Science 5–6

Chapter 3 — Processing, modelling and analysing

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.

Significant effort has been made to ensure this content is legal. Please send any areas of concern to admin@vwx.au with appropriate document/legal references so errors can be verified and changes be made.

Tables, graphs and models that show what the data says

Words to know data · representation · table · column graph · line graph · axis · scale · unit · key · category · pattern · trend · relationship · model · annotate · circuit diagram

When you measure things in science, you end up with numbers and notes. That collection of numbers and notes is called **data**. A list of data on its own is hard to think with, so we sort it into a shape we can see: a table, a graph, a labelled picture or a model. Any display that stands for data is called a **representation**. A good representation makes the story in the data easy to see — it shows the **patterns**, **trends** and **relationships** hiding in the numbers. In this section we learn to choose the right representation, build it the right way, and read it back with numbers.

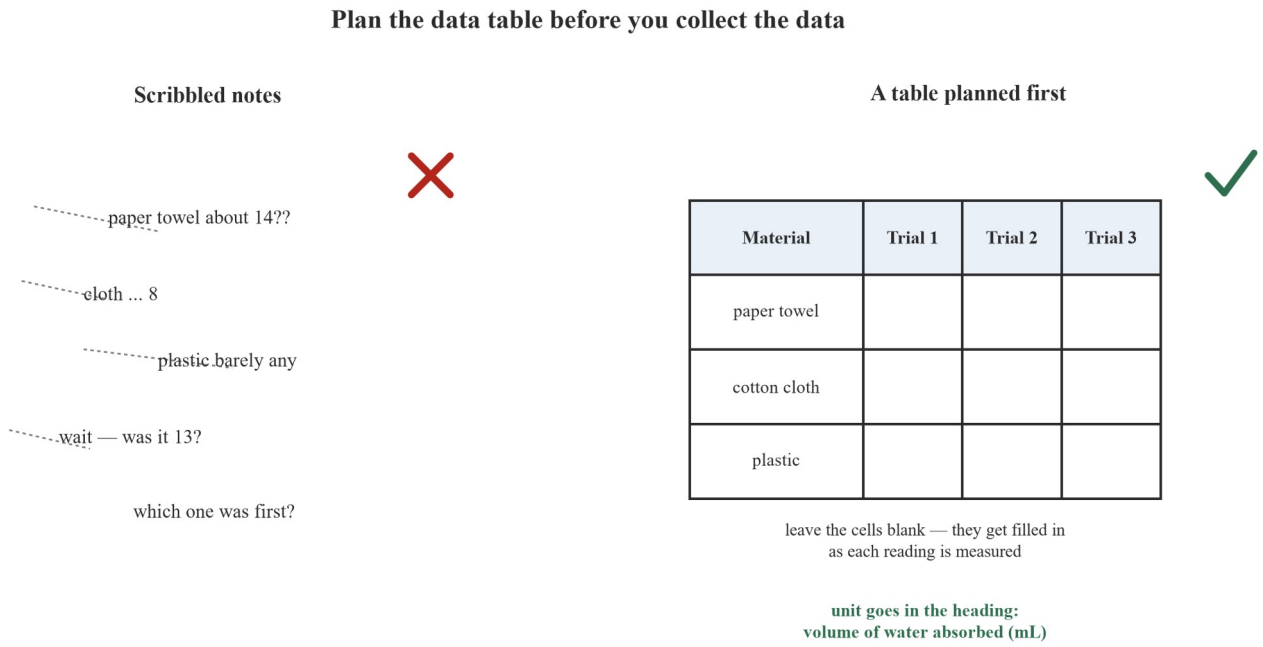
Theory

Plan the table first

Good data starts with a good table, and the table is drawn **before** the data is collected, not after. A planned table tells you exactly what to write down as you work, so nothing gets lost.

A **table** is a grid with a row and a column for everything you need to record. The top row of a table holds the **headings**, and each heading says what goes in the column under it. The heading also carries the **unit** — the thing we measure in. If we measure water in millilitres, the heading says "volume of water (mL)", so the unit is written once, not in every box.

When we repeat a test, each repeat is a **trial**. A planned table has one column for each trial, and the boxes are left blank until each reading is measured.



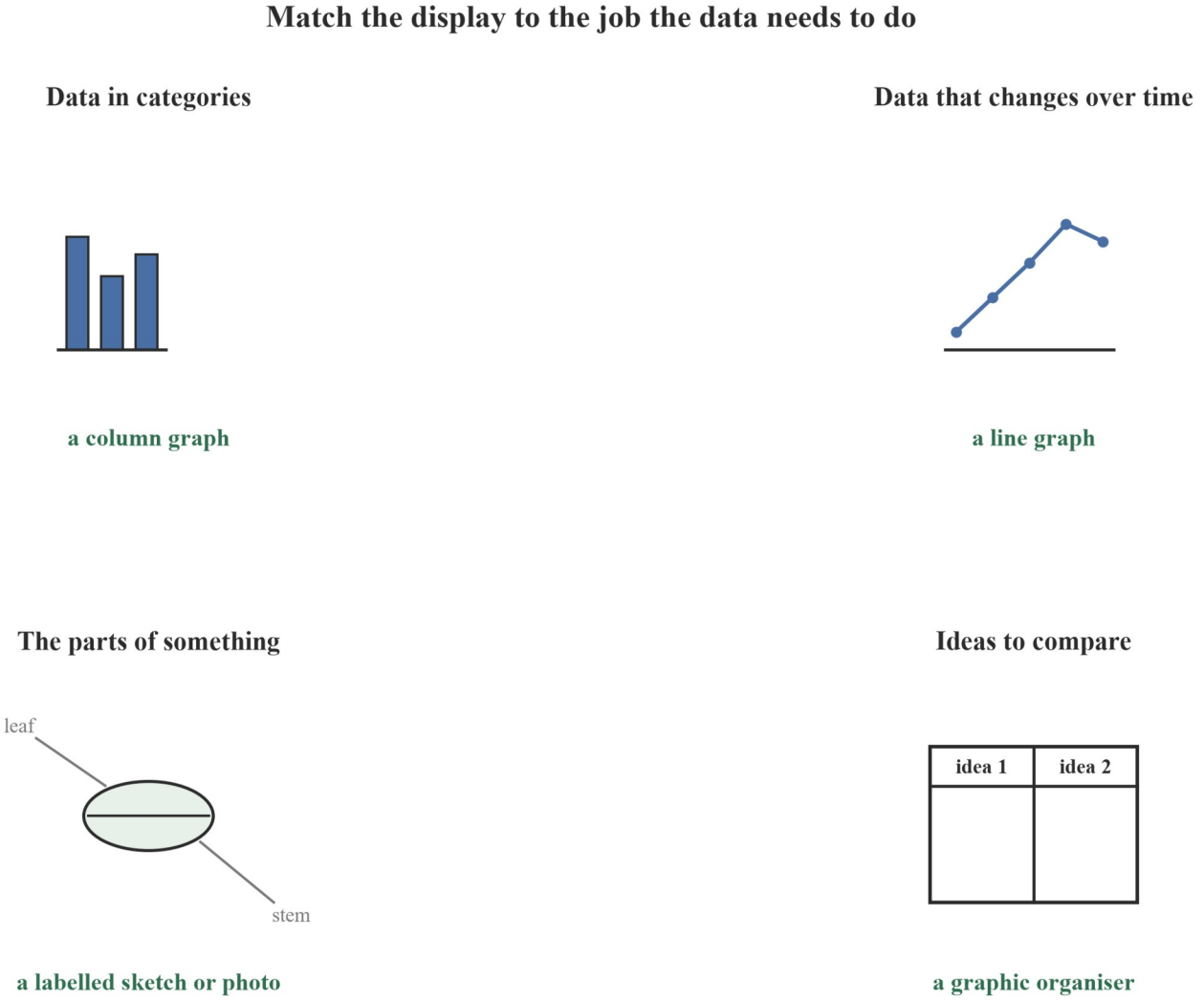
On the left, crossed-out scribbled notes that no longer make sense: "paper towel about 14??", "wait — was it 13?", "which one was first?" On the right, a planned table with the headings Material, Trial 1, Trial 2 and Trial 3, blank boxes ready for readings, and a note that the unit goes in the heading: volume of water absorbed (mL).

Choose the right representation

The data decides the display. Ask: what job does the data need to do?

- **Data in categories** — counts of different kinds of things — takes a **column graph**. A **category** is a group we sort things into: magpie, worm and beetle are categories.
- **Data that changes over time** — the same thing measured again and again — takes a **line graph**.
- **The parts of something** — the structure of a plant or an animal — takes a **labelled sketch** or an **annotated photograph**. To **annotate** a picture is to add short notes and lines that point to the parts.

- **Ideas to compare** — two explanations, two displays, two living things — takes a **graphic organiser**, a drawn frame that sorts ideas side by side.



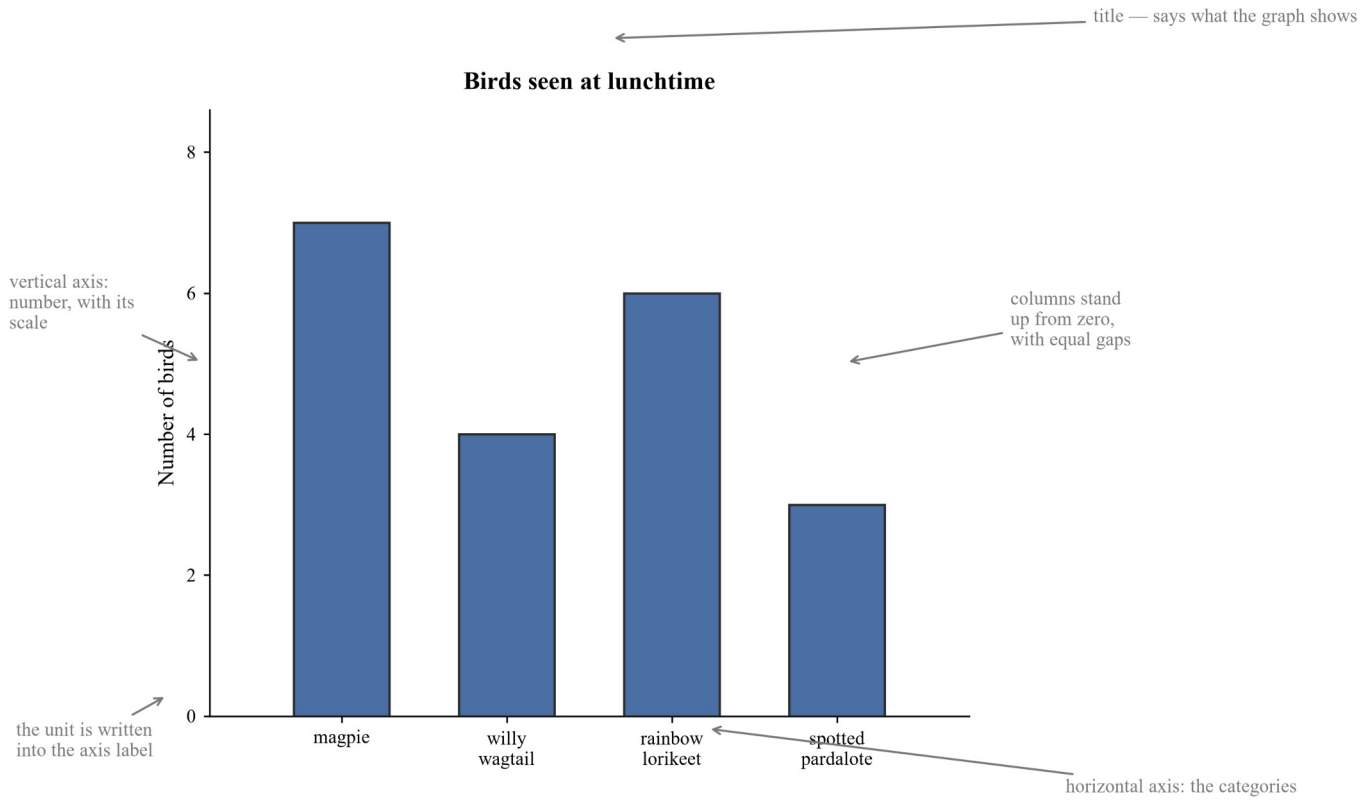
Four panels matching each job to its display: data in categories goes to a column graph; data that changes over time goes to a line graph; the parts of something go to a labelled sketch or annotated photograph; ideas to compare go to a graphic organiser.

Column graphs

A column graph stands one column over each category, so the heights can be compared at a glance. Every column graph has the same parts:

- a **title** that says what the graph shows;
- a **horizontal axis** (the left-to-right line) carrying the categories;
- a **vertical axis** (the up-and-down line) carrying the numbers;
- a **scale** — the numbers on the axis, going up in equal steps;
- the **unit**, written into the axis label, such as “Number of birds”;
- columns of the same width, standing up from zero with equal gaps between them.

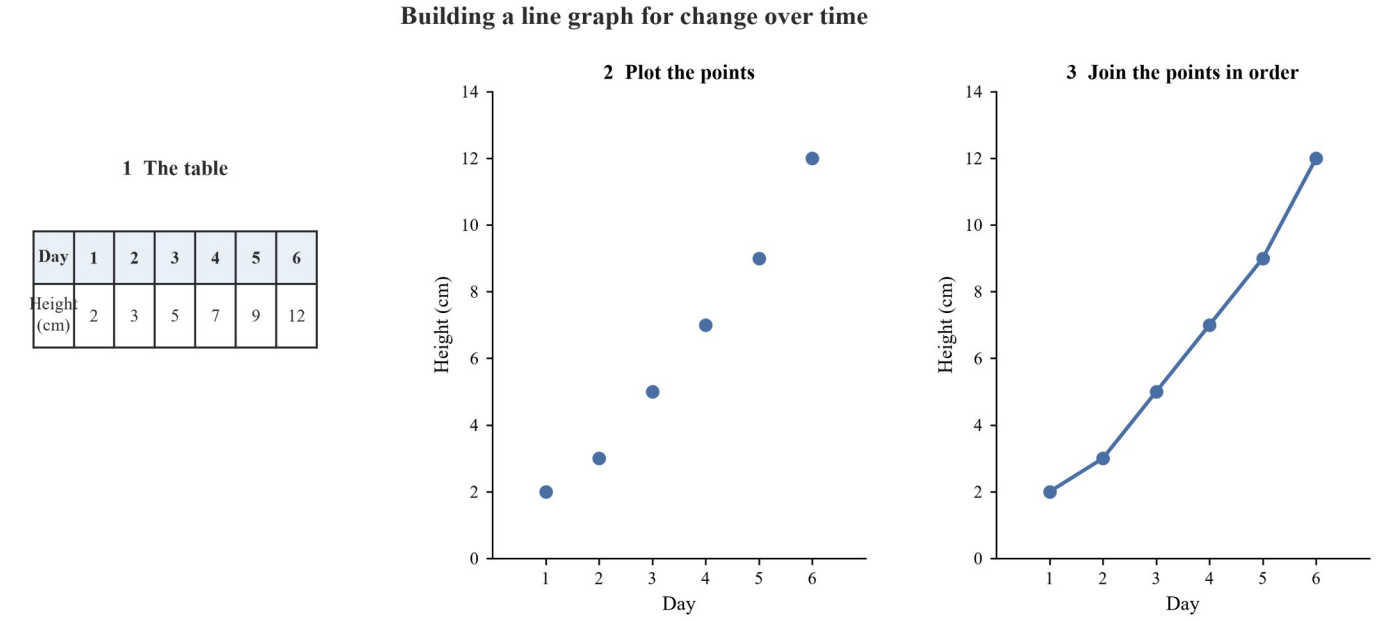
If a graph uses more than one colour or symbol, it also needs a **key** — a small box saying what each colour or symbol means.



An annotated column graph titled "Birds seen at lunchtime": the title, the vertical axis with its number scale, the horizontal axis with its categories (magpie, willy wagtail, rainbow lorikeet, spotted pardalote), the unit written into the axis label, and columns of equal width standing up from zero with equal gaps, are each pointed out with an arrow.

Line graphs

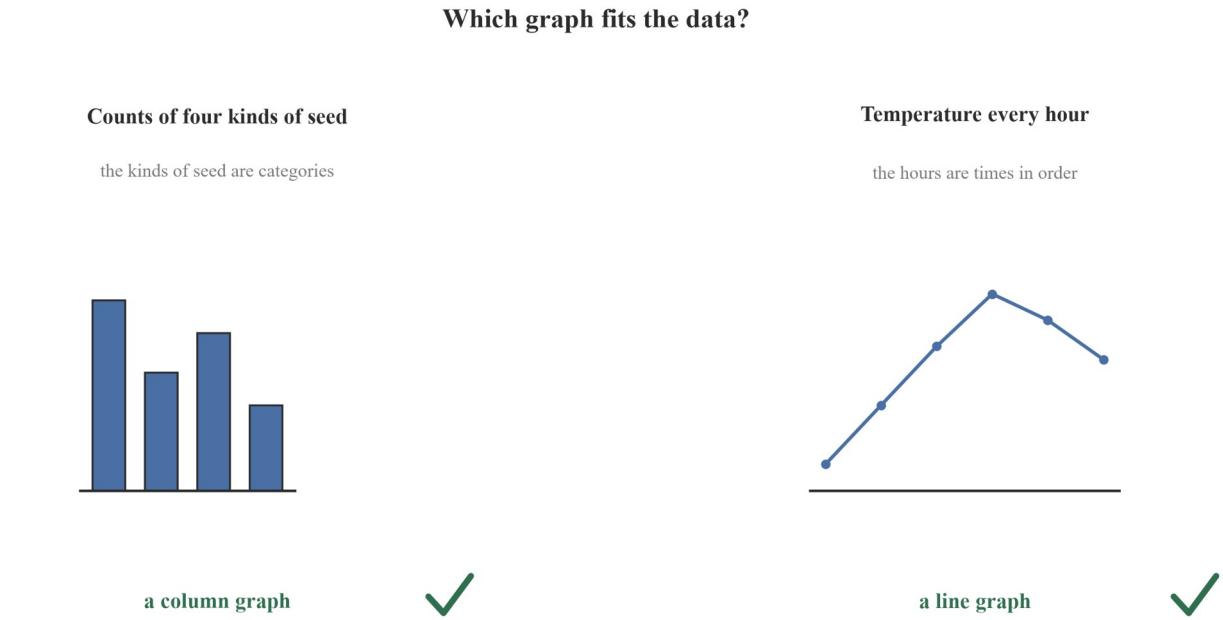
A line graph shows change over time. Build it in three steps: read each pair of values from the table, plot a point for each pair, then join the points **in order** with straight lines. The line is the story: its shape shows how the thing changed.



Day	1	2	3	4	5	6
Height (cm)	2	3	5	7	9	12

Three panels building a line graph of a bean seedling's height: panel 1 is the table of day and height in centimetres; panel 2 shows the points plotted; panel 3 shows the points joined in order with straight lines.

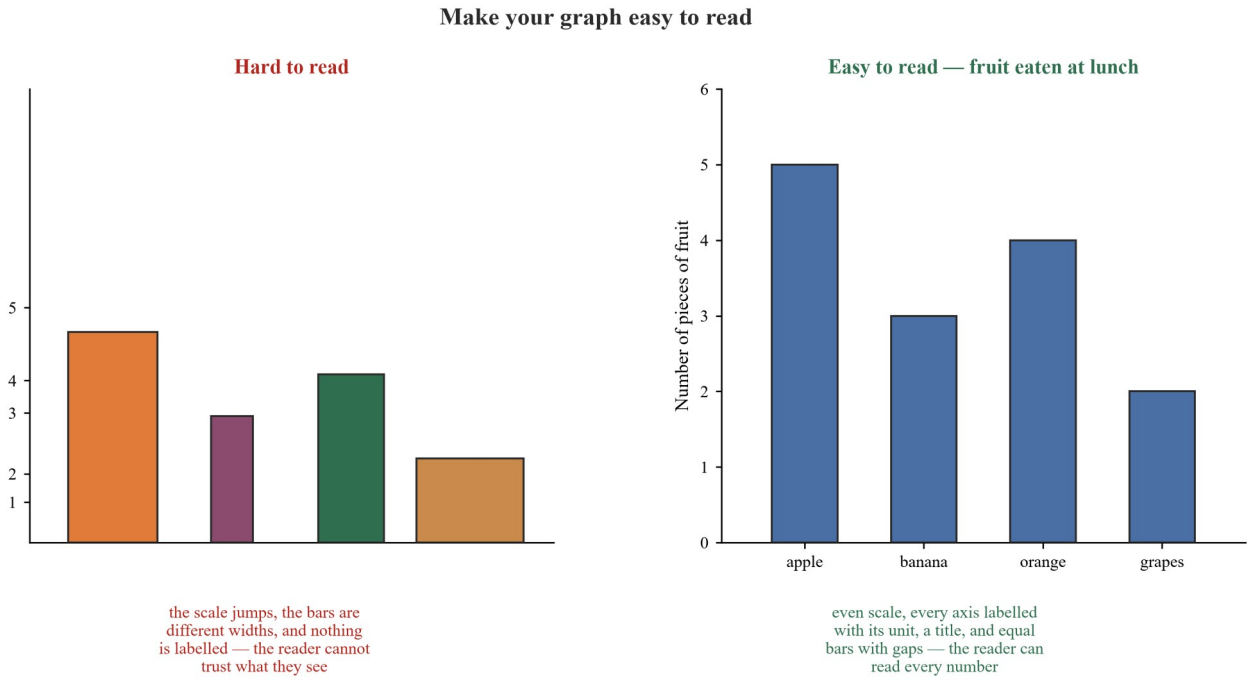
Which graph fits? Counts of four kinds of seed are categories, so the columns stand alone. Temperature measured every hour is change over time, so the points are joined in order.



Two panels: counts of four kinds of seed, which are categories, correctly drawn as a column graph; temperature every hour, which are times in order, correctly drawn as a line graph.

Make your graph easy to read

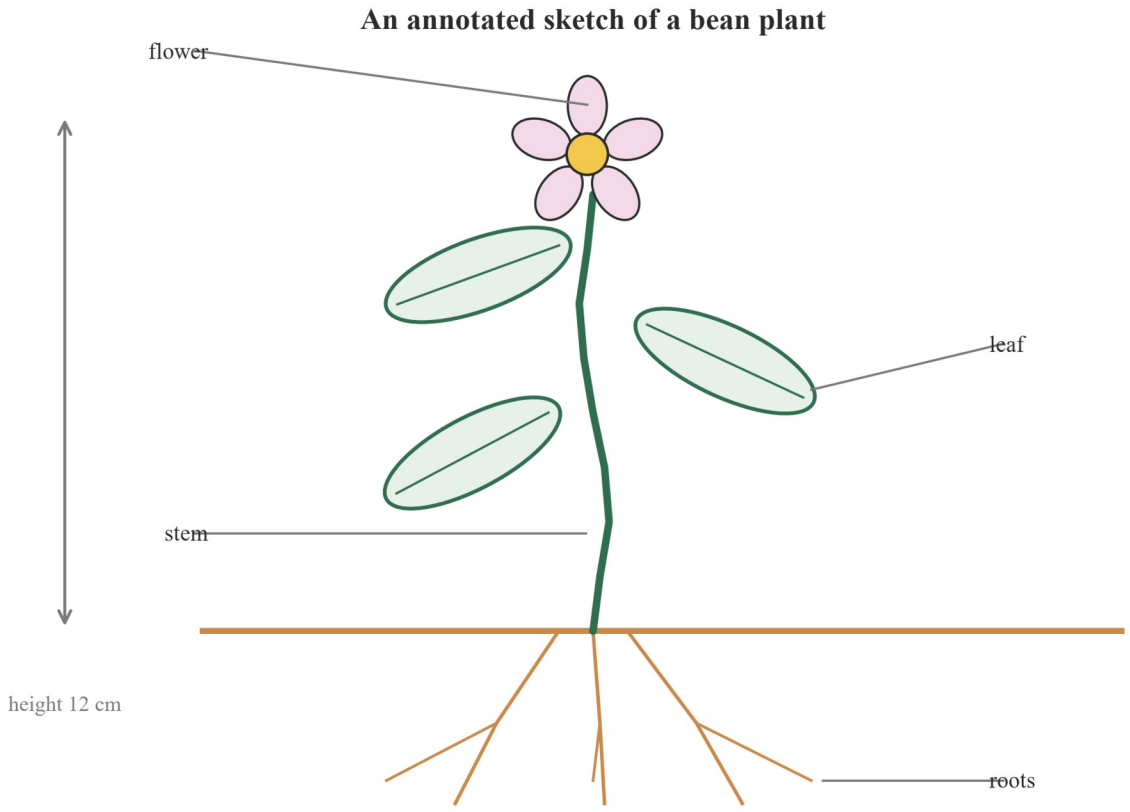
A graph is a message to the reader, and a messy graph sends a message nobody can trust. The scale must go up in **equal steps** — a scale that jumps 1, 2, then 5 makes the columns lie. Every axis needs a label with its unit, the graph needs a title, and columns need to be the same width with equal gaps.



Two graphs of the same fruit data side by side. The left graph is hard to read: the scale jumps, the bars are different widths and different colours, and nothing is labelled. The right graph is easy to read: an even scale, every axis labelled with its unit, a title, and equal bars with gaps.

Labelled sketches and annotated photographs

Not all data is a number. When you study the structure of a living thing, the right representation is a field sketch or a photograph with notes added. The notes follow two rules: the lines that point to a part (the **leader lines**) go straight from the note to the part, and the notes stay short. A measurement, such as the height of the plant, can be added with an arrow.



An annotated field sketch of a bean plant: straight leader lines run from the short notes "flower", "stem", "leaf" and "roots" to each part, and a double-headed arrow beside the plant records its height, 12 centimetres. A note below says leader lines go straight from the note to the part, and notes stay short.

A digital photograph can be annotated the same way: print it or mark it on screen, and add the same straight leader lines and short notes.

Graphic organisers

A **graphic organiser** is a drawn frame that sorts ideas so they are easy to compare. The simplest organiser is a **T-chart**: two columns under two headings, one row per idea. Here is the T-chart that compares the two graphs of this section.

A T-chart is a graphic organiser

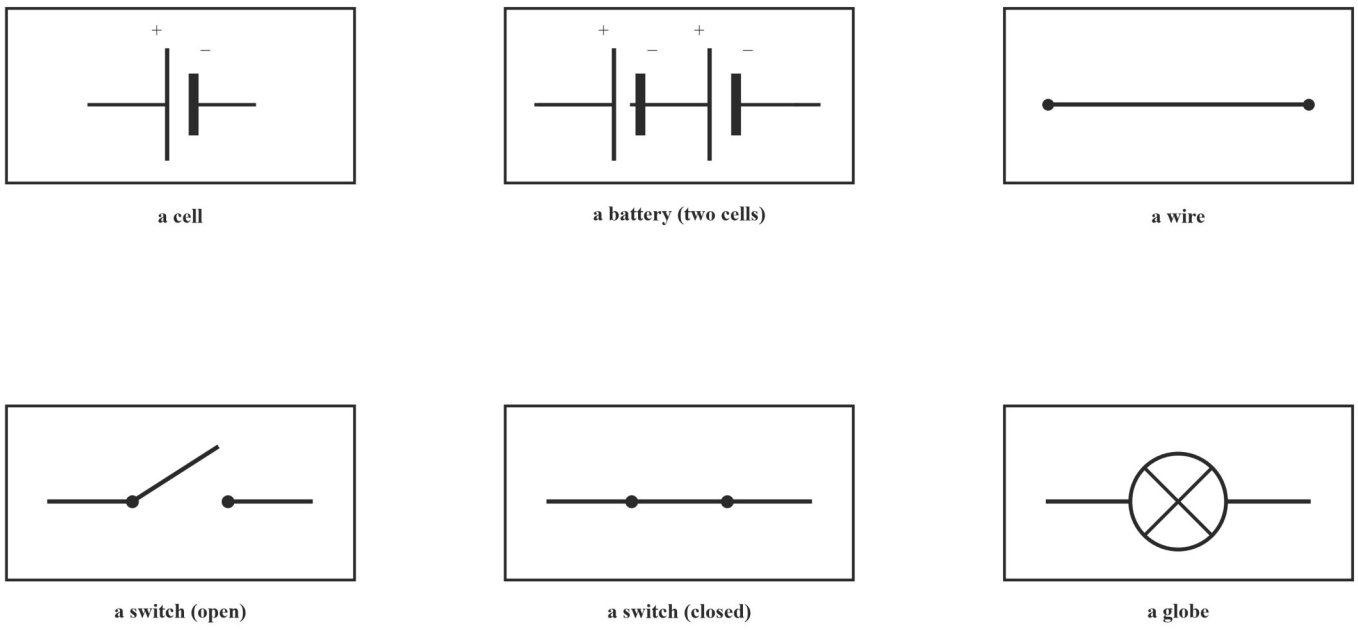
Column graph	Line graph
data sits in categories	data changes over time
columns stand alone	points joined in order
good for comparing amounts	good for showing a trend

an organiser sorts ideas so they are easy to compare

A T-chart graphic organiser comparing column graphs and line graphs in three rows: data sits in categories against data changes over time; columns stand alone against points joined in order; good for comparing amounts against good for showing a trend.

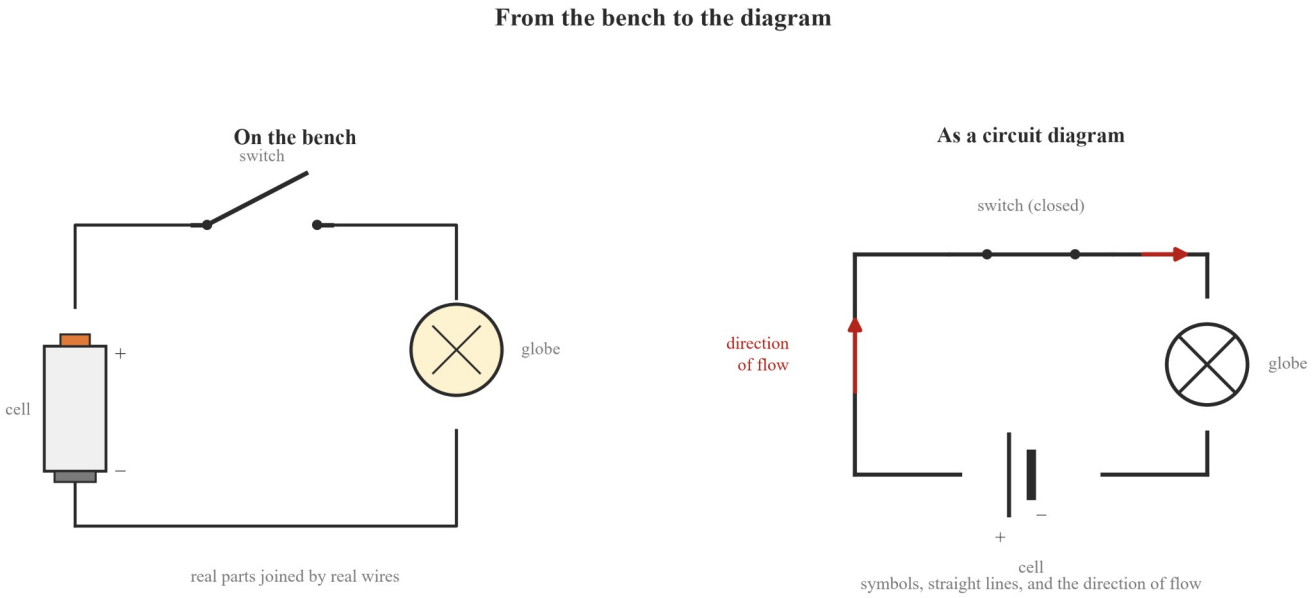
Circuit diagrams

Scientists and electricians do not draw pictures of real circuits — they draw **circuit diagrams**, in which every part is a small agreed symbol and every wire is a straight line. The symbols for this book are: a **cell** (one long thin line marked + and one short thick line marked −), a **battery** (two or more cells joined), a **wire**, a **switch** (open or closed) and a **globe** (a circle with a cross inside).



Six panels showing the agreed circuit symbols: a cell with its long positive line and short negative line, a battery of two cells, a wire, a switch drawn open, a switch drawn closed, and a globe drawn as a circle with a cross inside.

A circuit diagram is drawn as a loop with straight lines and square corners. An arrow on a wire shows the **direction of the flow of electricity** around the loop, out from the + end of the cell and back to the − end. In a later book you will learn *why* circuits behave as they do; here the skill is the drawing itself — the same circuit, drawn by two different people, must look the same, so that both readers see the same circuit.



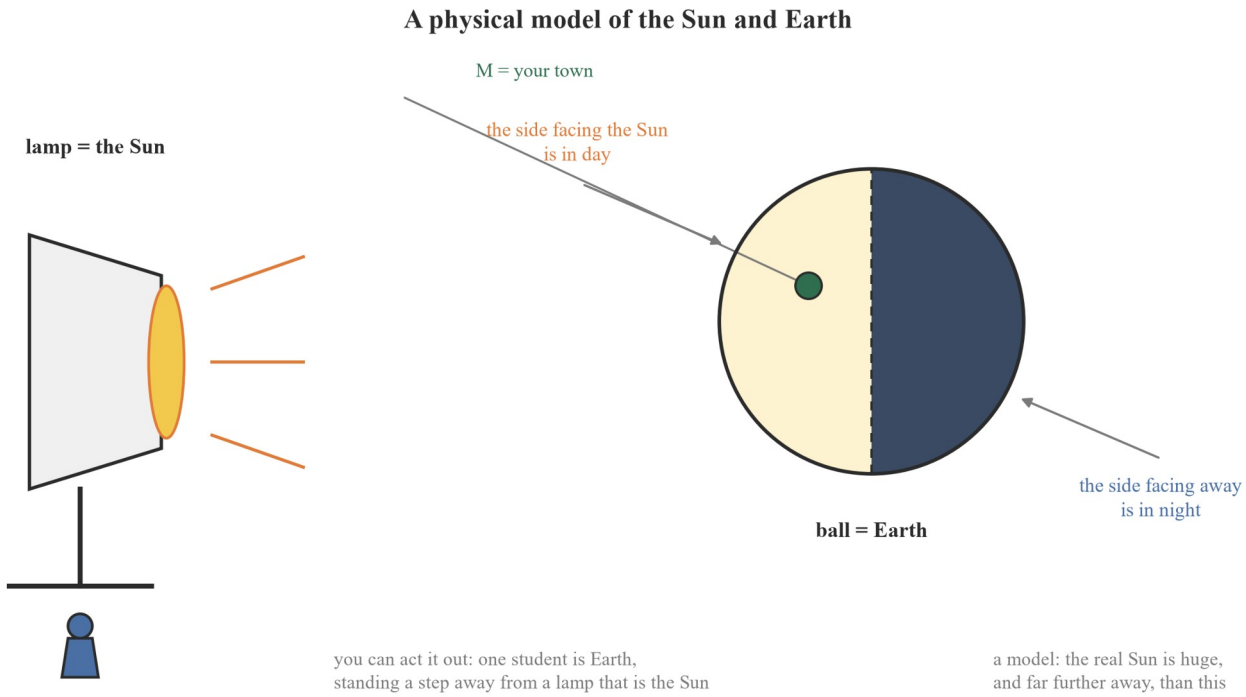
Two panels. Left: a bench circuit of a cell, an open switch and a globe joined by real wires. Right: the same circuit drawn as a circuit diagram — a rectangular loop with the cell, closed switch and globe symbols — with red arrows marking the direction of flow out from the positive end of the cell.

Models

A **model** is a stand-in for something that is too big, too small, too fast, too slow or too far away to study directly. A physical model uses real objects to stand for the real things.

A lamp and a ball model the Sun and the Earth. The half of the ball facing the lamp is lit — that side is in **day**. The half facing away is dark — that side is in **night**. A sticker marks your town, so you can see whether your town is on

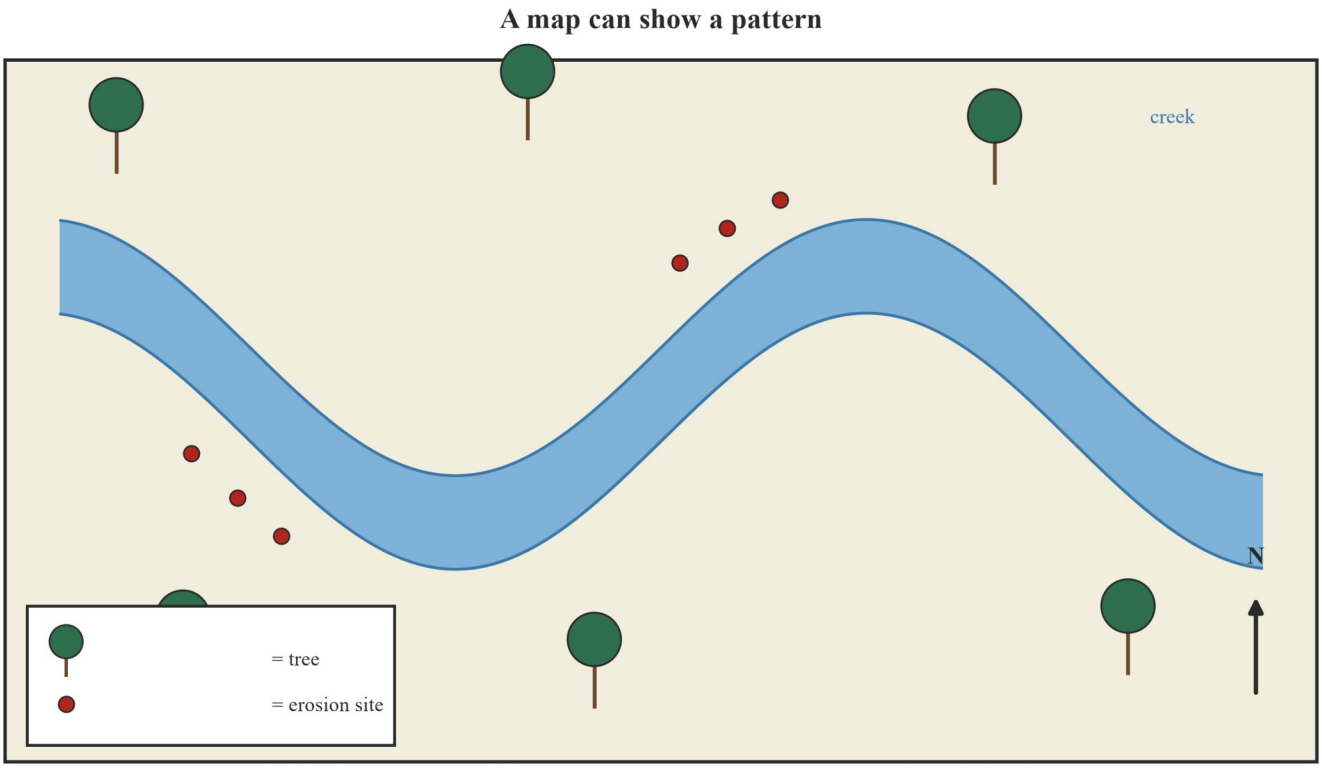
the day side or the night side. The same idea works as a role-play: one student is the Earth, standing a step from a lamp that is the Sun.



A physical model: a lamp stands for the Sun and a ball stands for the Earth; the half of the ball facing the lamp is light and labelled "the side facing the Sun is in day", the half facing away is dark and labelled "the side facing away is in night", and a small sticker labelled M marks your town on the day side. A note reminds the reader that the real Sun is huge, and far further away, than the model.

Every model has parts that are **not** like the real thing, and saying what they are is part of using a model well. In this one, the lamp is far too small and far too close: the real Sun is huge, and far further away than the lamp. The model shows which side is in day and which is in night; the full story of *why* day and night happen is told in a later book.

A map is a model too, and a map can show a **pattern** in data. The practice map below plots erosion sites beside a creek. **Erosion** is the wearing away of land by moving water or wind. The dots are not scattered at random: they cluster on the outer sides of the bends, and that cluster is the pattern.



SCENARIO — a practice map. The pattern: most erosion sites sit on the outer sides of the bends.

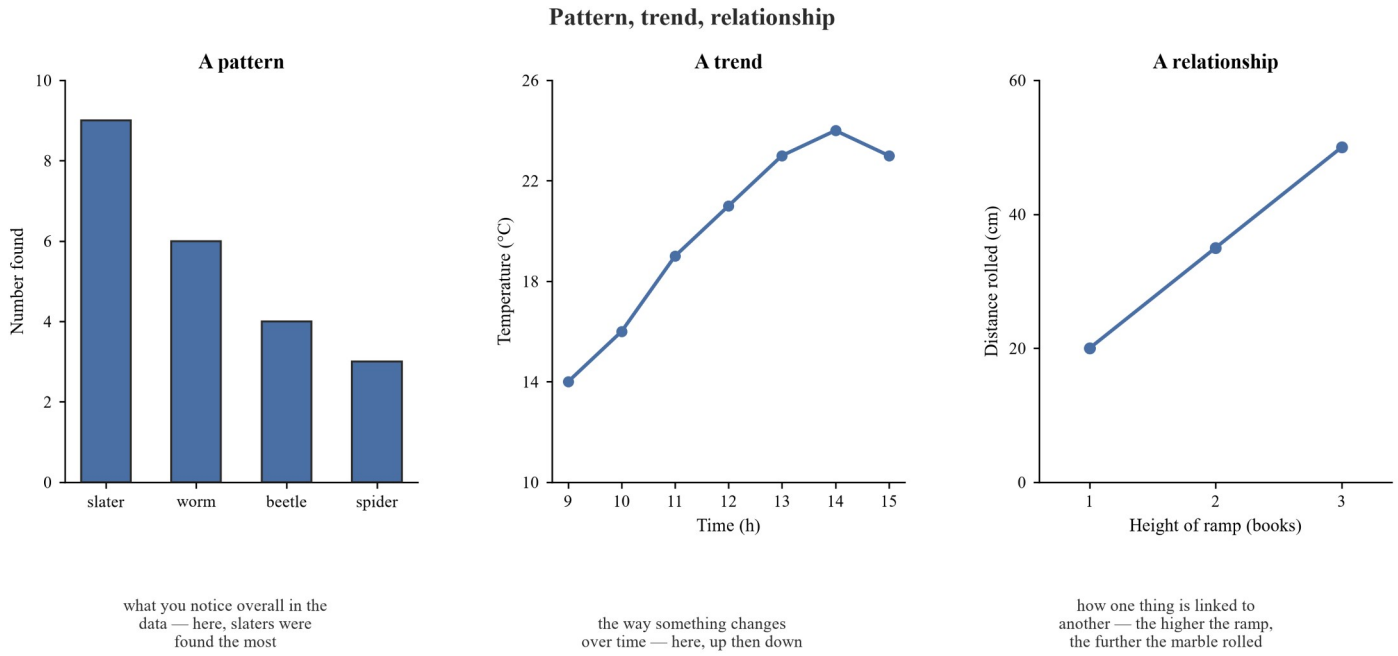
A SCENARIO practice map of a winding creek with red dots marking erosion sites and small symbols marking trees, a key, and a north arrow: the erosion sites cluster on the outer sides of the two bends.

Models of the tiny pieces of matter come later in this book: in Chapter 7 you will model how the tiny pieces of a solid, a liquid and a gas are arranged, and use that model to explain what you observe.

Read the display: pattern, trend, relationship

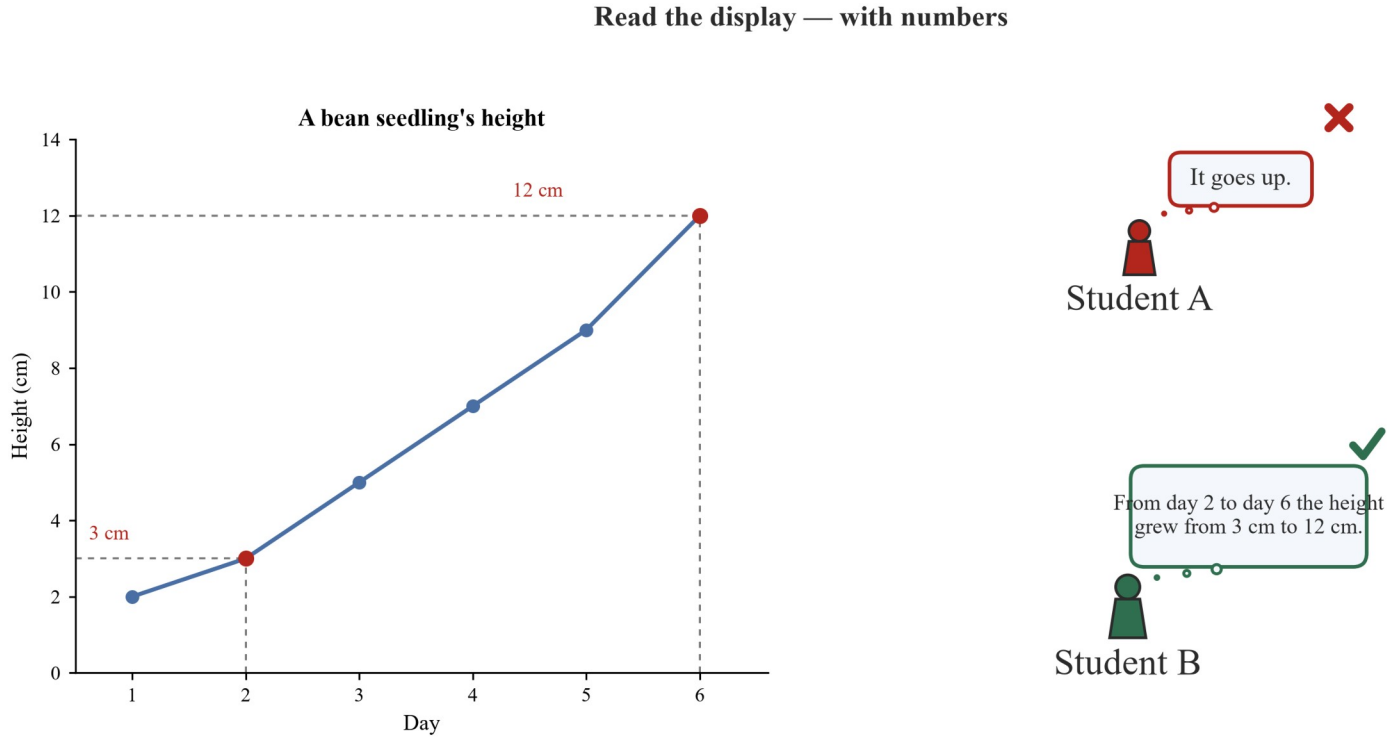
Three words name the stories a display can tell.

- A **pattern** is what you notice overall in the data — the slaters were found the most, the erosion sites cluster at the bends.
- A **trend** is the way something changes over time — up, down, up then down.
- A **relationship** is a link between two things — the higher the ramp, the further the marble rolled.



Three small displays side by side: a column graph of minibeast counts labelled "a pattern"; a line graph of temperature over the day, rising then falling, labelled "a trend"; and a line graph of distance rolled against ramp height, rising in a straight line, labelled "a relationship".

And one rule governs all reading in this book: **quote the figures**. "It goes up" is not a reading. A reading names the numbers.



A line graph of a bean seedling's height with two readings marked by dashed lines: 3 centimetres on day 2 and 12 centimetres on day 6. Beside it, Student A says only "It goes up", which is crossed out, while Student B says "From day 2 to day 6 the height grew from 3 centimetres to 12 centimetres", which is ticked.

Worked examples

Example 1 — with support

SCENARIO — A Year 6 class counts the birds seen at lunchtime: magpie 7, willy wagtail 4, rainbow lorikeet 6, spotted pardalote 3. Construct a column graph of the data.

Working	Comment
The data is counts of kinds of bird — categories.	Categories take a column graph.
Draw the axes: categories on the horizontal axis, numbers on the vertical axis. The biggest count is 7, so a scale from 0 to 8, going up by 1s, fits.	The scale must go up in equal steps and hold the biggest value.
Label both axes — "Number of birds" on the vertical axis — and add the title "Birds seen at lunchtime".	The unit lives in the label; the title says what the graph shows.
Draw one column per category, all the same width, with equal gaps: magpie 7, willy wagtail 4, rainbow lorikeet 6, spotted pardalote 3.	Columns stand up from zero, so the heights can be compared honestly.

The finished graph is the one shown in the column-graph figure above: a reader can now see the whole story in one look.

Example 2 — with support

SCENARIO — The line graph of the bean seedling's height (the figure in "Line graphs") was built from this table.

Day	1	2	3	4	5	6
Height (cm)	2	3	5	7	9	12

(a) Read the height on day 4. (b) Describe the trend, quoting figures.

Working	Comment
(a) Find 4 on the horizontal axis, go up to the point, read across: 7 cm.	Reading a graph means running the eye along the axes, not guessing.
(b) Day 1: 2 cm. Day 6: 12 cm.	Quote the figures at the ends of the data.
The height grew every day, from 2 cm on day 1 to 12 cm on day 6; the biggest daily jump was from day 5 to day 6 (9 cm to 12 cm, a 3 cm jump).	A trend is described with numbers, never with "it goes up".

Example 3 — by yourself

SCENARIO — A class litter survey around the school oval counted: plastic wrappers 14, paper 9, bottle caps 6, other 5. Choose the right representation for this data, construct it in your notebook, and write one sentence that reads it back with figures.

Practice questions

With support

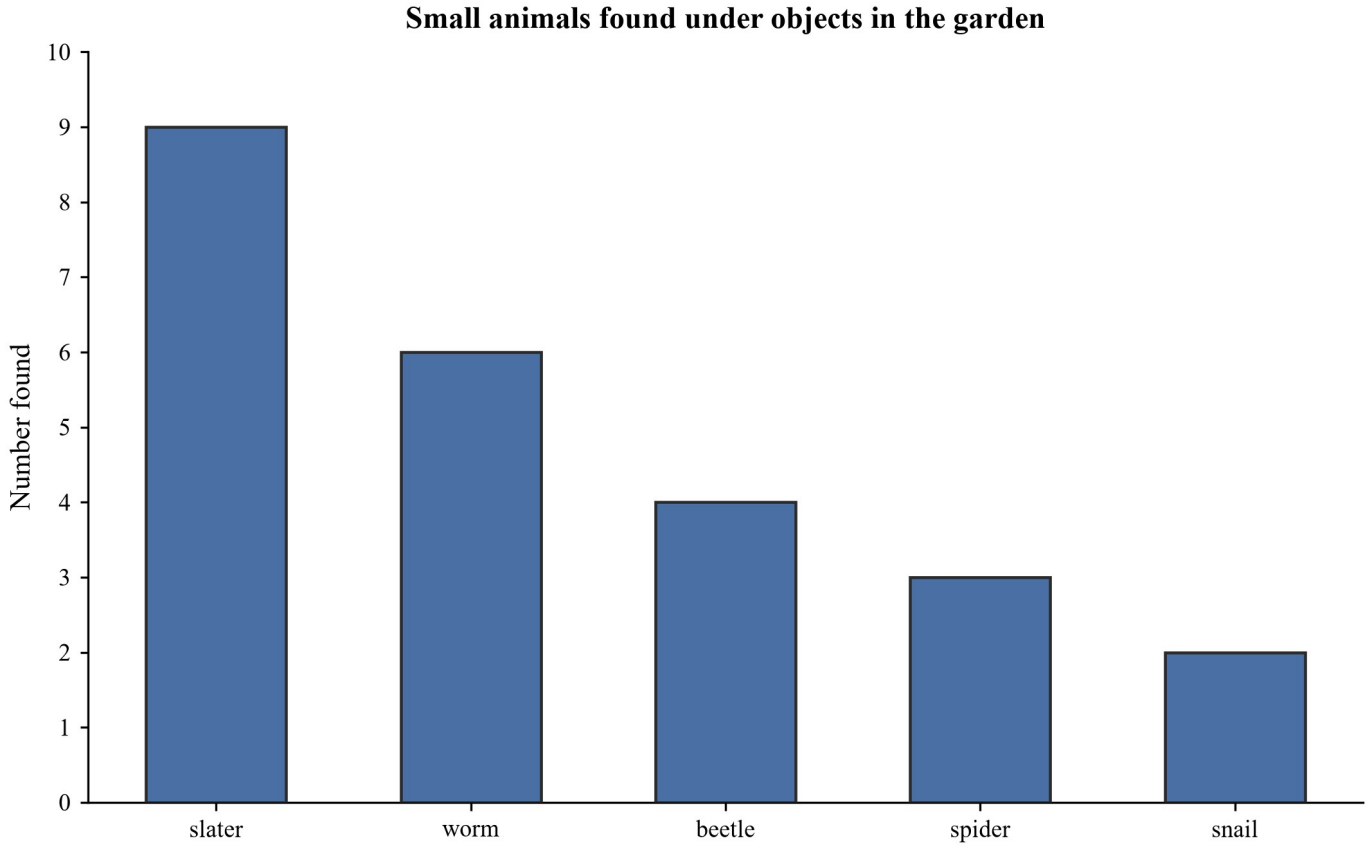
Q1. Write a sentence of your own for each word. *(3 marks)* (a) data (b) representation (c) model

Q2. Choose the better representation and say why. *(2 marks)* (a) The number of each kind of seed a class collected. (b) The temperature of a cup of water, read every hour of the day.

Q3. A class tests how many drops of water a five-cent coin can hold before the water spills, doing three trials. Draw the table they should have planned **before** collecting the data, with headings and blank boxes. *(2 marks)*

Q4. Name four things every good column graph must have. *(4 marks)*

Q5. The column graph below shows a SCENARIO count of small animals found under objects in a garden. *(2 marks)*



A column graph titled "Small animals found under objects in the garden": slater 9, worm 6, beetle 4, spider 3, snail 2, on a vertical scale from 0 to 10 going up by 1s.

(a) How many slaters were found?

(b) How many more slaters than snails were found? Quote both figures.

Q6. Look at the circuit symbols figure in the theory. *(2 marks)* (a) Which part is drawn as a circle with a cross inside? (b) How can you tell, from the drawing, whether a switch is open or closed?

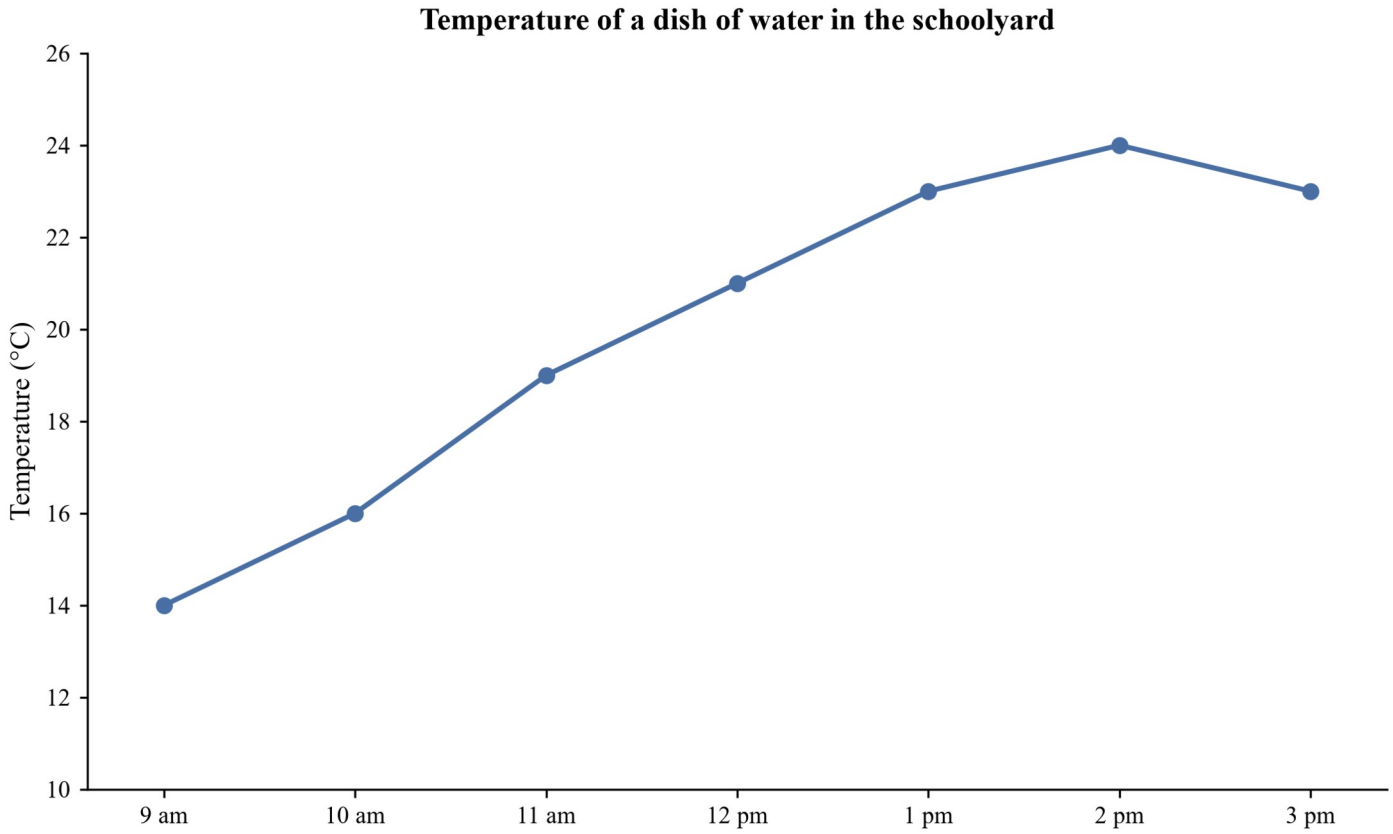
By yourself

Q7. Choose column graph or line graph for each data set, and say why. *(2 marks)* (a) The heights of five different students, measured once. (b) The height of one bean plant, measured every day for ten days.

Q8. The "hard to read" graph in the graph-mistakes figure shows the same data as the easy-to-read one. Name two things wrong with it, and say how each is fixed. *(2 marks)*

Q9. SCENARIO — A class read the soil temperature at 9 am each morning for a week: Monday 12 °C, Tuesday 13 °C, Wednesday 13 °C, Thursday 15 °C, Friday 14 °C. Construct a line graph of the data in your notebook: title, labelled axes with units, an even scale, points joined in order. *(3 marks)*

Q10. The line graph below shows SCENARIO readings of the temperature of a dish of water left in the schoolyard. *(3 marks)*



A line graph titled "Temperature of a dish of water in the schoolyard": 14, 16, 19, 21, 23, 24 and 23 degrees Celsius at 9 am, 10 am, 11 am, 12 pm, 1 pm, 2 pm and 3 pm, on a vertical scale from 10 to 26 going up by 2s.

(a) At what time was the water hottest, and what was the reading? *(1 mark)*

(b) Describe the trend from 9 am to 3 pm, quoting two figures. *(2 marks)*

Q11. A sketch of a garden spider is printed for annotating. State two rules for the notes and leader lines. *(2 marks)*

Q12. Copy the T-chart of the graphic organiser figure into your notebook. The first row is done for you ("data sits in categories" against "data changes over time"). Fill in the two missing rows. *(3 marks)*

Q13. A circuit holds one cell, one switch and one globe, all joined in a single loop, and the switch is closed. Draw the circuit diagram using the agreed symbols, and add an arrow showing the direction of the flow of electricity. *(2 marks)*

Q14. The Sun–Earth model of the theory used a lamp and a ball. *(3 marks)* (a) What does the lamp stand for, and what does the ball stand for? (b) Which half of the ball is in night? (c) Give one way the model is not like the real Sun and Earth.

Q15. SCENARIO — Sam's notebook holds these messy notes of a count of bees at the drinking fountain: "Monday 5, Tuesday 7, Wednesday 7, Thursday 9, Friday 8". Draw the planned table Sam should have used, with headings and blank boxes for the readings. *(2 marks)*

Q16. SCENARIO — A class rolls a marble down a ramp made of books and measures how far it rolls. One book high: 20 cm. Two books high: 35 cm. Three books high: 50 cm. *(5 marks)* (a) Which representation suits this data — column graph or line graph — and why? *(1 mark)* (b) Construct the graph in your notebook with a title, labelled axes with units and an even scale. *(2 marks)* (c) Describe the relationship, quoting two figures. *(2 marks)*

Practical — which material soaks up the most water?

> **PRACTICAL** — this page plans or analyses work done in the classroom, laboratory or field. It is not a substitute for doing it.

Question: Of paper towel, cotton cloth and plastic, which material soaks up the most water?

Equipment: three squares the same size (10 cm × 10 cm) — paper towel, cotton cloth, plastic; three cups; a measuring cylinder; water; tongs or a clip; a timer; paper towel for spills.

Safety: Water on the floor is a slipping risk, so wipe spills up straight away. Handle the measuring cylinder carefully and tell the teacher if it breaks.

Risk	How we stay safe
Water spilled on the bench or floor	Wipe spills up straight away.
A dropped or broken measuring cylinder	Carry it low and slowly; tell the teacher if it breaks.
Water splashed into eyes	Rinse with water; wear safety glasses if your teacher asks.

Variables (the things we change, measure and keep the same):

Variable	Choice
The one we change	the material: paper towel, cotton cloth or plastic
The one we measure	the volume of water soaked up (mL)
The ones we keep the same	the size of the square (10 cm × 10 cm); the starting volume of water (20 mL); the dip time (10 s); the drip time (5 s)

Method:

1. Copy the results table below into your notebook **before** you start.
2. Measure 20 mL of water into a cup.
3. Lay the paper towel square on the water and start the timer.
4. After 10 s, lift the square with the tongs and hold it over the cup while it drips for 5 s.
5. Pour the water left in the cup into the measuring cylinder and read the volume left.
6. Work out the water soaked up: 20 mL − the volume left. Record it under Trial 1.
7. Repeat steps 2–6 two more times with paper towel. Compare your three trials: if one reading does not fit the other two, do that trial again and record the reading that fits.
8. Repeat steps 2–7 for the cotton cloth, then for the plastic.

Results: record your readings in a table like this one.

Material	Trial 1 (mL)	Trial 2 (mL)	Trial 3 (mL)	Our reading (mL)
paper towel				
cotton cloth				
plastic				

Thinking about the results:

1. Construct a column graph of your three "our reading" values: title, labelled axes with the unit, an even scale, equal gaps.
2. Which material soaked up the most water? Which soaked up the least? Quote your readings in a full sentence.
3. Look back at your three trials for each material. Did any trial not fit? What did you do about it?
4. Why did the test keep the size of the squares and the dip time the same?

Make a claim and defend it. Finish this writing frame in full sentences:

- I claim that _____ soaks up the most water of the three materials.
- My evidence is _____ (quote your readings, in mL).
- We can trust this result because _____ .
- If someone claimed the plastic soaked up water too, I would answer _____ .

Answers

Q1 Answers vary; each sentence must use the word sensibly. (a) Data is the numbers and notes we collect. (b) A representation is any display — table, graph, labelled picture, model — that stands for data. (c) A model is a stand-in for something too big, small, fast, slow or far to study directly. **Q2** (a) A column graph — kinds of seed are categories. (b) A line graph — the temperature changes over time. **Q3** A table with the headings "Trial" and "Number of drops on the coin" (counts have no unit), and three blank rows for Trials 1–3. **Q4** Any four of: a title; an even scale in equal steps; axis labels with the unit; columns of equal width standing from zero with equal gaps; a key if more than one colour or symbol is used. **Q5** (a) 9. (b) 9 − 2 = 7 more slaters than snails. **Q6** (a) The globe. (b) Open: the lever line lifts off one contact, breaking the loop. Closed: the line joins both contacts, completing the loop. **Q7** (a) Column graph — the five students are categories. (b) Line graph — one plant's height changes over time. **Q8** Any two, with the fix: the scale jumps → redraw with equal steps; the bars are different widths → make them equal; no labels, unit or title → label both axes with the unit and add a title. **Q9** A correct line graph: day on the horizontal axis, temperature (°C) on the vertical axis, an even scale holding 12–15 °C, the five points plotted and joined in order, title and labels present. **Q10** (a) 2 pm, 24 °C. (b) The temperature rose from 14 °C at 9 am to 24 °C at 2 pm, then dropped to 23 °C by 3 pm — up, then down. **Q11** Leader lines go straight from the note to the part; the notes stay short. **Q12** Row 2: columns stand alone / points joined in order. Row 3: good for comparing amounts / good for showing a trend. **Q13** A rectangular loop with the cell, closed switch and globe symbols, and an arrow on a wire running out from the + end of the cell around the loop. **Q14** (a) The lamp stands for the Sun; the ball stands for the Earth. (b) The half facing away from the lamp. (c) Any one: the lamp is far too small; the lamp is far too close. **Q15** A table with the headings "Day" and "Number of bees at the fountain", and five blank rows for Monday–Friday. **Q16** (a) Line graph — it shows how one measured thing (distance rolled) changes as another (ramp height) changes. (b) A correct graph with title, labelled axes and units, even scales, and the three points. (c) The higher the ramp, the further the marble rolled — at 1 book it rolled 20 cm; at 3 books it rolled 50 cm.

Worked solutions

Q1 *(3 marks: 1 each)* (a) Data is the numbers and notes we collect when we measure or count. *1 mark* (b) A representation is any display that stands for data — a table, a graph, a labelled picture or a model. *1 mark* (c) A model is a stand-in for something we cannot study directly, like the ball that stands for the Earth. *1 mark*

Q2 *(2 marks: 1 each)* (a) A column graph, because the kinds of seed are categories, and categories take columns that stand alone. *1 mark* (b) A line graph, because the same thing (temperature) is measured over time, and change over time takes points joined in order. *1 mark*

Q3 *(2 marks)* Headings that name the trial and the thing measured — "Trial" and "Number of drops on the coin" — with the unit question settled in the heading (a count of drops needs no unit). *1 mark* Three blank rows, one per trial, ready to be filled in as each reading is taken. *1 mark*

Q4 *(4 marks: 1 each)* A title that says what the graph shows; a scale that goes up in equal steps; both axes labelled, with the unit in the label; columns of equal width, standing up from zero, with equal gaps. (A key, where more than one colour or symbol is used, also counts.) *1 mark each*

Q5 *(2 marks: 1 each)* (a) 9 slaters. *1 mark* (b) Slaters 9, snails 2, so 9 − 2 = 7 more slaters than snails. *1 mark*

Q6 *(2 marks: 1 each)* (a) The globe. *1 mark* (b) In the open switch the lever line lifts away from one of the contacts, so the loop is broken; in the closed switch the line joins both contacts, so the loop is complete. *1 mark*

Q7 *(2 marks: 1 each)* (a) Column graph — the five students are categories, measured once. *1 mark* (b) Line graph — the height of one plant is measured again and again over time, so the points are joined in order. *1 mark*

Q8 *(2 marks: 1 per wrong thing with its fix)* The scale jumps (1, 2 close together, then a big gap) — fixed by redrawing the axis with equal steps. *1 mark* The bars are different widths and nothing is labelled — fixed by equal-width bars with gaps, labels with the unit on both axes, and a title. *1 mark*

Q9 *(3 marks)* Axes labelled "Day" and "Temperature (°C)", with a title. *1 mark* An even scale on the vertical axis that holds the readings (for example 10–16 °C by 1s or 2s). *1 mark* The five points (12, 13, 13, 15, 14) plotted correctly and joined in order. *1 mark*

Q10 *(3 marks)* (a) Hottest at 2 pm, reading 24 °C. *1 mark* (b) The temperature rose from 14 °C at 9 am to 24 °C at 2 pm, then dropped to 23 °C at 3 pm — the trend is up, then down. *2 marks* (a trend named *and* two figures quoted)

Q11 *(2 marks: 1 each)* Leader lines run straight from the note to the part they name. *1 mark* The notes themselves stay short. *1 mark*

Q12 *(3 marks: 1 per row)* Row 2: column graph — columns stand alone; line graph — points joined in order. *1 mark* Row 3: column graph — good for comparing amounts; line graph — good for showing a trend. *1 mark* Correct copy of the organiser with two columns under the two headings. *1 mark*

Q13 *(2 marks)* A single rectangular loop drawn with straight lines and square corners, holding the cell symbol, the closed switch symbol and the globe symbol. *1 mark* An arrow on a wire showing the flow out from the + end of the cell and around the loop back to the − end. *1 mark*

Q14 *(3 marks: 1 each)* (a) The lamp stands for the Sun and the ball stands for the Earth. *1 mark* (b) The half of the ball facing away from the lamp is in night. *1 mark* (c) Any one honest way the model is not like the real thing: the lamp is far too small to stand for the real Sun; the lamp is far too close. *1 mark*

Q15 *(2 marks)* Headings “Day” and “Number of bees at the fountain” — the heading carries what is counted, so the boxes hold plain numbers. *1 mark* Five blank rows labelled Monday to Friday, ready for the readings. *1 mark*

Q16 *(5 marks)* (a) A line graph: the data shows how one measured thing (distance rolled) changes as another (height of the ramp) changes, so it is a relationship, and the points are joined in order. *1 mark* (b) Horizontal axis “Height of ramp (books)” with 1–3; vertical axis “Distance rolled (cm)” with an even scale holding 0–50 cm; a title. *1 mark* The three points (1, 20), (2, 35), (3, 50) plotted and joined. *1 mark* (c) The higher the ramp, the further the marble rolled. *1 mark* At 1 book high the marble rolled 20 cm; at 3 books high it rolled 50 cm. *1 mark*