls**, and the rule is to work down the list only when you must [S2].

1. **Eliminate** the hazard — do not use a naked flame at all; heat with an electric hot-water bath instead.
2. **Substitute** something safer — use a dilute acid instead of a concentrated one.
3. **Isolate** people from it — put a safety screen between the flame and the class.
4. **Use safe procedures** — one person at the bench; hair tied back; the tube points away from everyone.
5. **Wear PPE** — safety glasses and a lab coat: the last line of defence, not the first.



An inverted pyramid of five coloured bands, widest at the top, titled "The hierarchy of controls — work downwards only when you must". From top to bottom: 1. ELIMINATE the hazard — do not use a naked flame at all, heat with an electric hot-water bath; 2. SUBSTITUTE something safer — use a dilute acid instead of a concentrated one; 3. ISOLATE people from it — put a safety screen between the flame and the class; 4. USE SAFE PROCEDURES — one person at the bench, hair tied back, the tube points away from people; 5. WEAR PROTECTIVE EQUIPMENT (PPE) — safety glasses and a lab coat, the last line of defence, not the first. An arrow on one side reads "more effective — removes or reduces the hazard itself"; on the other side, "relies more on people behaving correctly every single time"

Read the two arrows on the figure. The top levels remove or reduce the hazard itself; the bottom levels rely more and more on people behaving correctly every single time. That is why PPE is last and not first. Safety glasses left in the box protect nobody — and even worn ones only stand between the harm and your eyes.

Reading hazard symbols before you open the bottle

Chemical bottles carry their warnings as symbols. The symbols come from one system used around the world — the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) — so a bottle in Australia warns you in the same way as the same bottle would in every other country [S4].

Hazard symbols on chemical bottles (GHS pictograms)

Every symbol sits in a red diamond. Read the symbol before you open the bottle.

Six GHS hazard symbols, each a black picture inside a red diamond, with its meaning underneath. Flame: FLAMMABLE — catches fire easily. Flame over a circle: this one gives out oxygen and makes fires burn harder. Drops eating into a hand and a metal bar: CORROSIVE — burns skin and eats through metals. Skull and crossed bones: TOXIC — poisonous, can kill or cause serious illness. Exclamation mark: HARMFUL / IRRITANT — can hurt or irritate skin, eyes, lungs. Gas cylinder: GAS UNDER PRESSURE — cylinder can burst if heated. Caption: every symbol sits in a red diamond; read the symbol before you open the bottle

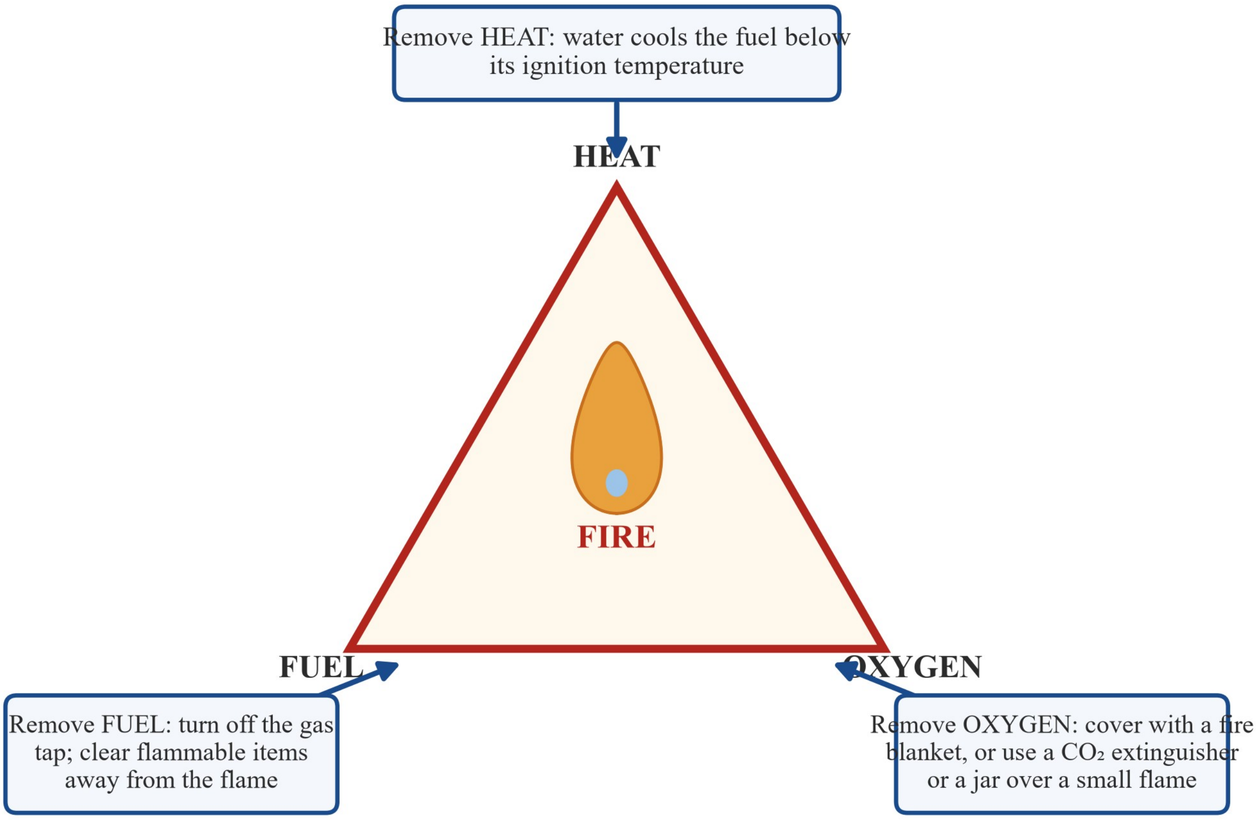
Six symbols cover most of what you will meet in the school laboratory:

- **Flammable** — catches fire easily. Keep it away from flames and sparks.
- **Flame over a circle** — chemicals in this family give out oxygen, so they make fires burn harder. Keep them away from anything flammable.
- **Corrosive** — burns skin and eats through metals. Acids at school concentration are usually in this family.
- **Toxic** — poisonous: can kill or cause serious illness. The skull and crossed bones mean *do not taste, do not breathe, do not touch*.
- **Harmful or irritant** — can hurt or irritate skin, eyes or lungs. The exclamation mark is the symbol that means *be careful with this one* — a real warning, not a decoration.
- **Gas under pressure** — the cylinder can burst if heated.

The rule is printed under the figure: **read the symbol before you open the bottle**.

The fire triangle — what a fire needs (`VC2S8I02.E03`)

Managing the risk of fire starts with knowing what a fire needs. Every fire needs three things at once: **heat**, **fuel** and **oxygen**. Take any one of the three away, and the fire goes out [S5].



A fire needs all three sides of the triangle. Take any one away and the fire goes out.

The fire triangle: a flame labelled FIRE in the centre of a triangle whose three sides are labelled HEAT, FUEL and OXYGEN. Outside each side sits a box describing how to remove it. Remove HEAT: water cools the fuel below its ignition temperature. Remove FUEL: turn off the gas tap; clear flammable items away from the flame. Remove OXYGEN: cover with a fire blanket, or use a CO_2 extinguisher or a jar over a small flame. Caption: a fire needs all three sides of the triangle — take any one away and the fire goes out

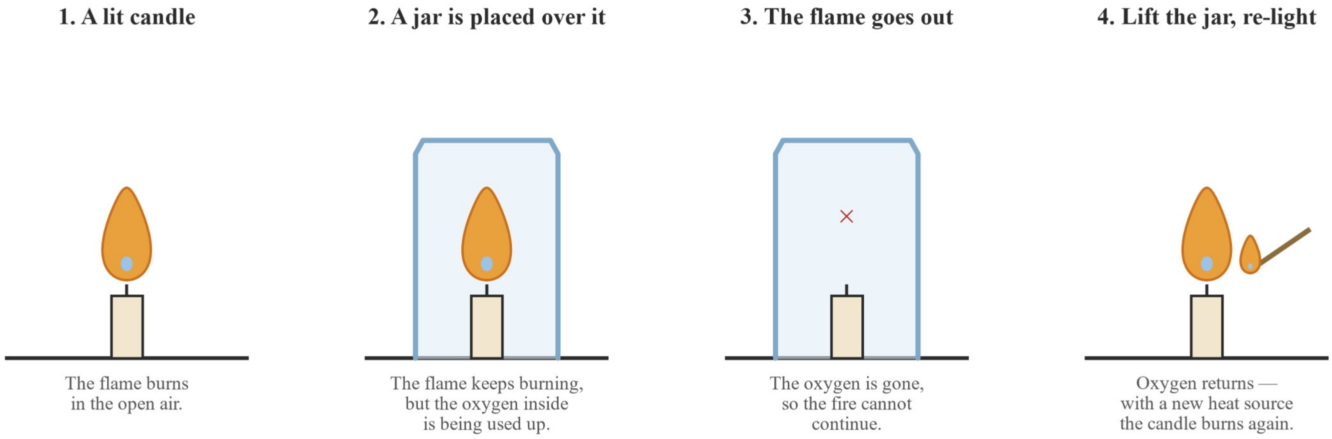
Each side of the triangle is also a way to fight a fire:

- **Remove heat** — water cools the fuel below the temperature at which it can catch fire.
- **Remove fuel** — turn off the gas tap; move flammable items away from the flame.
- **Remove oxygen** — cover a small fire with a fire blanket or a jar, or use a CO_2 extinguisher. The blanket does not squash the fire so much as cut off its air.

That is why the safe response to a pan or a small bench fire is to *cover* it, and why the first move with a gas flame is always the gas tap.

Try it — a candle under a jar (`VC2S8I02.E03`)

This is a teacher-led demonstration. Risk assessment first: the hazard is a naked flame and a jar that gets hot — tie hair back, clear paper from the bench, the teacher lights the candle and handles the jar, and the jar is left to cool before anyone touches it.



Four steps in a row. 1. A lit candle — the flame burns in the open air. 2. A jar is placed over it — the flame keeps burning, but the oxygen inside is being used up. 3. The flame goes out — the oxygen is gone, so the fire cannot continue. 4. Lift the jar, re-light — oxygen returns, and with a new heat source the candle burns again

Watch for the four steps in the figure, and as you watch, answer these in your head:

1. Which side of the fire triangle does the jar remove?
2. When the jar lifts, oxygen comes back — so why does the candle not light itself? (What else has to be there before a flame returns?)
3. Name two safe laboratory practices for working with heat or flames that this demonstration explains. (Think about what happens when the fuel is a gas tap left on, and about why a fire blanket works.)

Write your three answers, then compare them with the class. The point of the demonstration is not the candle — it is that every rule about flames in a laboratory follows from one triangle.

Writing a risk assessment

A **risk assessment** is the thinking written down before the work starts: name the hazards, say what could happen, list the controls, and list the PPE [S3]. Every practical in this book carries one — writing it before you start is the job.

Risk assessment — heating a liquid in a test tube over a Bunsen burner

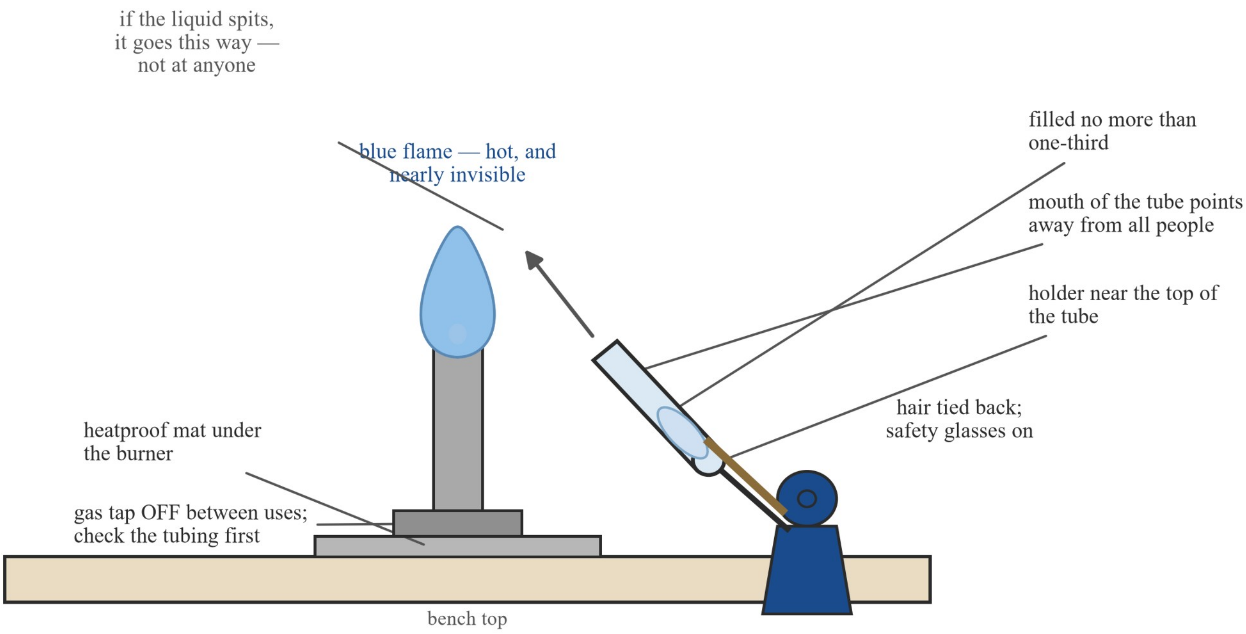
Hazard	What could happen	Controls	PPE
Bunsen burner flame	Burns to skin; hair, sleeves or paper catch fire	Tie hair back; roll up sleeves; clear the bench of paper; remember the blue flame is nearly invisible; turn the gas off at the tap between uses	Safety glasses; lab coat
Hot glass and hot liquid	The tube is touched while hot; boiling liquid spits out of the mouth of the tube	Hold the tube with a holder near the top; point the mouth away from you and everyone else; fill no more than one-third; keep the tube moving in the flame	Safety glasses; lab coat
Gas tubing and connections	Gas leaks into the room; the tubing pulls loose from the tap	Check all connections before lighting; stand the burner on a heatproof mat; if you smell gas, turn off the tap and tell the teacher	—
Breakage	A cracked tube shatters when heated and hot liquid spills	Check the tube for cracks before starting; stand it in a rack when not held; report all breakage at once	Closed shoes

Every practical in this book carries a risk assessment like this one. Writing it before you start is the job.

A risk assessment table for heating a liquid in a test tube over a Bunsen burner, with four columns: Hazard, What could happen, Controls, PPE. Rows: Bunsen burner flame — burns to skin, hair, sleeves or paper catch fire — tie hair back, roll up sleeves, clear the bench of paper, remember the blue flame is nearly invisible, turn the gas off at the tap between uses — safety glasses, lab coat. Hot glass and hot liquid — the tube is touched while hot, boiling liquid spits out of the mouth of the tube — hold the tube with a holder near the top, point the mouth away from you and everyone else, fill no more than one-third, keep the tube moving in the flame — safety glasses, lab coat. Gas tubing and connections — gas leaks into the room, the tubing pulls loose from the tap — check all connections before lighting, stand the burner on a heatproof mat, if you smell gas turn off the tap and tell the teacher. Breakage — a cracked tube shatters when heated and hot liquid spills — check the tube for cracks before starting, stand it in a rack when not held, report all breakage at once — closed shoes. Caption: every practical in this book carries a risk assessment like this one; writing it before you start is the job

The table is worth reading line by line — but the one line to memorise is the second: hot glass looks exactly like cold glass, and a boiling liquid that spits goes wherever the mouth of the tube points. The safe setup gathers the rules into one picture.

Heating a liquid in a test tube — the safe setup



Same rules for any heating step in this book — 10A, 10B, 10D and 11C all point back here.

A labelled safe-heating setup: a Bunsen burner standing on a heatproof mat on the bench, with a nearly invisible blue flame, and a person holding a test tube at an angle with a holder near the top of the tube. The tube is filled no more than one-third, and its mouth points away from all people, with an arrow showing that if the liquid spits it goes away from everyone. Labels: heatproof mat under the burner; gas tap OFF between uses, check the tubing first; holder near the top of the tube; mouth of the tube points away from all people; filled no more than one-third; hair tied back, safety glasses on. Caption: the same rules apply to any heating step in this book

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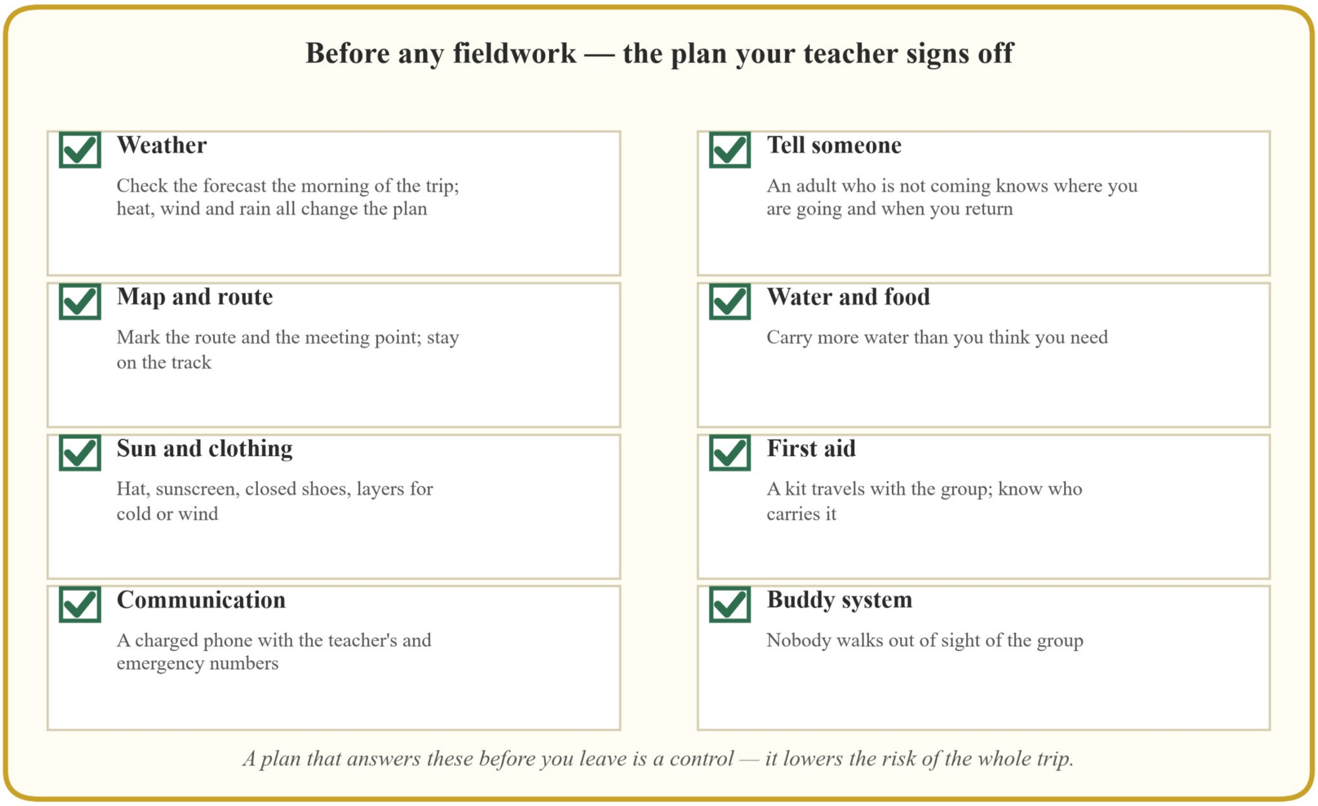
Field hazards — the plan before you leave

Fieldwork swaps the laboratory's hazards for new ones: weather, distance, sun, and the simple fact that help is further away. The method does not change — hazards get named and managed before the work starts. For fieldwork, the control is a plan, and the plan has eight items.

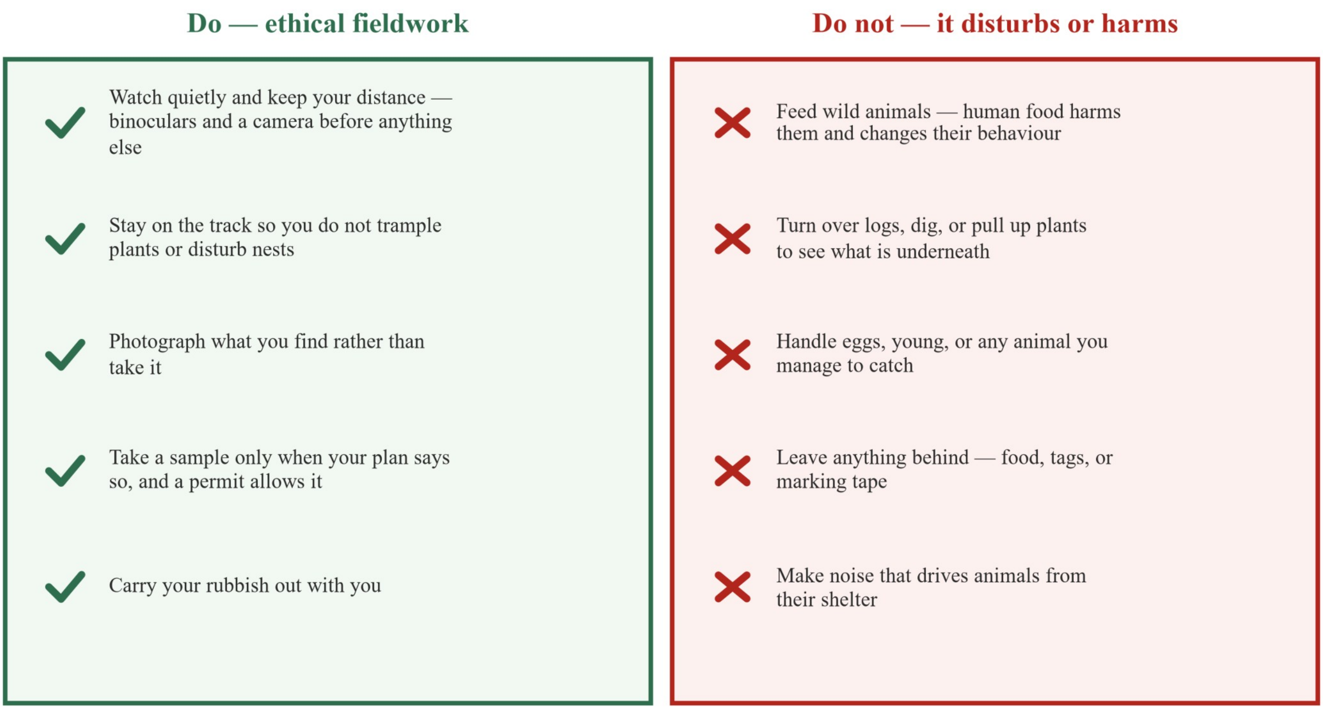


A checklist card titled "Before any fieldwork — the plan your teacher signs off", with eight ticked boxes: Weather — check the forecast the morning of the trip, heat, wind and rain all change the plan; Tell someone — an adult who is not coming knows where you are going and when you return; Map and route — mark the route and the meeting point, stay on the track; Water and food — carry more water than you think you need; Sun and clothing — hat, sunscreen, closed shoes, layers for cold or wind; First aid — a kit travels with the group, know who carries it; Communication — a charged phone with the teacher's and emergency numbers; Buddy system — nobody walks out of sight of the group. Caption: a plan that answers these before you leave is a control — it lowers the risk of the whole trip

Notice what the plan really is: eight controls, written down. The weather check lowers the risk of heat and storm; the buddy system lowers the risk of someone being hurt alone; the phone lowers the risk of a small problem becoming a big one. A plan that answers all eight before you leave is not paperwork around the fieldwork — it is the fieldwork's risk assessment.

Ethics with living things in the field

Safety is about harm to people. **Ethics** widens the question: *who and what else does this work touch, and is what we are doing right and fair to them?* In fieldwork, the first answer is the living things you have come to observe.



The rule of thumb: leave the place exactly as you found it — and leave its animals alone.

Two panels. Left, green, "Do — ethical fieldwork": watch quietly and keep your distance — binoculars and a camera before anything else; stay on the track so you do not trample plants or disturb nests; photograph what you find rather than take it; take a sample only when your plan says so, and a permit allows it; carry your rubbish out with you. Right, red, "Do not — it disturbs or harms": feed wild animals — human food harms them and changes their behaviour; turn over logs, dig, or pull up plants to see what is underneath; handle eggs, young, or any animal you manage to catch; leave anything behind — food, tags, or marking tape; make noise that drives animals from their shelter. Caption: the rule of thumb — leave the place exactly as you found it, and leave its animals alone

The do-not list is not there to spoil the trip. A log rolled over and left upside-down is a home pulled apart; food offered to wild animals is harm dressed up as kindness; a nest disturbed once is sometimes a nest abandoned. The rule of thumb at the bottom of the figure covers all of it: **leave the place exactly as you found it — and leave its animals alone.**

Ethics with data — and with people

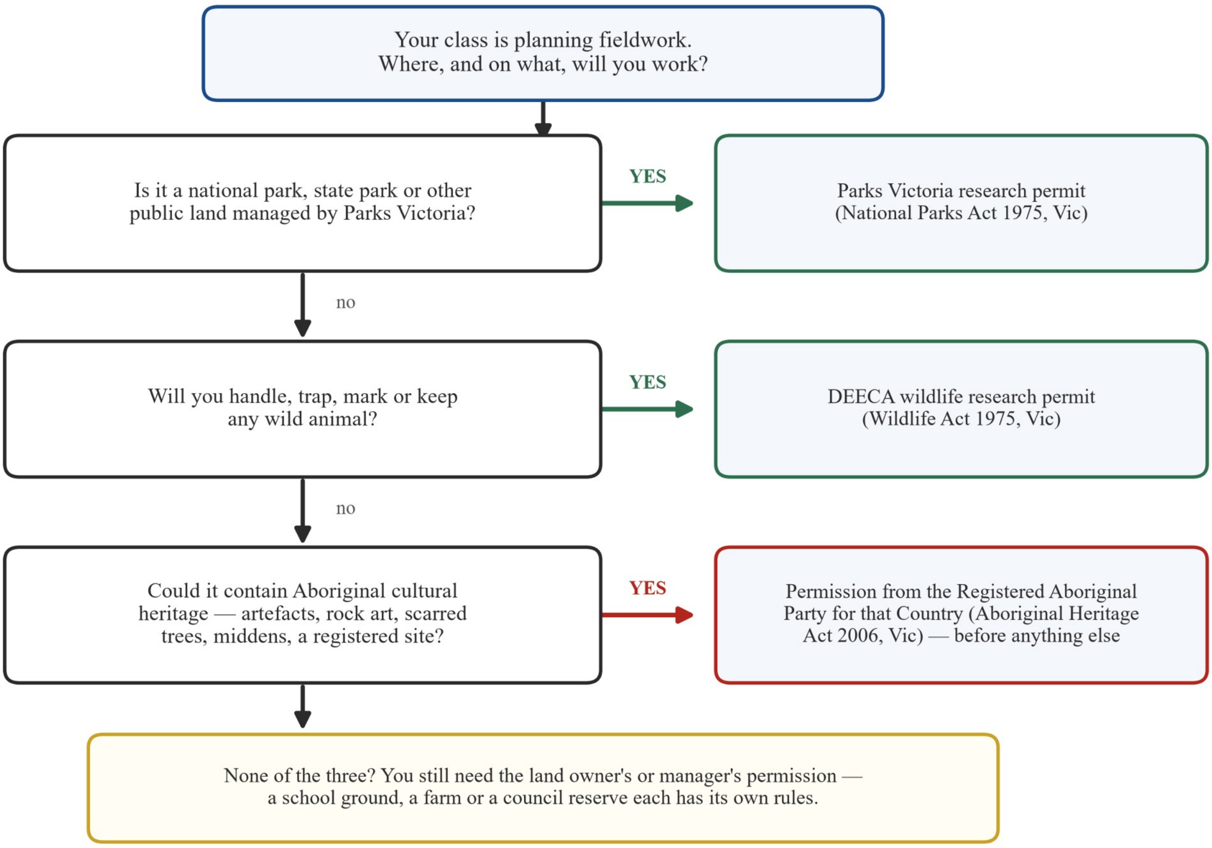
The second ethical territory is the data itself. Two rules carry it.

- **Acknowledge your sources.** When a report uses secondary data — numbers or images someone else collected — it names where they came from. A chart copied from a website with no source under it is someone else's work wearing your name, and it breaks the promise science makes in subtopic 3A: a result is something anyone can check. A check that cannot be traced to its source cannot be checked (`VC2S8I02.E05`).
- **Be fair when the data is about people.** This is the ground this book shares with maths (`VC2M8ST04`): *ethical and fair methods to make inferences about the population*. Ask before you survey; keep answers anonymous when the questions are personal; and ask in a *fair* way — a conclusion about "students at our school" built on a survey of your ten friends is not about the school. It is about your friends.

There is a written code for the deepest version of this. The **AIATSIS Code of Ethics** — AIATSIS is the Australian Institute of Aboriginal and Torres Strait Islander Studies — sets out the ethical principles researchers follow when working with Aboriginal and Torres Strait Islander Peoples, including about the sharing of particular information [S7]. It is a real document, it is used in real research, and it is the grown-up version of what this section teaches: respect and permission come before the work starts.

Permissions — who can say yes

The third territory is **protocols**: the rules for entering and working at places that are not yours to do with as you please. In Victoria, permission is not only good manners — for some places it is the law. The pathway below is the one this book follows.



Permission is not paperwork for adults only — your risk assessment names it, and your report records it.

A flow diagram titled "Your class is planning fieldwork. Where, and on what, will you work?". Three questions in a column, each with a YES arrow to its answer. Question 1: Is it a national park, state park or other public land managed by Parks Victoria? — YES: Parks Victoria research permit (National Parks Act 1975, Vic). Question 2: Will you handle, trap, mark or keep any wild animal? — YES: DEECA wildlife research permit (Wildlife Act 1975, Vic). Question 3: Could it contain Aboriginal cultural heritage — artefacts, rock art, scarred trees, middens, a registered site? — YES: Permission from the Registered Aboriginal Party for that Country (Aboriginal Heritage Act 2006, Vic) — before anything else. At the bottom: None of the three? You still need the land owner's or manager's permission — a school ground, a farm or a council reserve each has its own rules. Caption: permission is not paperwork for adults only — your risk assessment names it, and your report records it

Three named instruments do most of the work:

- **Parks Victoria land** — a national park, a state park, or other public land Parks Victoria manages: research needs a permit under the *National Parks Act 1975* (Vic) [S6].
- **Wild animals** — handling, trapping, marking or keeping any wild animal needs a wildlife research permit from DEECA — the Victorian Department of Energy, Environment and Climate Action — under the *Wildlife Act 1975* (Vic) [S6].
- **Aboriginal cultural heritage** — artefacts, rock art, scarred trees, middens, registered sites: permission comes from the **Registered Aboriginal Party** for that Country, under the *Aboriginal Heritage Act 2006* (Vic) — and it comes **before anything else** [S6]. That Act also sets up the Registered Aboriginal Party system: local Aboriginal groups can be registered as the formal voice for the heritage on their Country, with applications decided by the Victorian Aboriginal Heritage Council. Where a Party is registered, it is the body to ask.

If none of the three applies, the rule still does: every place has an owner or a manager — a school, a farm, a council reserve — and their permission is needed too.

Four ideas hold the whole pathway together:

1. **Protection can be invisible.** Nothing about the look of a place tells you it is registered, protected or sacred. You find out *before* you go, not after you arrive.
2. **Consent can sit with a body other than the landholder.** For Aboriginal cultural heritage, the right to say yes belongs to the Registered Aboriginal Party — not only to whoever owns or manages the land.
3. **Approval comes before the work starts.** Permission asked for afterwards is not permission.
4. **A refusal is an answer, not a failure.** If the answer is no, the fieldwork goes somewhere else or goes unwritten. That is the protocol working, not breaking.

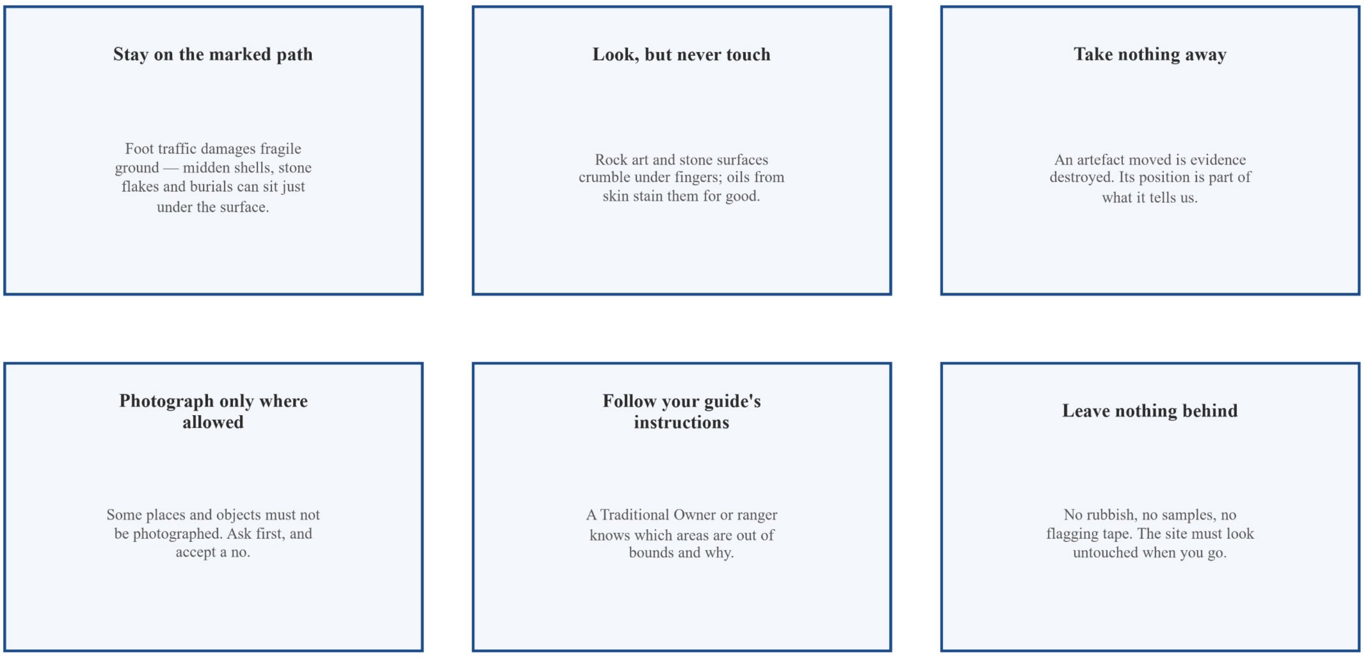
Working respectfully at cultural sites (`VC2S8I02.E06`)

The curriculum asks you to recognise and acknowledge artefacts and sites of cultural significance — in its own examples, ceremonial grounds and traditional quarries. The family is wider than that: rock art; **scarred trees**, which carry the marks where bark was carefully removed for canoes, shelters or containers; shell **middens**, ancient piles of shells and food remains; stone flakes and the scatters they gather in; and grinding grooves worn into rock where tools were sharpened.

One Victorian example is documented in this book already: the Wurundjeri greenstone hatchet quarry at Wil-im-ee Mooring (Mount William), about 9 km north-east of Lancefield [S8]. It is a traditional quarry on Wurundjeri Country, included on the Australian National Heritage List on 25 February 2008 [S8][S10], and ownership of the site was returned to the Wurundjeri in 2012 — access to the quarry requires the permission of the Wurundjeri Council [S9]. Subtopic 13B tells the rock story of that place; here it is the permission story. A science class wanting to visit is doing exactly what this subtopic teaches: ask first, and accept the answer.

Where the permission has been given, the visit still carries rules — the standing rules below apply on every visit, with or without a sign.

Permitted fieldwork on a cultural site — the standing rules



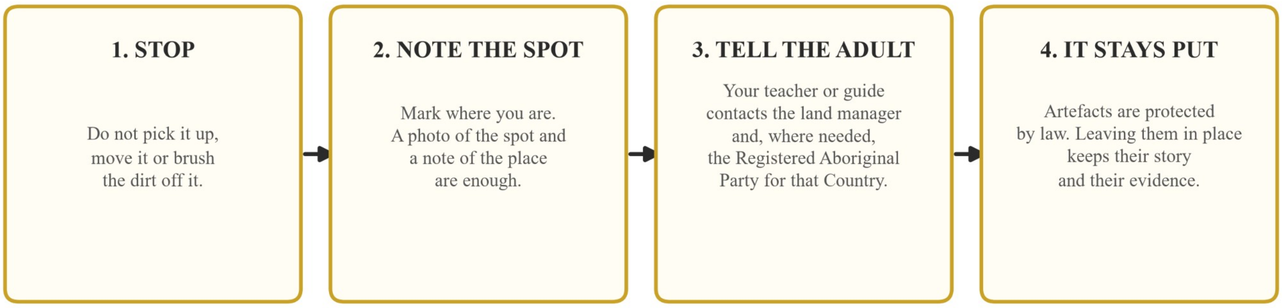
These rules apply on every visit, with or without a sign — the permission you were given carries them.

Six rule cards titled “Permitted fieldwork on a cultural site — the standing rules”. Stay on the marked path — foot traffic damages fragile ground; midden shells, stone flakes and burials can sit just under the surface. Look, but never touch — rock art and stone surfaces crumble under fingers; oils from skin stain them for good. Take nothing away — an artefact moved is evidence destroyed; its position is part of what it tells us. Photograph only where allowed —

some places and objects must not be photographed; ask first, and accept a no. Follow your guide's instructions — a Traditional Owner or ranger knows which areas are out of bounds and why. Leave nothing behind — no rubbish, no samples, no flagging tape; the site must look untouched when you go. Caption: these rules apply on every visit, with or without a sign — the permission you were given carries them

And if something turns up underfoot? A stone flake, a grinding groove, a scatter of worked stone — if in doubt, treat it as significant and follow the four steps.

You found something that might be an artefact. Now what?



A stone flake, a grinding groove, a shell midden, a scatter of worked stone — if in doubt, treat it as significant and follow the steps. The Aboriginal Heritage Act 2006 (Vic) protects these places.

Four steps in a row, titled "You found something that might be an artefact. Now what?". 1. STOP — do not pick it up, move it or brush the dirt off it. 2. NOTE THE SPOT — mark where you are; a photo of the spot and a note of the place are enough. 3. TELL THE ADULT — your teacher or guide contacts the land manager and, where needed, the Registered Aboriginal Party for that Country. 4. IT STAYS PUT — artefacts are protected by law; leaving them in place keeps their story and their evidence. Caption: the Aboriginal Heritage Act 2006 (Vic) protects these places

Why so strict? Because an artefact is evidence, and its position is part of what it tells us. A flake moved from where it lay has lost the story of who dropped it, where, and next to what — and the *Aboriginal Heritage Act 2006* (Vic) protects these places for exactly that reason [S6]. Leaving it in place is not doing nothing. It is the single most useful thing a scientist can do with a discovery: keep the evidence whole for the people whose heritage it is.

The whole story in four sentences

A risk is a hazard with its chance of harm added in, and it is managed before the work starts — rated on a grid, then worked down the hierarchy of controls, from eliminating the hazard to wearing the protection. Ethics asks who and what the work touches — the living things at a field site, the people a survey asks about, the sources a report borrows from — and holds the work to what is right, fair and honest. Protocols make permission part of the method: in Victoria the *National Parks Act 1975*, the *Wildlife Act 1975* and the *Aboriginal Heritage Act 2006* name who can say yes, and for Aboriginal cultural heritage that answer comes before anything else. And when something that might be an artefact turns up underfoot, the work stops, the spot is noted, an adult is told, and the object stays put — that is science behaving the way it should.

Worked examples

Example 1 — scaffolded

A group plans to heat 100 mL of water in a beaker over a Bunsen burner.

(a) Identify two hazards in this task.
(b) Before controls, the group rates the likelihood of harm at 2 and the severity at 3. Give the score and the band.
(c) Suggest two controls for this task from *different* levels of the hierarchy of controls, and name the level of each.

Working	Comment
(a) Any two of: the Bunsen flame — burns, or hair and sleeves catching fire; the hot beaker and hot water — burns from touch or splashes; the gas tubing — a leak if a connection pulls loose.	A hazard is anything with the potential to cause harm — name the thing *and* the harm it can do.
(b) Score = likelihood × severity = 2 × 3 = 6. Scores 6–8 rate HIGH.	The band comes from the grid: 1–2 LOW, 3–4 MEDIUM, 6–8 HIGH, 9–16 EXTREME.
(c) Any two from different levels, for example: heat with an electric hot-water bath instead of the flame — *eliminate*; put a safety screen between the flame and the rest of the class — *isolate*; tie hair back, roll up sleeves, one person at the bench — *use safe procedures*; safety glasses and a lab coat — *PPE*.	Name the level each control sits at. A control that removes the hazard outranks one that relies on people behaving correctly every time.

Example 2 — scaffolded

A group wants to answer the question *do students at our school recycle?* Their plan: stand outside the canteen at lunch and ask 20 of their friends. Their report also includes a bar chart copied from the council's website, with no source written under it.

(a) What is the ethical problem with asking only friends?
(b) What is the ethical problem with the copied chart?
(c) Suggest one fix for each.

Working	Comment
(a) The method is not fair: friends of the group are more likely to give the answer the group wants to hear, so the result says more about the friends than about the school.	This is the maths interlock `VC2M8ST04` — ethical and fair methods to make inferences about a population. A claim about the school needs a fair spread of the school.
(b) The chart is secondary data — someone else's work. Using it without naming the source presents it as the group's own and leaves nothing for a reader to check.	`VC2S8I02.E05`: acknowledging sources when using or citing secondary data. It also breaks reproducibility — subtopic 3A's promise that a result is something anyone can check.
(c) Any fair fix each: ask students from several year levels chosen by the teacher, or every third student through the gate; and write a source line under the chart — who published it, and the year.	A fix names *who* is asked and *how* they are chosen, and gives the chart back to its owner in words.

Example 3 — unscaffolded

A class plans fieldwork in a national park to measure how clear the creek water is. Before they leave, they learn the creek bank they want to work on is a recorded place of Aboriginal cultural heritage. Explain what permissions the class needs before the fieldwork can go ahead, and what the class must do — and must not do — while it is there.

The class needs two permissions before anything starts, because two of the pathway's three questions answer yes. The site is public land managed by Parks Victoria, so the class needs a research permit under the *National Parks Act 1975* (Vic); and the creek bank is a recorded place of Aboriginal cultural heritage, so the class needs permission from the Registered Aboriginal Party for that Country under the *Aboriginal Heritage Act 2006* (Vic) — and that permission comes before anything else. On site, the standing rules apply: stay on the marked path, look but never touch, take nothing away, photograph only where allowed, follow the guide's instructions, and leave nothing behind. And if a stone flake or any possible artefact turns up, the work stops, the spot is noted, the adult is told, and the object stays put. ∴ the fieldwork goes ahead only when both permissions are granted, and its conduct is governed by the rules the permissions carry — not by what the class feels like doing on the day.

Example 4 — unscaffolded

A student says: *"We are all wearing safety glasses, so the risk of this practical is low."* Evaluate this claim, using the hierarchy of controls and the difference between a hazard and a risk.

The claim mistakes one control for a risk assessment. Safety glasses are PPE — the last level of the hierarchy — and they only stand between one kind of harm (a splash or a flying fragment) and one part of the body (the eyes). They do nothing to lower the *likelihood* of the harm happening: a Bunsen flame with hair loose over it is just as likely to catch the hair whether glasses are worn or not. Risk is likelihood × severity, and a control that leaves the likelihood untouched can only lower one slice of the severity — so a task rated HIGH does not become LOW because glasses are on. The fair evaluation starts from the hazards, rates the risk, and works *down* the hierarchy: eliminate or substitute if you can, isolate, use safe procedures, and only then rely on PPE. ∴ the claim is not reliable: PPE worn is necessary but it is the last line of defence, and a risk is low only when the rating says so — after the controls above PPE have done their work.

Practice questions

Scaffolded

Q1. Answer the following about hazard and risk. (a) What is a hazard, in one sentence? (b) What is a risk, in one sentence? (c) In the wet-floor figure, both panels show the same hazard. Which panel shows the higher risk, and why?

Q2. Answer the following about the risk-rating grid. (a) What two questions does the grid ask? (b) A group rates a task at likelihood 2 and severity 3. What is the score, and what band does it rate? (c) After controls, the same task rates likelihood 1 and severity 3. What is the new score and band — and what changed, and what did not?

Q3. Answer the following about the hierarchy of controls. (a) Name the five levels, in order from best to last resort. (b) Why is PPE last in the ranking, not first? (c) Classify each control as eliminate, substitute, isolate, safe procedures or PPE: heating with an electric hot-water bath instead of a flame; a safety screen between the flame and the class; safety glasses.

Q4. Answer the following about hazard symbols. (a) What shape and colour surrounds every GHS symbol? (b) What do the flame symbol and the skull-and-crossed-bones symbol each warn you about? (c) When should you read a bottle's symbol?

Q5. Answer the following about the fire triangle. (a) Name the three things every fire needs at once. (b) Which side of the triangle does a fire blanket remove? (c) In the candle-under-a-jar demonstration, which side does the jar remove — and what must come back, as well as that side, before the candle burns again?

Q6. Answer the following about permissions. (a) Who gives permission for research in a national park, and under which Act? (b) Which permit is needed to handle, trap or mark a wild animal, and which department issues it? (c) If a site could contain Aboriginal cultural heritage, whose permission is needed — and when?

Unscaffolded

Q7. Using the wet-floor figure, explain why the same hazard can carry two different risks. *(2 marks)*

Q8. Give one control from near the top of the hierarchy and one from the bottom for the task of heating a liquid over a flame, and say why the top one is the stronger control. *(2 marks)*

Q9. On fieldwork, a student turns over a log to see what lives underneath, then leaves it upside-down. Identify two problems with this, using the ethical rules for fieldwork. *(2 marks)*

Q10. A group asks the ten students standing nearest the school gate at 8:55 a.m. how they got to school, then writes: "most students at our school walk to school." Evaluate the fairness of the method. *(2 marks)*

Q11. A class walks 2 km to a council reserve to watch water birds on a hot, windy day. Choose the two items of the fieldwork plan that matter most on this day and say why each matters — and say whose permission the class needs for the site. *(3 marks)*

Q12. A student picks up a sharp-edged stone flake, puts it in her bag to show the class, and later puts it back "where she thinks it came from". Identify two things wrong with this, and state the correct four-step procedure. *(3 marks)*

Q13. Explain why a group must seek permission *before* entering a recorded Aboriginal cultural site, rather than deciding on the day whether to ask. In your answer use the term *Registered Aboriginal Party* and name the Act. *(3 marks)*

Q14. A group's report uses rainfall records from a website, with no source written in any part of the report. Explain the ethical problem, say what the group should do instead, and say why acknowledging sources matters to science as a whole. *(3 marks)*

Answers

Q1. (a) Anything with the potential to cause harm. (b) The chance that a hazard actually harms someone, together with how bad that harm would be. (c) The right-hand panel — people walk through the wet area, so they are exposed; on the left, nobody is. **Q2.** (a) How likely is it? and How bad could it be? (b) 2 × 3 = 6; HIGH. (c) 1 × 3 = 3; MEDIUM. The likelihood changed (controls lowered it); the severity — and the hazard itself — did not. **Q3.** (a) Eliminate, substitute, isolate, use safe procedures, wear PPE. (b) PPE relies on people behaving correctly every single time, and it only stands between the harm and the person — higher levels remove or reduce the hazard itself. (c) Electric hot-water bath — eliminate; safety screen — isolate; safety glasses — PPE. **Q4.** (a) A red diamond. (b) Flame — flammable, catches fire easily; skull and crossed bones — toxic, poisonous, can kill or cause serious illness. (c) Before you open the bottle. **Q5.** (a) Heat, fuel and oxygen. (b) Oxygen. (c) Oxygen; heat — the wick must be heated again before the flame returns. **Q6.** (a) Parks Victoria, under the *National Parks Act 1975* (Vic). (b) A wildlife research permit, issued by DEECA (the Victorian Department of Energy, Environment and Climate Action) under the *Wildlife Act 1975* (Vic). (c) The Registered Aboriginal Party for that Country, under the *Aboriginal Heritage Act 2006* (Vic) — before anything else. **Q7.** The hazard is the same wet floor in both panels, but risk also depends on exposure: on the left the floor is fenced off and nobody is exposed, so the risk is low; on the right people walk through it, so the risk is high. **Q8.** Top (any one): heat with an electric hot-water bath instead (eliminate). Bottom: safety glasses and a lab coat (PPE). The top control is stronger because it removes the hazard itself; PPE only stands between the harm and the person, and relies on being worn correctly every time. **Q9.** Any two: turning the log over disturbs or destroys the home of the animals living under it; leaving it upside-down leaves the harm in place instead of restoring it; the rule of thumb is to leave the place exactly as you found it. **Q10.** The method is not fair: students nearest the gate at 8:55 a.m. are the ones who arrived at that time — walkers and latecomers are over-represented and bus and car students who arrived earlier are missed. The conclusion is about the ten asked, not about the school. **Q11.** Any two with matching reasons: water and food — on a hot day the body loses water fast, so carry more than you think you need; sun and clothing — hat, sunscreen and closed shoes against burn and heat, layers for wind; weather — a hot, windy day can change the plan (fire danger, shade). Permission: the council, as the reserve's owner or manager. **Q12.** Wrong: she moved the artefact, and she put it back at a guessed spot, not where it lay. Correct: STOP — do not pick it up, move it or brush it off; NOTE THE SPOT — a photo and a note of the place; TELL THE ADULT — the teacher or guide contacts the land manager and, where needed, the Registered Aboriginal Party; IT STAYS PUT. **Q13.** Protection can be invisible — nothing about the look of a place says it is recorded — so finding out on the day is too late. The right to say yes sits with the Registered Aboriginal Party for that Country under the *Aboriginal Heritage Act 2006* (Vic), not with the group itself; and approval must come before the work starts — permission asked afterwards is not permission. **Q14.** The records are secondary data — someone else's work — and using them without naming the source presents them as the group's own and leaves nothing a reader can check. The group should write a source line naming who published the records and the year. It matters because science's promise is that a result is checkable — a claim that cannot be traced to its source cannot be checked.

Fully-worked solutions

Q1. (a) A **hazard** is anything with the potential to cause harm *(1 mark)*. (b) A **risk** is the chance that a hazard actually harms someone, together with how bad that harm would be *(1 mark)*. (c) The **right-hand panel** shows the higher risk — the hazard is the same wet floor, but people are **exposed** to it; on the left the floor is fenced off and nobody is, so the risk is low *(1 mark)*.

Q2. (a) **How likely is it?** and **how bad could it be?** *(1 mark)*. (b) 2 × 3 = **6**, which rates **HIGH** (the band 6–8) *(1 mark)*. (c) 1 × 3 = **3**, which rates **MEDIUM**; the **likelihood** changed — the controls lowered it — while the **severity** (and the hazard itself) did not *(1 mark)*.

Q3. (a) **Eliminate → substitute → isolate → use safe procedures → wear PPE** *(1 mark)*. (b) PPE is last because it **relies on people behaving correctly every single time** and only stands between the harm and the person; the higher levels **remove or reduce the hazard itself** *(1 mark)*. (c) Electric hot-water bath — **eliminate**; safety screen — **isolate**; safety glasses — **PPE** *(1 mark)*.

Q4. (a) A **red diamond** *(1 mark)*. (b) Flame — **flammable, catches fire easily**; skull and crossed bones — **toxic, poisonous, can kill or cause serious illness** *(1 mark)*. (c) **Before you open the bottle** *(1 mark)*.

Q5. (a) **Heat, fuel and oxygen** *(1 mark)*. (b) **Oxygen** — the blanket cuts off the fire's air *(1 mark)*. (c) The jar removes **oxygen**; before the candle burns again, **heat** must come back too — the wick has cooled, so a new flame (a match) is needed *(1 mark)*.

Q6. (a) **Parks Victoria**, under the ***National Parks Act 1975*** **(Vic)** *(1 mark)*. (b) A **wildlife research permit**, issued by **DEECA** (the Victorian Department of Energy, Environment and Climate Action) under the ***Wildlife Act 1975*** **(Vic)** *(1 mark)*. (c) The **Registered Aboriginal Party** for that Country, under the ***Aboriginal Heritage Act 2006*** **(Vic)** — and it is sought **before anything else** *(1 mark)*.

Q7. The hazard is the same wet floor in both panels *(1 mark)* — but risk also depends on **exposure**: fenced off, nobody reaches it and the risk is low; walked through, people are exposed and the risk is high. Same hazard, different risk, because risk is the hazard with its chance of hurting someone added in *(1 mark)*.

Q8. One mark each: a top control — **heat with an electric hot-water bath instead of the flame (eliminate)** — and a bottom control — **safety glasses and a lab coat (PPE)** *(1 mark)*. The top control is stronger because it **removes the hazard itself**, while PPE only stands between the harm and the person and relies on being worn correctly every single time *(1 mark)*.

Q9. One mark each for any two: turning the log over **disturbs or destroys the home** of the animals living under it; leaving it upside-down **leaves the harm in place** instead of restoring the spot; the ethical rule is to **leave the place exactly as you found it** — and leave its animals alone *(2 marks)*.

Q10. The method is **not fair**: the ten students nearest the gate at 8:55 a.m. over-represent walkers and latecomers and miss students who arrived earlier by bus or car *(1 mark)*. So the conclusion is really about **the ten students asked**, not about the school — an inference about a population needs a fair way of choosing who is asked (`VC2M8ST04`) *(1 mark)*.

Q11. One mark each for two items with matching reasons: **water and food** — on a hot day the body loses water fast, so carry more than you think you need; **sun and clothing** — hat, sunscreen and closed shoes against the sun, layers for the wind; **weather** — a hot, windy morning can change the whole plan *(2 marks)*. Permission: the **council**, as the reserve's owner or manager — none of the three pathway questions applies, but the rule still does *(1 mark)*.

Q12. One mark for the two wrongs: she **moved the artefact**, and she put it back at a **guessed** spot rather than where it lay — its position is part of what it tells us, so both moves damage the evidence *(1 mark)*. One mark for the procedure: **STOP** — do not pick it up, move it or brush it off; **NOTE THE SPOT** — a photo and a note of the place; **TELL THE ADULT** — the teacher or guide contacts the land manager and, where needed, the Registered Aboriginal Party; **IT STAYS PUT** *(1 mark)*.

Q13. Protection can be invisible — nothing about the look of a place says it is recorded, so deciding on the day is deciding blind *(1 mark)*. The right to say yes sits with the **Registered Aboriginal Party** for that Country under the ***Aboriginal Heritage Act 2006*** **(Vic)** — consent does not belong to the visiting group, and may belong to a body other than the landholder *(1 mark)*. And **approval comes before the work starts** — permission asked afterwards is not permission; a refusal, if it comes, is an answer the science accepts *(1 mark)*.

Q14. The records are **secondary data** — someone else's work — and using them with no source presents them as the group's own and leaves a reader **nothing to check** *(1 mark)*. The group should **write a source line** naming who published the records and the year *(1 mark)*. It matters because science's promise is that a result is **checkable** — a claim that cannot be traced to its source cannot be checked, which is the promise subtopic 3A builds the whole plan around (`VC2S8I02.E05`) *(1 mark)*.

Sources

Web sources below were retrieved 2026-08-21.

- **[S1]** Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8I02` and its elaborations, 2026. vcaa.vic.edu.au
- **[S2]** Science ASSIST (ASTA), "Risk management", 2026. asta.edu.au
- **[S3]** Science ASSIST (ASTA), "Science safety essentials: risk assessment in science", 2026. asta.edu.au

- **[S4]** Wikipedia, “Globally Harmonized System of Classification and Labelling of Chemicals”, 2026. en.wikipedia.org
- **[S5]** Wikipedia, “Fire triangle”, 2026. en.wikipedia.org
- **[S6]** *National Parks Act 1975* (Vic); *Wildlife Act 1975* (Vic); *Aboriginal Heritage Act 2006* (Vic) — legislation.vic.gov.au, named in this book’s TOC §6 approved source list; verified 2026-08-21. Named as instruments only; no provision numbers are cited in this subtopic.
- **[S7]** AIATSIS, “Code of Ethics”, 2026. aiatsis.gov.au
- **[S8]** Wikipedia, “Mount William stone axe quarry”, 2026. en.wikipedia.org
- **[S9]** Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation, “Management of Wurundjeri Properties — Significant Places”, 2026. wurundjeri.com.au
- **[S10]** Wikipedia, “National Heritage List (Australia)”, 2026. en.wikipedia.org

All scenarios, ratings and survey examples in this subtopic — including the 100 mL beaker, the recycling survey, the creek-water fieldwork and the rainfall report — are **simulated examples for practice**: made-up situations to think with and argue about, not records of real events. The Mount William example is the exception: every fact stated about it is sourced to [S8], [S9] and [S10], exactly as delivered in subtopic 13B.

Elaboration contexts used: `VC2S8I02.E03` (the fire triangle, delivered as the candle-under-a-jar demonstration with its safe-laboratory discussion), `VC2S8I02.E05` (ethical principles for using or citing secondary data — acknowledging sources — and respecting cultural protocols, with the curriculum’s own definition of cultural protocols quoted in the Word watch) and `VC2S8I02.E06` (recognising and acknowledging artefacts and sites of cultural significance, permission sought to enter, and no harm caused during permitted fieldwork, with the traditional-quarry example drawn from 13B’s sourced set).

Teacher-facing note — D10/ICIP framing, E03 delivery and the 3A reservation (not student text). The protocols limb is CD text and is mandatory; this subtopic teaches it as method — process and law — against named Victorian instruments (*National Parks Act 1975*, *Wildlife Act 1975*, *Aboriginal Heritage Act 2006*, all Vic) and the Registered Aboriginal Party system administered through the Victorian Aboriginal Heritage Council, per TOC §6: the instruments are named, and no section numbers, provisions, Registered Aboriginal Parties or determinations are invented in any part of the section. The one named cultural example — the Wurundjeri greenstone hatchet quarry at Wil-im-ee Mooring (Mount William) — is delivered only from the sources already verified in subtopic 13B ([S8], [S9], [S10] here), including the National Heritage List date (25 February 2008) and the permission requirement; nothing about Peoples, communities, ceremonies or knowledge is stated beyond what those sources carry. E03’s candle demonstration is delivered as a teacher-led demonstration with the risk assessment stated in-line, per Science ASSIST guidance [S2][S3]. The maths interlock `VC2M8ST04` is served in its ethical-and-fair-methods sense only — no sampling theory beyond “ask in a fair way, ask permission, keep it anonymous” is taught (D9). The reserved elaborations `VC2S8I02.E01`, `.E02` and `.E04` belong to 3A; nothing of variables, assumptions or reproducibility-as-planning is taught or assessed here except the backward reference to 3A’s promise — a result is something anyone can check — that acknowledging sources serves.

Equipment and precision: selecting instruments, reading a scale to its finest graduation, and generating and recording data with digital tools

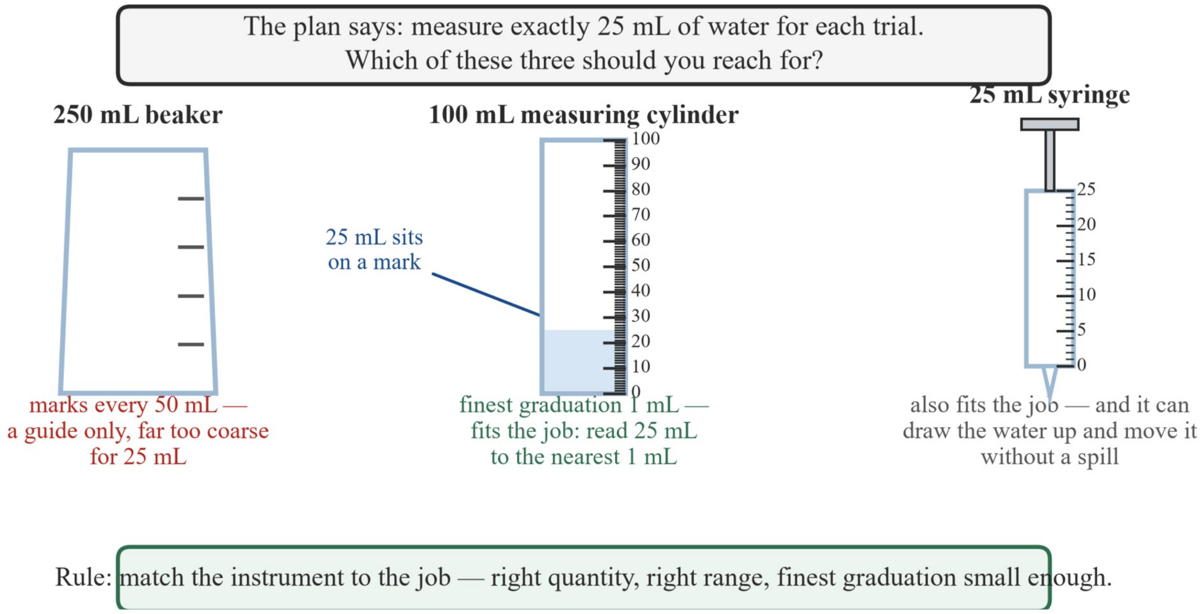
What we teach here — `VC2S8I03` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"equipment can be selected and used to generate and record data with attention to precision, using digital tools as appropriate"* **This subtopic owns the whole content description** — there is no † split here (D6): choosing the right instrument for the job, working out what one small division of a scale is worth, reading a scale to its finest graduation (and one estimated figure when a reading sits between two marks), zeroing before measuring, recording readings with the right sign, unit and number of figures, building results tables the conventions can hold, and using digital tools — sensors and data loggers, recognition apps, digital microscopes and video — where they genuinely fit the job. **In our words:** a measurement is a promise: *this number is what the instrument said, read the way anyone else would read it.* The promise is kept by small habits — picking a tool fine enough for the job, finding what one small division is worth before reading anything, keeping your eye level with the scale, zeroing before you measure, and writing the number down with its sign, its unit and no extra figures. Digital tools can take over when a job is too slow, too small or too far away for a hand tool — but "as appropriate" means they earn their place; a ruler still beats an app for the length of the desk. **Achievement-standard extract served here (D13):** *"They select and use equipment to generate and record data with precision."* 3C owns `VC2S8I03` whole, so the sentence appears here in full. **Elaborations drawn on:** `VC2S8I03.E01` (selecting and using equipment with required precision, such as reading the bottom of a meniscus to determine the precise volume of a liquid in a reproducible way), `VC2S8I03.E02` (recording data with precision appropriate to the instrument, such as rounding up or down with finer graduations or estimating an intermediate value with coarser graduations), `VC2S8I03.E03` (using digital tools such as sensors to measure abiotic factors, and apps with image or call recognition to make field identifications), `VC2S8I03.E04` (using digital tools such as digital microscopes, simulations and video-recording devices, as appropriate, to observe, measure and record qualitative and quantitative data for cells), `VC2S8I03.E05` (using conventions related to dependent and independent variables with relevant units when constructing tables and spreadsheets) and `VC2S8I03.E06` (using appropriate positive and negative signs for standard units, number of decimal points and exponential notation, where relevant, when recording data). **Authored from the CD text and the elaboration contexts (D12):** the CD names the three skills this subtopic teaches — selecting equipment, generating data, and recording it with attention to precision, with digital tools where appropriate; the six elaborations supply the contexts practised here — the meniscus (E01), recording to the instrument's finest graduation (E02), sensors and recognition apps (E03), digital microscopes, simulations and video (E04), table conventions (E05), and signs, decimal places and exponent notation (E06). Scope is capped by D9 and D11: exponent notation stays at positive integer exponents and the zero exponent only (`VC2M8N02`); drawing graphs and writing spreadsheet formulas belong to 4A; evaluating accuracy and naming the two shapes of error in a data set belong to 5A. **Maths interlocks (D11):** `VC2M7N04` (rounding and estimating to check that a result makes sense), `VC2M8N02` (exponent notation — positive integer and zero exponents only) and, kept warm from Level 6, `VC2M6M01` (converting between metric units). **No Aboriginal or Torres Strait Islander content is delivered here (D10):** none of the elaborations drawn on carry any, and this subtopic has no named D10 delivery.

Word watch — *precision*, *accuracy*, *graduation*, *meniscus*, *abiotic factor*, *exponent notation*, *tare*. The Victorian Curriculum uses these terms and does not define them. This subtopic therefore treats them as follows, and every question here is answerable on these definitions alone. **Precision** is how closely readings of the same thing agree with each other; an instrument's precision is set by its finest graduation. **Accuracy** is how close a reading is to the true value — judging it is 5A's job. A **graduation** is one of the marked lines on a scale; the **finest graduation** is the smallest step the scale marks. A **meniscus** is the curve on the surface of a liquid in a narrow container — water climbs the glass a little, so the surface dips in the middle. An **abiotic factor** is a non-living part of a habitat, such as temperature, light, humidity or pH. **Exponent notation** is a short way to write repeated multiplying by 10: $10^3 = 10 \times 10 \times 10 = 1\,000$. To **tare** an instrument is to set its display back to zero before measuring, so the reading that follows is the sample alone.

Theory

Match the instrument to the job (`VC2S8I03.E01`)

A plan from 3A names the equipment with amounts and units; this subtopic is about the moment you actually reach for the tool. The rule is: **match the instrument to the job — right quantity, right range, finest graduation small enough.**



Three instruments lined up against one job — measure exactly 25 mL of water for each trial. A 250 mL beaker with marks every 50 mL, labelled "a guide only, far too coarse for 25 mL"; a 100 mL measuring cylinder holding water at the 25 mL mark, labelled "finest graduation 1 mL — fits the job: read 25 mL to the nearest 1 mL"; and a 25 mL syringe with 1 mL marks, labelled "also fits the job — and it can draw the water up and move it without a spill". The rule at the bottom: match the instrument to the job — right quantity, right range, finest graduation small enough

The beaker's marks are a guide only — nobody reads a beaker to the nearest mL. The cylinder's finest graduation is 1 mL, so 25 mL can be read to the nearest 1 mL: the job and the tool match. The syringe fits too, and it earns its place when the water must be drawn up and moved without a spill. Two tools can both fit a job; what never fits is a tool whose smallest mark is bigger than the amount you care about.

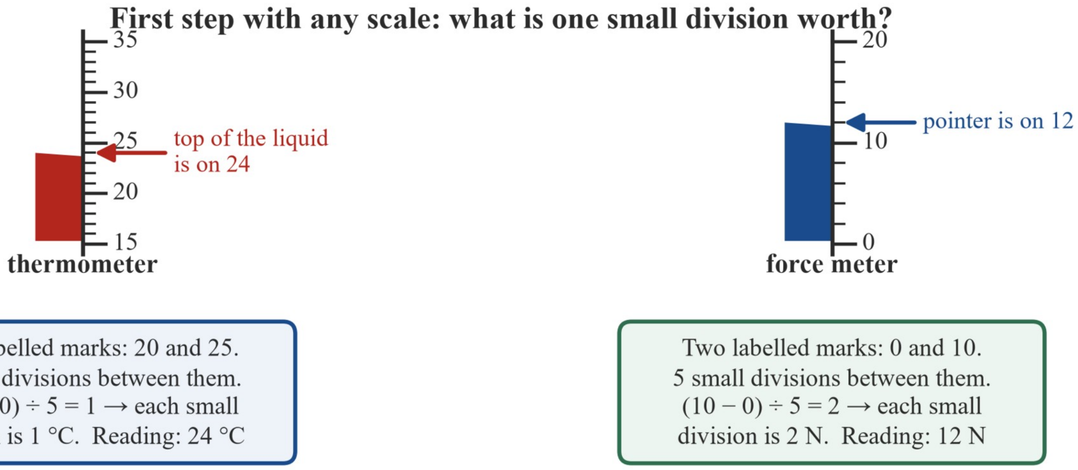
Here are the bench instruments this book uses, with the finest graduation you can read from each.

Instrument	Measures	Usual range	Finest graduation
cm ruler	length	0–30 cm	1 mm
100 mL measuring cylinder	volume of a liquid	0–100 mL	1 mL
25 mL syringe	volume of a liquid — draws up and moves it	0–25 mL	1 mL
250 mL beaker	volume of a liquid, roughly	0–250 mL	50 mL
laboratory thermometer	temperature	−10 to 110 °C	1 °C
spring force meter	force	0–10 N	0.2 N
digital balance	mass	0–500 g	0.1 g
stopwatch	time	0 upward	display to 0.01 s

First step with any scale: what is one small division worth?

Before you read *any* scale, find the value of one small division. Never assume it is 1 — scales are printed with divisions worth 1, 2, 5, 0.2 and more.

The rule takes three steps. Pick two labelled marks next to each other. Subtract the smaller from the larger. Divide by the number of small divisions between them.



Never assume a small division is worth 1 — count the divisions between two labelled marks and divide.

Two vertical scales side by side. Left, a thermometer labelled 15 to 35 with five small divisions between each pair of labelled marks and the top of the red liquid at 24: two labelled marks are 20 and 25, five small divisions between them, (25 − 20) ÷ 5 = 1, so each small division is 1 °C and the reading is 24 °C. Right, a force meter labelled 0 to 20 with five small divisions between labelled marks and the pointer at 12: two labelled marks are 0 and 10, five small divisions between them, (10 − 0) ÷ 5 = 2, so each small division is 2 N and the reading is 12 N. Caption: never assume a small division is worth 1 — count the divisions between two labelled marks and divide

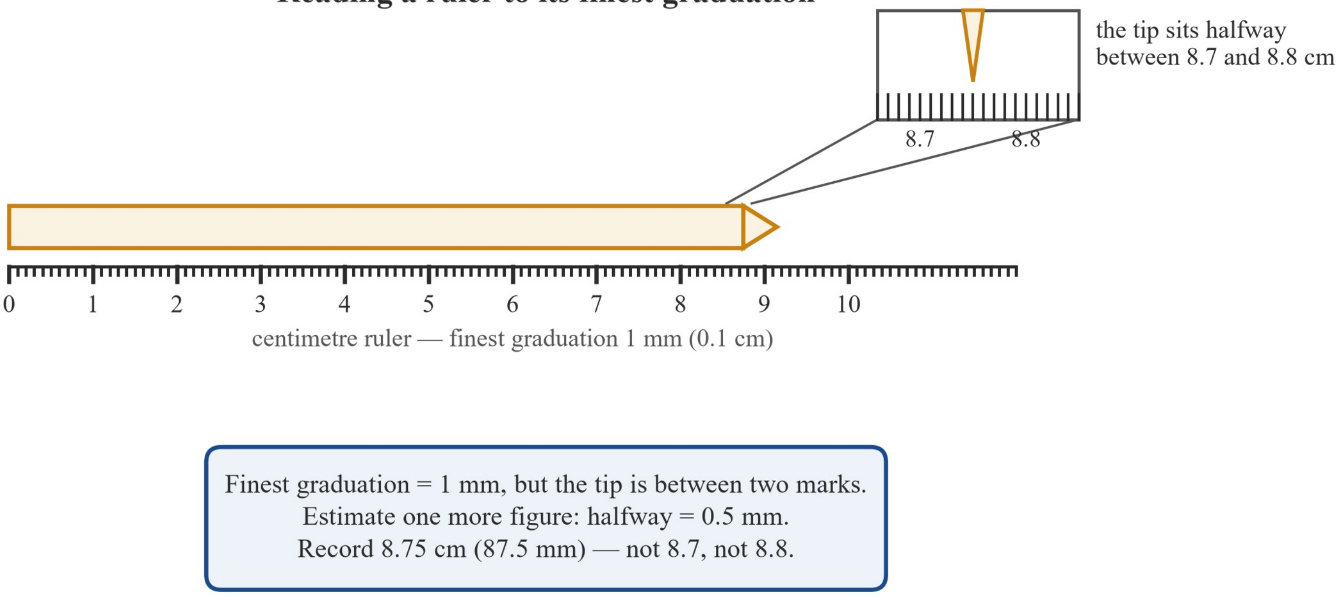
The thermometer's small divisions are worth 1 °C each; the force meter's are worth 2 N each. Same rule, different answers — the value comes from the scale in front of you, not from habit. Dividing like this, and then checking that the answer makes sense, is the same rounding-and-estimating skill the maths interlock `VC2M7N04` asks for (D11): if your division value says a classroom thermometer's small marks are worth 10 °C each, something went wrong — check the count again.

Read to the finest graduation — and one estimated figure (`VC2S8I03.E02`)

Now the reading itself. The rule for any scale you read yourself:

- record the reading to the instrument's **finest graduation**;
- if the pointer, the liquid or the tip sits *between* two marks, **estimate one more figure**;
- if it sits very close to a mark, round to that mark — record the number the scale can actually give, not one you invented.

Reading a ruler to its finest graduation



A pencil lying along a centimetre ruler whose finest graduation is 1 mm, its tip at 8.75 cm; a zoomed strip shows the tip halfway between the 8.7 and 8.8 marks, with the rule: finest graduation 1 mm, but the tip is between two marks, so estimate one more figure — halfway is 0.5 mm — and record 8.75 cm (87.5 mm), not 8.7 and not 8.8

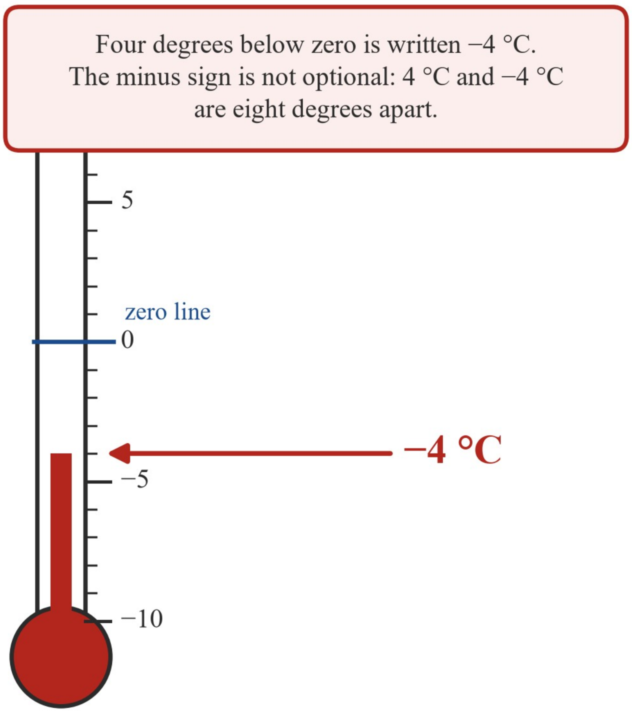
The ruler's finest graduation is 1 mm, and the pencil tip sits halfway between 8.7 and 8.8 cm. Estimate one more figure: halfway is 0.5 mm, so record **8.75 cm**. Writing 8.7 or 8.8 would pick a mark the tip is not on; writing 8.75 says *between the marks, about halfway* — which is exactly what your eye saw.

Digital instruments are different. A display already shows its finest graduation as its last digit: a balance showing 12.3 g reads to 0.1 g, and that final 3 is the estimated figure the machine has done for you. Record a digital reading **exactly as displayed** — adding extra figures claims a precision the instrument never gave.

The sign is part of the reading (`VC2S8I03.E06`)

Some scales run below zero. When they do, the minus sign belongs to the reading just as much as the number and the unit.

The sign is part of the reading



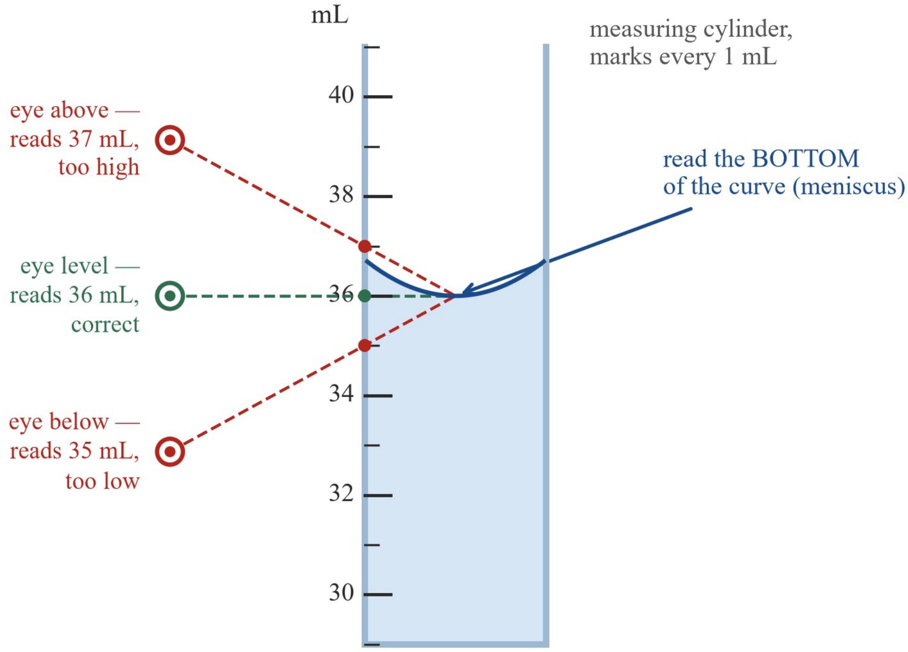
A cold morning in the Victorian high country can sit below 0 °C — record what the scale actually says, sign included.

A thermometer scaled from −10 to 10 degrees with the zero line marked in blue and the top of the red liquid four degrees below zero, labelled −4 °C; a box reads: four degrees below zero is written −4 °C, the minus sign is not optional — 4 °C and −4 °C are eight degrees apart; the caption notes a cold morning in the Victorian high country can sit below 0 °C, so record what the scale actually says, sign included

Four degrees below zero is written **−4 °C**. Leave the sign out and the reading says *4 °C* — the wrong side of zero, and eight degrees away from the truth. Signs matter for any standard unit that can run negative: temperature in °C, a change in mass in g, a fall in height in cm. Record what the scale actually says — sign included (`VC2S8I03.E06`).

Liquids and needles: where your eye must be (`VC2S8I03.E01`)

Water climbs the glass of a measuring cylinder a little, so the surface curves — it is higher at the walls and dips in the middle. That curve is the **meniscus**, and the rule is: read the **bottom** of the curve, with your eye level with it.



Water climbs the glass a little, so the surface curves. The bottom of the curve is the level to read — with your eye level with it.

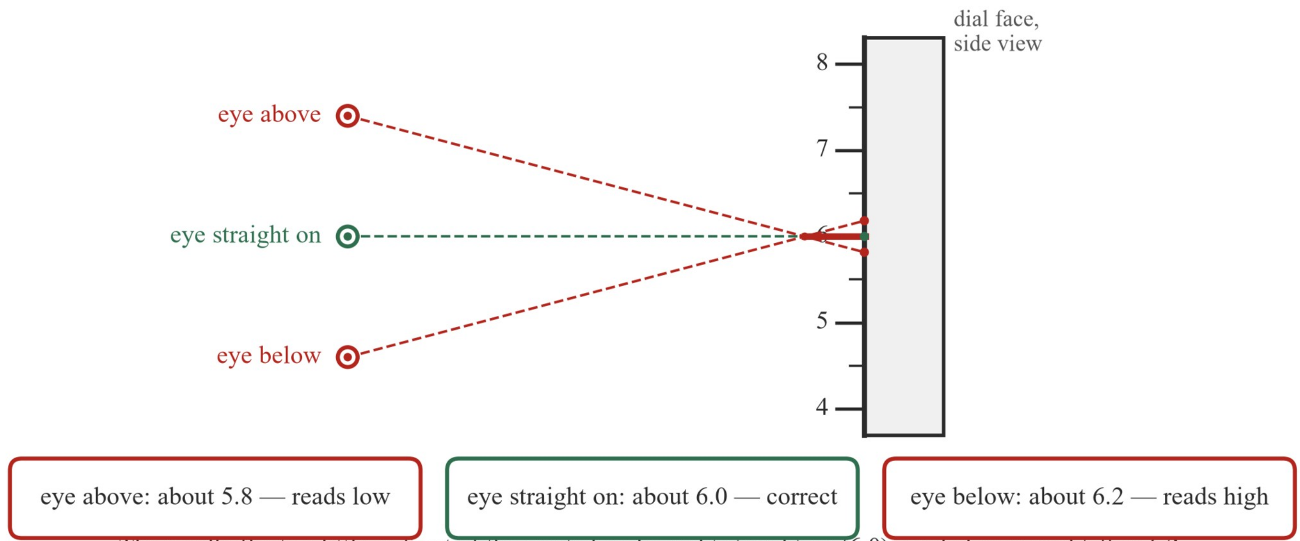
Sight lines drawn to scale: each eye looks at the same meniscus bottom, but only the level eye meets the scale at 36 mL.

A measuring cylinder with marks every 1 mL and labels every 2 mL from 30 to 40; the water surface curves up at the glass walls, and three eyes look at the bottom of the curve — an eye above reads 37 mL, too high; an eye level with the meniscus reads 36 mL, correct; an eye below reads 35 mL, too low; a callout says read the bottom of the curve (the meniscus), with your eye level with it; the caption notes the sight lines are drawn to scale — each eye looks at the same meniscus bottom, but only the level eye meets the scale at 36 mL

The three sight lines in the figure are drawn to scale: every eye looks at the same meniscus bottom, but an eye above it meets the scale too high (37 mL), an eye below meets it too low (35 mL), and only the level eye reads the true value (36 mL). Reading the bottom of the meniscus, the same way, every time, is what makes a volume reading reproducible — another group gets the same number because they followed the same rule (`VC2S8I03.E01`).

Needle scales carry the same trap in a different shape. The needle floats a little in front of the printed dial, so an angled sight line meets the scale at the wrong number.

A needle scale: sight straight on



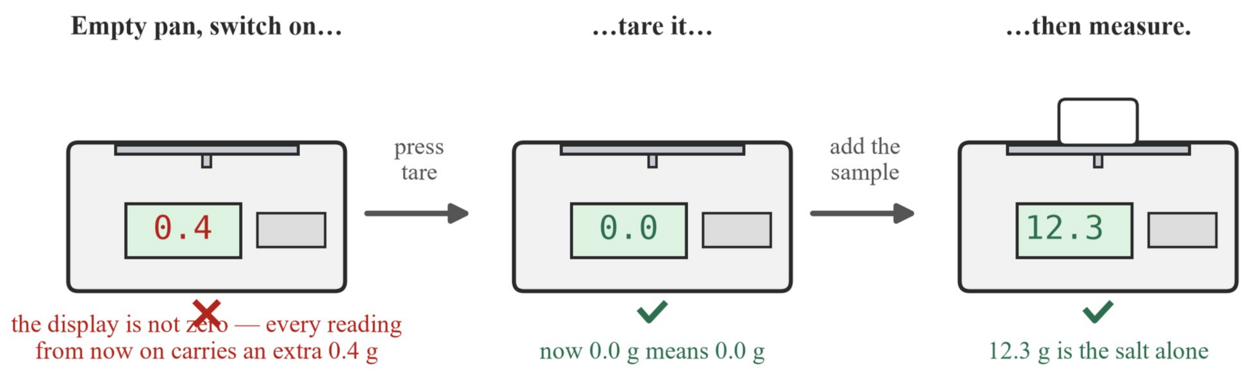
Side view of a needle scale running from 4 to 8: the red needle floats a little in front of the printed dial face, and three dashed sight lines run from eyes through the needle tip to the scale — an eye above the needle reads about 5.8, too low; an eye straight on reads 6.0, correct; an eye below reads about 6.2, too high; caption: the needle floats a little in front of the printed scale — sight straight on (6.0); angled eyes read 5.8 or 6.2

The fix is the same habit: **sight straight on**. The figure computes each sight line: the eye above reads about 5.8, the eye below about 6.2, and only the straight-on eye reads the true 6.0. Two readings of the same needle by two people with different sight lines are not two opinions — one of them is simply wrong, and the straight-on one wins.

Zero before you measure

An instrument that does not start at zero does not measure — it adds. Switch a digital balance on with nothing on the pan, and if the display reads anything but 0.0, press **tare** to set it back to zero before the first weighing.

Zero the instrument before you measure



Three digital balances left to right. First: an empty pan, display 0.4 g, marked wrong — the display is not zero, so every reading from now on carries an extra 0.4 g. An arrow labelled "press tare" leads to the second: display 0.0 g, marked right — now 0.0 g means 0.0 g. An arrow labelled "add the sample" leads to the third: salt on the pan, display 12.3 g, marked right — 12.3 g is the salt alone

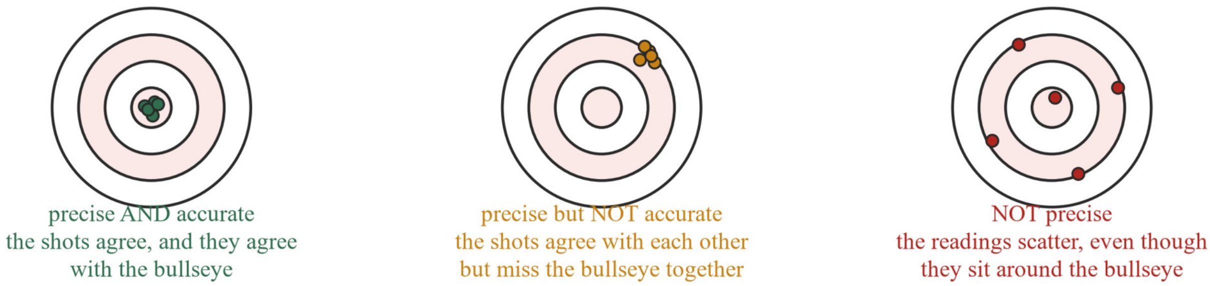
Forget the tare and every reading that follows carries the same extra 0.4 g — the whole set of readings shifts by the same amount, together. That is one shape of error in a data set; 5A will name the two shapes and teach how to judge them. Here the habit is enough: **zero the instrument before you measure, every time.**

The same habit covers instruments that can drift. Before you trust a probe or a thermometer, check it in a condition you already know — a mix of ice and water should read close to 0 °C. If it does not, the digits it gives you later cannot be trusted either.

Precision and accuracy are different ideas

These two words sound alike and are not the same. **Precision** is how closely readings agree with each other; **accuracy** is how close a reading is to the true value. An instrument's precision is set by its finest graduation; accuracy is something you *check* — and evaluating it is 5A's job.

Precision and accuracy are different ideas



Precision: how closely readings agree with each other — set by the instrument's finest graduation.
Accuracy: how close a reading is to the true value — evaluated in 5A.

Three target boards side by side. Left: five shots tight on the bullseye — precise and accurate, the shots agree and they agree with the bullseye. Middle: five shots tight together but off to one side of the bullseye — precise but not accurate, the shots agree with each other but miss the bullseye together. Right: five shots scattered around the bullseye — not precise, the readings scatter even though they sit around the bullseye. Caption: precision — how closely readings agree with each other, set by the instrument's finest graduation; accuracy — how close a reading is to the true value, evaluated in 5A

The middle target is the one to remember: readings can sit close together and still miss the true value, all of them, by the same amount. That is exactly what a forgotten tare does — the readings agree with each other (precise) but every one carries the same extra 0.4 g (not accurate). A balance zeroed before measuring aims for the left target: readings that agree with each other *and* with the true value.

Writing data down: tables, signs and figures (`VC2S8I03.E05`, `VC2S8I03.E06`)

A reading that is not written down is not data — and the way it is written down matters as much as the number. The table is drawn **before the first reading**, and it follows the same conventions 3A's plan names: the independent variable — the one you change — goes on the left, and the dependent variable — the one you measure — goes on the right. 4A keeps the same names when the table becomes a graph (`VC2S8I03.E05`).

A results table is drawn before the first reading

results

time	temp
2	22 degrees
4	24.5
6	26°C

units scribbled in the body,
quantities not named,
no room for repeats

Table 1 Temperature of the heated water

Time (min)	Temperature trial 1 (°C)	Temperature trial 2 (°C)
2	22.0	22.5
4	24.5	24.0
6	26.0	26.5

units live in the header row only,
each quantity is named,
one column per trial

independent variable —
the one you change — left

dependent variable —
the one you measure — right

The variable names follow the convention you will use again in 4A when the table becomes a graph.

Two results tables side by side. Left, a bad table headed only "time" and "temp" with body cells reading "22 degrees", "24.5" and "26°C", marked wrong: units scribbled in the body, quantities not named, no room for repeats. Right, a good table titled "Table 1 Temperature of the heated water" with header row Time (min), Temperature trial 1 (°C), Temperature trial 2 (°C) and readings written the same shape in every cell, marked right: units live in the header row only, each quantity is named, one column per trial; arrows note the independent variable — the one you change — sits on the left and the dependent variable — the one you measure — on the right, with the caption that these are the same variable names used again in 4A when the table becomes a graph

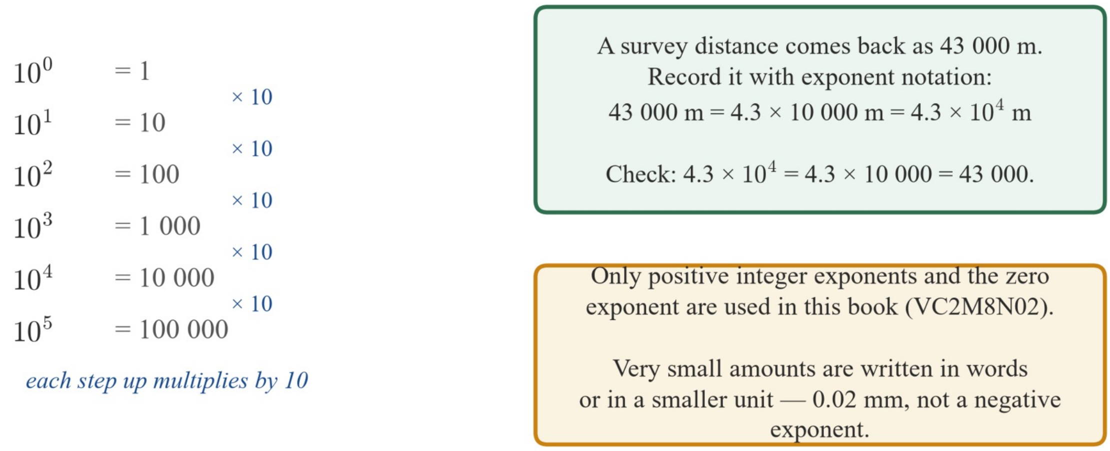
Four rules fall out of the figure:

1. **Units live in the header row only.** A cell holds a number and nothing else — "22 degrees" and "26°C" in the body are the same unit written twice in two wrong places.
2. **Each quantity is named.** "Time (min)" and "Temperature (°C)" say what the numbers are, not just what they are measured in.
3. **One column per trial.** The plan from 3A says how many trials there are; the table must have a home for every one of them before the test starts.
4. **Every reading is written the same shape.** If the finest graduation is 1 °C and you estimate to the nearest half-degree, every reading carries one figure after the point: 22.0, 24.5, 26.0 — not 22, 24.5, 26 (`VC2S8I03.E06`).

Big numbers: exponent notation (`VC2S8I03.E06`, `VC2M8N02`)

A long distance or a large count brings a string of zeros that clutters a table and invites mistakes. Exponent notation writes the zeros as a power of ten.

Powers of ten: a short way to record big numbers



Exponent notation keeps long strings of zeros out of the data table.

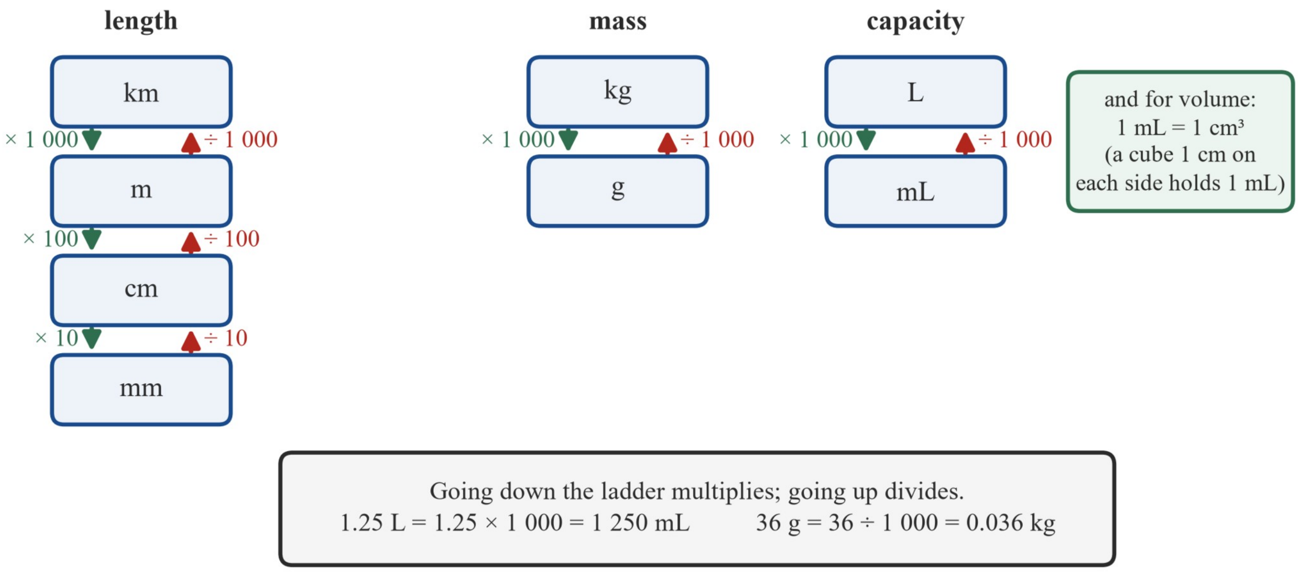
A ladder of powers of ten from 10 to the power 0 equals 1 up to 10 to the power 5 equals 100 000, each step up labelled "times 10"; a green box records a survey distance of 43 000 m in exponent notation — 43 000 m = 4.3 × 10 000 m = 4.3 × 10 to the power 4 m — and checks it by multiplying back: 4.3 × 10 to the power 4 = 4.3 × 10 000 = 43 000; an amber box notes that only positive integer exponents and the zero exponent are used in this book (VC2M8N02), and very small amounts are written in words or in a smaller unit — 0.02 mm, not a negative exponent

Each step up the ladder multiplies by 10: 10^3 = 10 × 10 × 10 = 1 000, 10^4 = 10 000. So 43 000 m = 4.3 × 10^4 m — and the check runs backwards: 4.3 × 10^4 = 4.3 × 10 000 = 43 000. The little exponent counts the zeros that moved. In this book, exponents are positive whole numbers or zero only — the maths interlock `VC2M8N02` sets that ceiling (D11) — and very small amounts are written in a smaller unit instead: 0.02 mm, not a negative exponent.

Keeping the Level 6 skill: moving between metric units (`VC2M6M01`)

Converting between metric units was built at Level 6 and stays in use here, because a table often needs the unit the plan named, not the unit the instrument gave.

Keeping the Level 6 skill: moving between metric units



Three unit ladders side by side. Length: km, m, cm, mm with factors 1 000, 100 and 10 between the rungs. Mass: kg and g with factor 1 000. Volume of a liquid: L and mL with factor 1 000. Down-arrows are labelled "multiply by" the factor and up-arrows "divide by" it; a side box notes 1 mL = 1 cm³ — a cube 1 cm on each side holds 1 mL; the bottom bar shows: going down the ladder multiplies, going up divides — 1.25 L = 1.25 × 1 000 = 1 250 mL and 36 g = 36 ÷ 1 000 = 0.036 kg

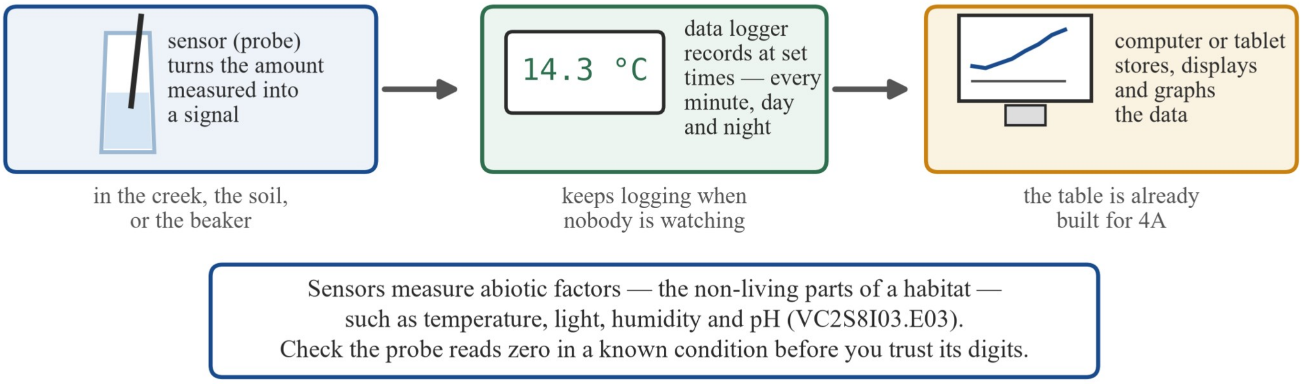
Going **down** a ladder multiplies by the factor on the rung; going **up** divides. So 1.25 L = 1.25 × 1 000 = 1 250 mL, and 36 g = 36 ÷ 1 000 = 0.036 kg. And for volume: 1 mL is the same as 1 cm^3 — a cube 1 cm on each side holds exactly 1 mL — so 250 mL = 250 cm^3 with no multiplying at all.

Digital tools — as appropriate (`VC2S8I03.E03`, `VC2S8I03.E04`)

The CD says digital tools are used *as appropriate* — which means they earn their place by doing a job a hand tool cannot. Three families do that here.

Sensors and data loggers. A sensor (probe) turns the amount it measures into a signal; a data logger records the signal at set times; a computer or tablet stores, displays and graphs the results.

A sensor chain: measure, log, store

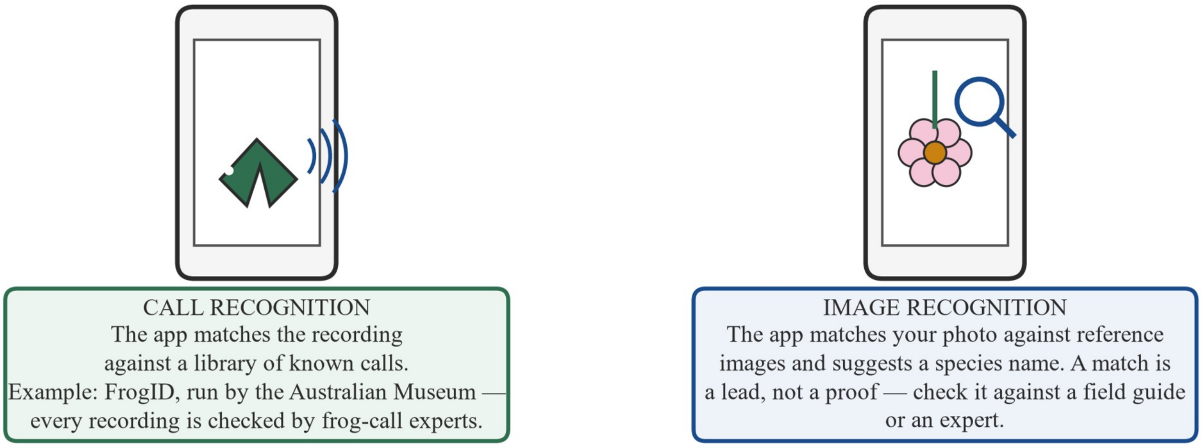


Three boxes joined by arrows. First: a sensor probe in a beaker, turning the amount measured into a signal — in the creek, the soil or the beaker. Second: a data logger displaying 14.3 °C, recording at set times — every minute, day and night — and keeping logging when nobody is watching. Third: a computer or tablet storing, displaying and graphing the data, with the table already built for 4A. Bottom box: sensors measure abiotic factors — the non-living parts of a habitat — such as temperature, light, humidity and pH (VC2S8I03.E03); check the probe reads zero in a known condition before you trust its digits

Sensors measure **abiotic factors** — the non-living parts of a habitat: temperature, light, humidity, pH (`VC2S8I03.E03`). The logger is the part no person can match: it records at set times, day and night, when nobody is watching, and the table arrives already built for 4A. The habit still applies: check the probe in a condition you know — an ice-and-water mix should sit close to 0 °C — before you trust its digits.

Recognition apps in the field. Apps can help identify what you find on a field trip in two ways.

Apps that identify organisms in the field (VC2S8I03.E03)

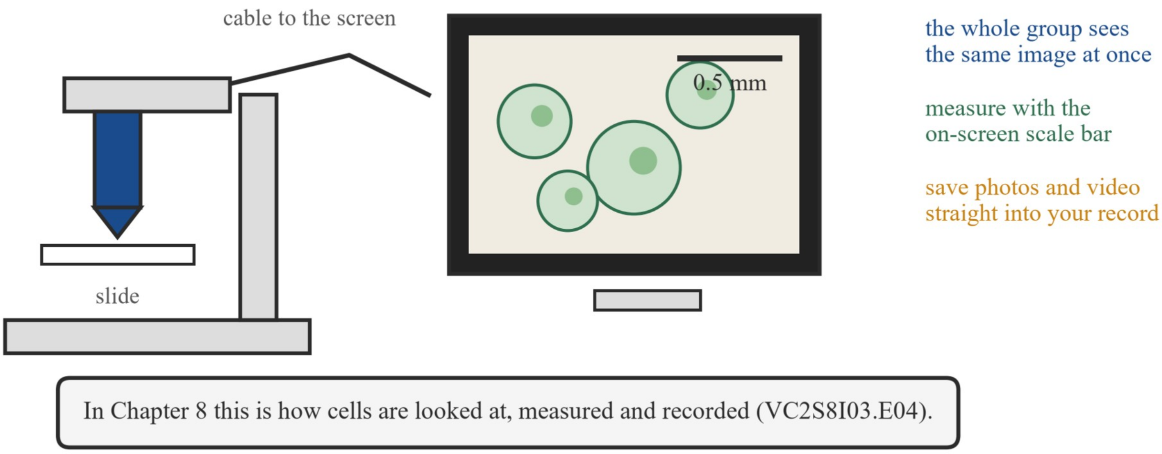


Two smartphones side by side. Left, call recognition: a frog calling, sound waves rippling out, and a box explaining the app matches the recording against a library of known calls — example: FrogID, run by the Australian Museum, where every recording is checked by frog-call experts. Right, image recognition: a flower photographed through a magnifier, and a box explaining the app matches the photo against reference images and suggests a species name — a match is a lead, not a proof; check it against a field guide or an expert

A **call-recognition** app matches a recording of an animal's call against a library of known calls. FrogID, run by the Australian Museum, works this way for frogs: you record the call, and every recording is listened to by one or more frog-call experts at the Australian Museum. An **image-recognition** app matches your photograph against reference images and suggests a species name. A match from an app is a **lead, not a proof** — check it against a field guide or an expert before it becomes a record (`VC2S8I03.E03`).

Digital microscopes and video. A digital microscope puts the image on a screen instead of into one pair of eyes.

A digital microscope puts the image on a screen

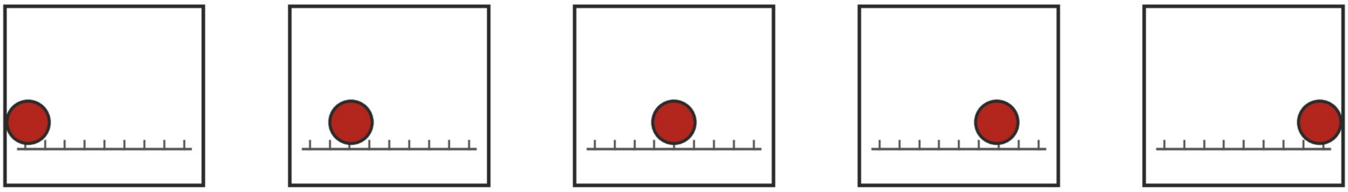


A digital microscope with a slide on its stage, a cable running to a screen that shows cells and an on-screen scale bar marked 0.5 mm, with three notes beside it: the whole group sees the same image at once; measure with the on-screen scale bar; save photos and video straight into your record; the bottom box reads: in Chapter 8 this is how cells are looked at, measured and recorded (VC2S8I03.E04)

The whole group sees the same image at once, lengths are measured with the on-screen scale bar, and photos go straight into the record (`VC2S8I03.E04`). This is the tool Chapter 8 uses for cells, where both kinds of data are collected: **qualitative** data — described in words, like shape and colour — and **quantitative** data — measured in numbers, like a cell's length in mm. Simulations on a screen belong to the same family: they show what a hand tool cannot reach, and Chapter 8 uses them where cells are concerned.

Video is the other recorder that beats the eye: it watches motion too fast to follow, and you can measure it afterwards.

Record once, measure many times: video, frame by frame



Play the video back frame by frame and measure how far the ball moved between frames — useful for motion too fast to follow with the eye or a stopwatch.

Five video frames of the same clip side by side, each showing a red ball a little further along a marked line, labelled frame 1 to frame 5; the caption reads: play the video back frame by frame and measure how far the ball moved between frames — useful for motion too fast to follow with the eye or a stopwatch

Record once, measure many times: play the video back frame by frame and measure how far the ball moved between frames (`VC2S8I03.E04`). A stopwatch cannot pause; a video can.

And the other half of *as appropriate*: when the hand tool fits the job, use it. A ruler measures the length of the desk faster and just as finely as any app. Choosing the simple tool *is* the skill.

Try it — scale-reading safari (`VC2S8I03.E02`)

This one is on paper — no equipment needed. Work out the value of one small division first, every time.

1. A thermometer has labelled marks at 10 and 20, with 5 small divisions between them. The top of the liquid sits 3 divisions above 10. What is one small division worth, and what is the reading?
2. A spring force meter has labelled marks at 0 and 5, with 5 small divisions between them. The pointer sits 1 division past 5. What is the reading?
3. A 100 mL measuring cylinder has marks every 1 mL. The bottom of the meniscus sits between 42 and 43, about halfway. What do you record?
4. A student writes down the temperature of the classroom as 62 °C. Without touching the thermometer, say why that number cannot be right — what does a sensible check say a classroom should be near?

Self-check: (1) one division is 2 °C, reading 16 °C; (2) one division is 1 N, reading 6 N; (3) 42.5 mL; (4) a classroom sits near 20 °C — 62 °C is hotter than the hottest summer day, so the number fails the sense check before anyone looks at the scale (`VC2M7N04`).

Ask yourself:

- In question 3, why is 42.5 mL a better record than 42 mL or 43 mL?
- Which of the four stations used an estimate, and which used only the marks on the scale?
- If station 2's pointer sat exactly on the 5 mark, would you write 5, 5.0 or 5.00? What decides?

Try it — draw the table before the test (`VC2S8I03.E05`)

A group investigates how fast a beaker of hot water cools. Their plan: read the temperature every 2 minutes, twice (two trials). The thermometer's finest graduation is 1 °C; readings are recorded to the nearest whole degree. Here are their raw notes (*simulated data — made-up values to think with, not measured results*):

> trial 1: start 68, 2 min 61, 4 min 56, 6 min 52, 8 min 49 trial 2: start 67, 2 min 61, 4 min 57, 6 min 53, 8 min 50

1. Before any number is written, draw the results table: a title, a header row with the quantity names and units, and a column for each trial. (Time is in minutes; temperature in °C.)
2. Fill the table from the raw notes, writing every reading the same shape.
3. The group's stopwatch displays 0.01 s, yet the plan reads the time every whole 2 minutes. Explain why recording "120.00 s" in the table would be silly even though the display shows it.
4. Write one assumption this table leans on — about the surroundings or the equipment.

Safety note: this Try-it runs on paper with simulated data. If your class runs the cooling test for real, use warm water rather than boiling water and follow your teacher's instructions.

Ask yourself:

- Which column holds the independent variable, and which the dependent variable — and how do you know?
- Trial 1 and trial 2 agree to within 1 °C at every time. Are the readings precise? Would that alone tell you the thermometer reads true?
- If the plan grew a third trial after the table was drawn, what would you have to do to the table before the test could start?

The whole story in four sentences

A measurement is only as good as the tool behind it and the care taken in reading it: match the instrument to the job, find what one small division is worth before reading anything, read to the finest graduation with one estimated figure when the reading sits between marks, keep your eye level with the scale, and zero the instrument before it measures. The record carries the same care — units live in the header row, every reading is written the same shape with its sign kept, big numbers go into exponent notation, and metric units convert by the Level 6 ladders. Digital tools — sensors and loggers, recognition apps, digital microscopes and video — take over when a job is too slow, too small or too far away for a hand tool, and every one of them is checked in a known condition before its digits are trusted. Precision says the readings agree with each other; accuracy says they agree with the true value — 3C builds the first, and 5A judges the second.

Worked examples

Example 1 — scaffolded

Two scales and one display.

(a) A thermometer has labelled marks at 20 and 30, with 5 small divisions between them. The top of the liquid sits 3 divisions above 20. Find the value of one small division and the reading.
(b) A spring force meter has labelled marks at 30 and 40, with 5 small divisions between them. The pointer sits 2 divisions above 30. Find the reading.
(c) A digital thermometer displays 21.4 °C. A student writes 21.42 °C. Explain why the extra figure cannot be earned.

Working	Comment
(a) One small division: (30 − 20) ÷ 5 = 2 °C. Reading: 20 + 3 × 2 = **26 °C**.	Two labelled marks, subtract, divide by the small divisions between — never assume a division is worth 1.
(b) One small division: (40 − 30) ÷ 5 = 2 N. Reading: 30 + 2 × 2 = **34 N**.	Same rule on a new scale — the value comes from the scale in front of you, not from habit.
(c) The display's last digit is already its finest graduation: 21.4 °C is all the instrument can say. The extra "2" claims a precision the instrument never gave; record a digital reading exactly as displayed.	Precision appropriate to the instrument (`VC2S8I03.E02`).

Example 2 — scaffolded

Three recording habits.

(a) A balance displays 0.4 g with nothing on the pan. The student forgets to tare; with the salt on the pan the display reads 12.7 g. Find the true mass of the salt.
(b) In a 100 mL measuring cylinder with marks every 1 mL, the bottom of the meniscus sits between 36 and 37, about one-fifth of a division above 36. What should the student record?
(c) During the night the lowest temperature is 4 degrees below zero. A student writes "4 °C". What is wrong with the record, and by how many degrees does it miss the truth?

Working	Comment
(a) 12.7 − 0.4 = **12.3 g**. The zero error shifts every reading up by the same 0.4 g, so take 0.4 g back off — or better, tare before measuring and there is nothing to subtract.	Zero the instrument before you measure; a forgotten zero shifts the whole set by the same amount.
(b) **36.2 mL**. The finest graduation is 1 mL and the level sits between two marks, so estimate one more figure: about one-fifth of a division past 36.	Estimate an intermediate value with coarser graduations (`VC2S8I03.E02`).
(c) The sign is missing: 4 degrees below zero is written **−4 °C**. Since 4 °C and −4 °C are 8 degrees apart, the record misses the truth by 8 degrees.	The sign is part of the reading (`VC2S8I03.E06`).

Example 3 — unscaffolded

A group's plan says two trials. Their notes for a heating-water test look like this:

time	temp
2	22 degrees
4	24.5
6	26°C

Find three things wrong with this table, and rewrite it the way the conventions ask. (The thermometer's finest graduation is 1 °C, and the group estimates to the nearest half-degree, the same way every time.)

The header row names no quantities and carries no units — "time" and "temp" say what kind of numbers these are but not *whose* time or *whose* temperature, and the units that belong in the header are scribbled into the body instead, in two different forms ("degrees" and "°C"), while one reading carries no unit at all. Cells should hold numbers only. The table also has one temperature column when the plan said two trials, so trial 2 has nowhere to live. And the readings are not written the same shape: 22, 24.5, 26 — even though the group's own rule says every reading is estimated to the nearest half-degree, which means one figure after the point every time. ∴ the rewritten table is:

Table 1 Temperature of the heated water

Time (min)	Temperature trial 1 (°C)	Temperature trial 2 (°C)
2	22.0	22.5
4	24.5	24.0
6	26.0	26.5

Units live in the header row only, each quantity is named, one column per trial, every reading the same shape — and the independent variable (time, the one changed) sits left with the dependent variable (temperature, the one measured) right, ready for 4A. The numbers in the trial 2 column are there to show that shape: the group fills them in as their second run happens.

Example 4 — unscaffolded

A group wants the temperature of the school creek every hour for a full week — day and night, including the weekend. A person with a hand thermometer cannot stay there. Design the measuring side of the plan: name the digital tools you would use, what they do that a person cannot, one check you would run before trusting the digits, and how you would record the readings.

The job is too long and too slow for a person, so the tools earn their place: a temperature probe (sensor) stands in the creek water, connected to a data logger set to record every hour. The logger is the part no person can match — it keeps recording at set times, day and night, when nobody is watching, and it stores the readings so the table arrives already built for the graphing in 4A. Before trusting the digits, the group checks the probe in a condition they already know: in a mix of ice and water it should read close to 0 °C, and they record that check with the data. Each reading is recorded exactly as the display shows it (to 0.1 °C), with the unit in the header row, not the cells. One limit is worth writing down with the plan: the probe measures only the water where it stands, so the plan says exactly where in the creek it sits. ∴ the digital tools are appropriate here because the job is too long for a person to attend — and every habit of this subtopic still applies: the tool is checked in a known condition, and the readings are recorded with their units and every figure the display gives.

Practice questions

Scaffolded

Q1. The plan says: measure exactly 25 mL of water for each trial. On the bench sit a 250 mL beaker with marks every 50 mL, a 100 mL measuring cylinder with marks every 1 mL, and a 25 mL syringe with marks every 1 mL. (a) Why is the beaker the wrong tool? (b) Why does the measuring cylinder fit the job? (c) The rule is "match the instrument to the job". Name the three things the rule matches.

Q2. A spring force meter has labelled marks at 10 and 20, with 5 small divisions between them. The pointer sits 3 divisions above 10. (a) What is one small division worth? (b) What is the reading?

Q3. The tip of a crayon on a centimetre ruler (finest graduation 1 mm) sits exactly halfway between the 6.3 cm and 6.4 cm marks. (a) What is the finest graduation, in cm? (b) What should you record? (c) Why not record 6.3 cm or 6.4 cm?

Q4. Recording practice. (a) A tared balance displays 12.3 g with salt on the pan. Write the reading, and say why you keep the last digit. (b) During the night the lowest temperature is 4 degrees below zero. Write the reading. (c) Why does the sign in (b) matter?

Q5. Sight lines. (a) When you read a measuring cylinder, which part of the meniscus do you read? (b) Why must your eye be level with it? (c) A needle scale holds its needle a little in front of the printed dial. Why must you sight straight on?

Q6. Digital tools. (a) Name two abiotic factors a sensor could measure in a habitat. (b) What does a data logger do that a person with a hand instrument cannot? (c) An image-recognition app suggests a species name for your photograph. Why is the match a lead, not a proof?

Unscaffolded

Q7. A freezer thermometer has labelled marks at −20 and −10, with 5 small divisions between them. The top of the liquid sits 2 divisions above −20. Find the value of one small division and the reading, sign included. *(2 marks)*

Q8. A balance displays 0.4 g with nothing on the pan. A student forgets to tare; the display with the sample reads 12.7 g. Find the true mass, and say what the student should have done first. *(2 marks)*

Q9. A group draws this table for a cooling test whose plan says two trials:

min	°C
0	68
2	61
4	56 degrees

Find three things wrong with the table, and rewrite the header row the way the conventions ask. *(3 marks)*

Q10. You need exactly 17 mL of water for a flask. On the bench sit a 250 mL beaker with marks every 50 mL, a 25 mL cylinder with marks every 1 mL, and a 10 mL cylinder with marks every 0.2 mL. Choose the best instrument, and justify your choice against the two you did not pick. *(2 marks)*

Q11. A group checks a balance by weighing a standard mass labelled 50.0 g. Their three readings are 50.7 g, 50.9 g and 50.8 g (*simulated data*). (a) Are the readings precise? Explain. (b) Are the readings accurate? Explain. (c) Give one cause of a set that is precise but not accurate, and say where accuracy gets evaluated. *(3 marks)*

Q12. Exponent notation. (a) Write 56 000 m using exponent notation. (b) Write out 3.1×10^3 g as an ordinary number. *(2 marks)*

Q13. Unit conversions, kept warm from Level 6. (a) 2.4 L = how many mL? (b) 75 g = how many kg? (c) 460 mL = how many cm^3? *(3 marks)*

Q14. Design the recording side of a plan for the question: *does a lid change how fast hot water cools?* (Two identical beakers of hot water start at the same temperature: one with a lid, one without.) Name the independent and dependent variables with the instrument and unit, draw the header row of a results table with room for two trials, and state one assumption about the equipment. *(4 marks)*

Answers

Q1. (a) Its marks are every 50 mL — a guide only, far too coarse to read 25 mL. (b) 25 mL fits inside its 0–100 mL range, and its 1 mL marks let you read to the nearest 1 mL. (c) Right quantity, right range, finest graduation small enough. **Q2.** (a) (20 − 10) ÷ 5 = 2 N. (b) 10 + 3 × 2 = 16 N. **Q3.** (a) 0.1 cm. (b) 6.35 cm. (c) The tip is between the two marks; estimating one more figure says where it actually sits, while 6.3 or 6.4 would pick a mark the tip is not on. **Q4.** (a) 12.3 g — the last digit is the display's finest graduation; dropping it throws away precision the instrument gave. (b) −4 °C. (c) 4 °C and −4 °C are 8 degrees apart; without the sign the reading says the wrong side of zero. **Q5.** (a) The bottom of the curve. (b) An eye above reads too high, an eye below reads too low; only a level eye reads the true value. (c) The needle floats in front of the dial, so an angled sight line meets the printed scale at the wrong number; sighting straight on removes the error. **Q6.** (a) Any two of: temperature, light, humidity, pH. (b) It keeps recording at set times — every minute, day and night — when nobody is watching, and stores the data. (c) The app matches your photo against reference images and can be wrong; check it against a field guide or an expert. **Q7.** One small division: (−10 − (−20)) ÷ 5 = 10 ÷ 5 = 2 °C. Reading: −20 + 2 × 2 = −16 °C. **Q8.** 12.7 − 0.4 = 12.3 g. The student should have pressed tare (set the display to zero) before measuring. **Q9.** The three things wrong: the quantities are not named (the header holds units, not quantity names); a unit is scribbled in the body ("56 degrees") — cells hold numbers only; and there is no column for the second trial the plan promised. Rewritten header: Time (min) | Temperature trial 1 (°C) | Temperature trial 2 (°C). **Q10.** The 25 mL cylinder: 17 mL fits inside its range and its 1 mL marks can land exactly on 17. The beaker's 50 mL marks are far too coarse; the 10 mL cylinder's range is too small, so 17 mL would take two fills — and each fill is another reading with its own error. **Q11.** (a) Yes — the three readings sit within 0.2 g of each other. (b) No — every reading sits about 0.8 g above the true 50.0 g. (c) A zero error (the balance not tared) shifts every reading the same way; evaluating accuracy is 5A's job. **Q12.** (a) 56 000 m = 5.6 × 10 000 m = 5.6 × 10^4 m. (b) 3.1 × 1 000 = 3 100 g. **Q13.** (a) 2.4 × 1 000 = 2 400 mL. (b) 75 ÷ 1 000 = 0.075 kg. (c) 460 cm³ (1 mL = 1 cm³). **Q14.** Independent variable: lid — on or off. Dependent variable: the temperature of the water, measured with a laboratory thermometer (finest graduation 1 °C), in °C. Header row: Time (min) | Temperature, lid on, trial 1 (°C) | Temperature, lid on, trial 2 (°C) | Temperature, lid off, trial 1 (°C) | Temperature, lid off, trial 2 (°C). Assumption (any one): the thermometer reads true — checked in ice-and-water close to 0 °C; the same thermometer is used for both beakers.

Fully-worked solutions

Q1. (a) The beaker's marks are every 50 mL — **a guide only, far too coarse** to read 25 mL. (b) The cylinder fits because 25 mL sits **inside its 0–100 mL range** and its **1 mL marks** let you read to the nearest 1 mL. (c) The rule matches **right quantity, right range, finest graduation small enough**.

Q2. (a) Two labelled marks 10 and 20, five small divisions between: (20 − 10) ÷ 5 = **2 N** per small division. (b) The pointer is 3 divisions above 10: 10 + 3 × 2 = **16 N**.

Q3. (a) The finest graduation is 1 mm = **0.1 cm**. (b) The tip sits exactly halfway between 6.3 and 6.4, so estimate one more figure: **6.35 cm**. (c) The tip is **between the two marks**, so 6.3 or 6.4 would pick a mark the tip is not on; the estimated figure says **where it actually sits**.

Q4. (a) **12.3 g** — the last digit is the display's **finest graduation**; dropping it **throws away precision** the instrument gave. (b) **−4 °C** — four degrees *below* zero keeps its minus sign. (c) 4 °C and −4 °C are **8 degrees apart**; without the sign the reading says **the wrong side of zero** (`VC2S8I03.E06`).

Q5. (a) The **bottom of the curve** — the meniscus dips in the middle. (b) An eye above reads **too high**, an eye below reads **too low**; only the **level eye** reads the true value. (c) The needle **floats in front of the printed dial**, so an angled sight line meets the scale at **the wrong number**; sighting **straight on** removes the error.

Q6. (a) Any two of: **temperature, light, humidity, pH** — the abiotic factors. (b) The logger **keeps recording at set times — every minute, day and night — when nobody is watching**, and stores the data ready for a table. (c) The app only **matches your photo against reference images** and can be wrong, so the match is **checked against a field guide or an expert** before it becomes a record.

Q7. One small division: (−10 − (−20)) ÷ 5 = 10 ÷ 5 = **2 °C** *(1 mark)*. The top of the liquid is 2 divisions above −20: −20 + 2 × 2 = **−16 °C**, sign included *(1 mark)*.

Q8. The forgotten zero shifts every reading up by 0.4 g, so the true mass is 12.7 − 0.4 = **12.3 g** *(1 mark)*. The student should have **pressed tare — set the display to zero — before measuring** *(1 mark)*.

Q9. One mark each for any two of three: the header holds units but **the quantities are not named** (°C of what? min of what?); **a unit is scribbled in the body** ("56 degrees") when cells hold numbers only; **no column for the second trial** the plan promised *(2 marks)*. Rewritten header row: **Time (min) | Temperature trial 1 (°C) | Temperature trial 2 (°C)** *(1 mark)*.

Q10. The **25 mL cylinder** *(1 mark)*: 17 mL fits inside its range and its 1 mL marks can land exactly on 17, while the beaker's **50 mL marks are far too coarse** and the 10 mL cylinder's **range is too small** — 17 mL would take two fills, each with its own reading error *(1 mark)*.

Q11. (a) **Yes — precise**: the three readings sit **within 0.2 g of each other** *(1 mark)*. (b) **No — not accurate**: every reading sits **about 0.8 g above the true 50.0 g** *(1 mark)*. (c) A **zero error** — the balance not tared — **shifts every reading the same way**; evaluating accuracy is **5A's job** *(1 mark)*.

Q12. (a) 56 000 m = 5.6 × 10 000 m = **5.6 × 10^4 m** — the exponent counts the zeros that moved *(1 mark)*. (b) 3.1 × 10^3 = 3.1 × 1 000 = **3 100 g** *(1 mark)*.

Q13. One mark each: (a) going down the ladder multiplies: 2.4 L = 2.4 × 1 000 = **2 400 mL**. (b) going up divides: 75 g = 75 ÷ 1 000 = **0.075 kg**. (c) 1 mL = 1 cm^3, so 460 mL = **460 cm^3** — no multiplying needed.

Q14. Independent variable: lid — on or off; dependent variable: the temperature of the water, measured with a laboratory thermometer (finest graduation 1 °C), in °C *(1 mark)*. Header row with units in the header and quantities named — e.g. **Time (min) | Temperature, lid on, trial 1 (°C) | Temperature, lid on, trial 2 (°C) | Temperature, lid off, trial 1 (°C) | Temperature, lid off, trial 2 (°C)** *(1 mark)*. **Room for two trials** of each lid value *(1 mark)*. One equipment assumption, e.g. **the thermometer reads true — checked in ice-and-water close to 0 °C**, or the same thermometer is used for both beakers *(1 mark)*.

Sources

Web sources below were retrieved 2026-08-21.

- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8I03` and its elaborations, 2026. vcaa.vic.edu.au
- Australian Museum, 'FrogID', 2026. frogid.net.au — retrieved 2026-08-21. Every FrogID recording is listened to by one or more frog-call experts at the Australian Museum.

All readings, instrument checks and results tables in this subtopic — including the cooling notes in the second Try-it and the balance readings in Q11 — are **simulated data for practice**: made-up values to read against and argue about, not measured results. The instrument graduations in the table and figures are drawn to match common school equipment, and every reading shown on a scale is computed from that scale's own marks.

Elaboration contexts used: `VC2S8I03.E01` (selecting equipment with the required precision — the meniscus read at its bottom, eye level, in a reproducible way), `VC2S8I03.E02` (recording with precision appropriate to the instrument — to the finest graduation, with one estimated figure between marks and exactly-as-displayed for digital readings), `VC2S8I03.E03` (sensors measuring abiotic factors through a probe–logger–computer chain, and field identification by call or image recognition, with FrogID as the sourced example), `VC2S8I03.E04` (digital microscopes, simulations and video-recording devices observing, measuring and recording qualitative and quantitative data — the cell context is handed to Chapter 8), `VC2S8I03.E05` (table conventions — units in the header row, quantities named, one column per trial, independent variable left and dependent variable right, ready for 4A) and `VC2S8I03.E06` (signs kept, readings written the same shape, exponent notation for big numbers — positive integer and zero exponents only, per `VC2M8N02`).

Teacher-facing note — division of labour and scope ceilings (not student text). 3C owns `VC2S8I03` whole and teaches instrument selection, scale reading, recording precision and digital tools. The split with the sibling subtopics is on purpose: 3A owns variables, planning and repeats (3C borrows the variable names for table headers); 4A owns the table-to-graph conventions and spreadsheet formulas (3C builds the table and hands it over); 5A owns the words *random* and *systematic* for the two shapes of error and the evaluation of accuracy (3C shows both shapes — scatter on the targets, the tare shift on the balance — without taking the words, and defers the judging). Sight-line error is taught descriptively ("sight straight on", "eye level"); its technical name is a later-years word and is left out on purpose. The `VC2M8N02` ceiling is enforced: exponents are positive integers and zero only, and very small amounts are written in smaller units rather than with negative exponents. No Aboriginal or Torres Strait Islander content is delivered in this subtopic (D10): none of the elaborations drawn on carry any. The only web claim in student text — the FrogID expert-checking process — comes from the named source above; nothing here is an invented fact, statute or person.