Science 5–6

Chapter 1 — Questioning and predicting

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Investigable questions and reasoned predictions

Words to know investigable question · prediction · reasoned prediction · reason · pattern · relationship · evidence · observe

Science starts with questions. But not every question can be answered with a test, and a good scientist thinks carefully before testing: *Can this question be tested at all? What do I think will happen, and why?* In this section we learn to sort questions, to turn a wondering into a testable question, and to make a **reasoned prediction** before we begin.

Theory

Three kinds of questions

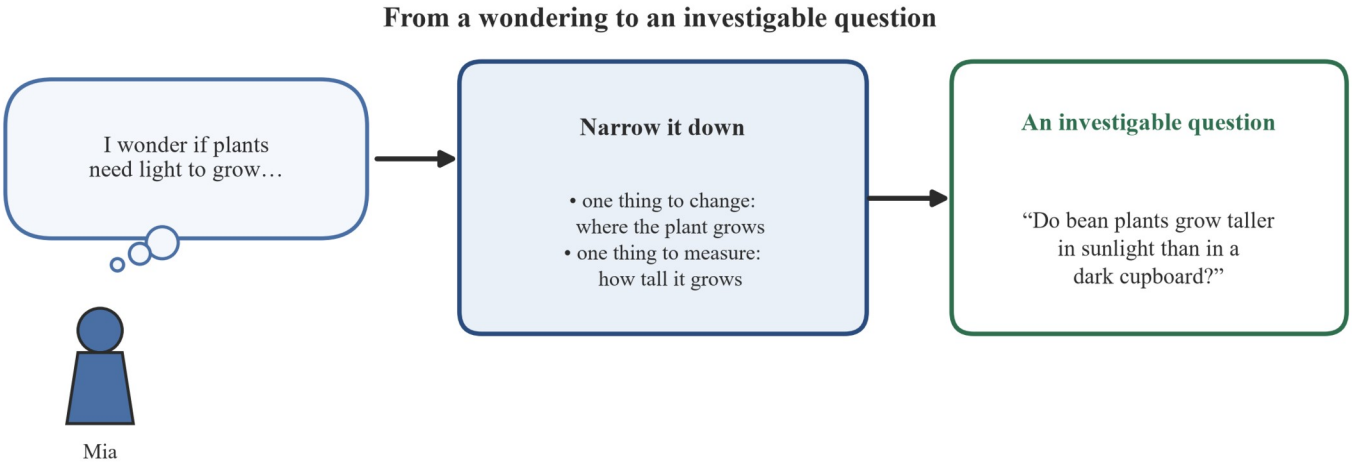
Questions come in three kinds. Only one kind can be answered by doing a test.

Three cards side by side. The green card is headed Investigable with a tick and holds the question "Do bean plants grow taller in sunlight than in a dark cupboard?" The red card is headed Not answerable by a test with a cross and holds the question "Which is nicer, a cat or a dog?" The blue card is headed Already settled with a magnifying glass and holds the question "How many planets are in our solar system?"

- An **investigable question** is a question we can answer by doing a test — we **observe** (watch carefully and note what happens) and we measure. "Do bean plants grow taller in sunlight than in a dark cupboard?" is investigable: we can grow two plants and measure them.
- Some questions are **not answerable by a test**. "Which is nicer, a cat or a dog?" is a matter of opinion. Everyone can have a different answer, and no test can prove one answer right.
- Some questions are **already settled** — people already know the answer. "How many planets are in our solar system?" is answered by looking it up in a good book or a trusted website, not by doing a new test.

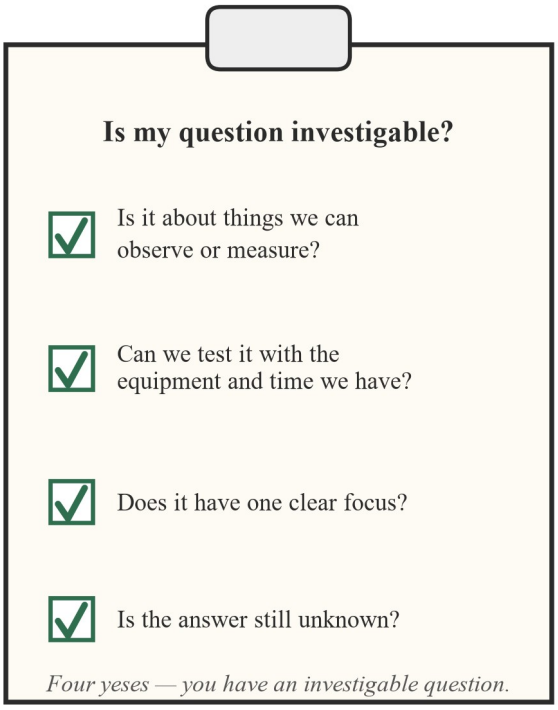
From a wondering to an investigable question

A **wondering** is a broad thought, like "I wonder if plants need light to grow?" It is a good start, but it is not yet a question we can test. To make it investigable, we narrow it down: we say the one thing we will change and the one thing we will measure.



A flow diagram. On the left, a student called Mia has a thought bubble reading "I wonder if plants need light to grow…" An arrow leads to a box headed Narrow it down, listing one thing to change (where the plant grows) and one thing to measure (how tall it grows). A second arrow leads to a green box holding the investigable question "Do bean plants grow taller in sunlight than in a dark cupboard?"

Before testing, run your question through four checks.

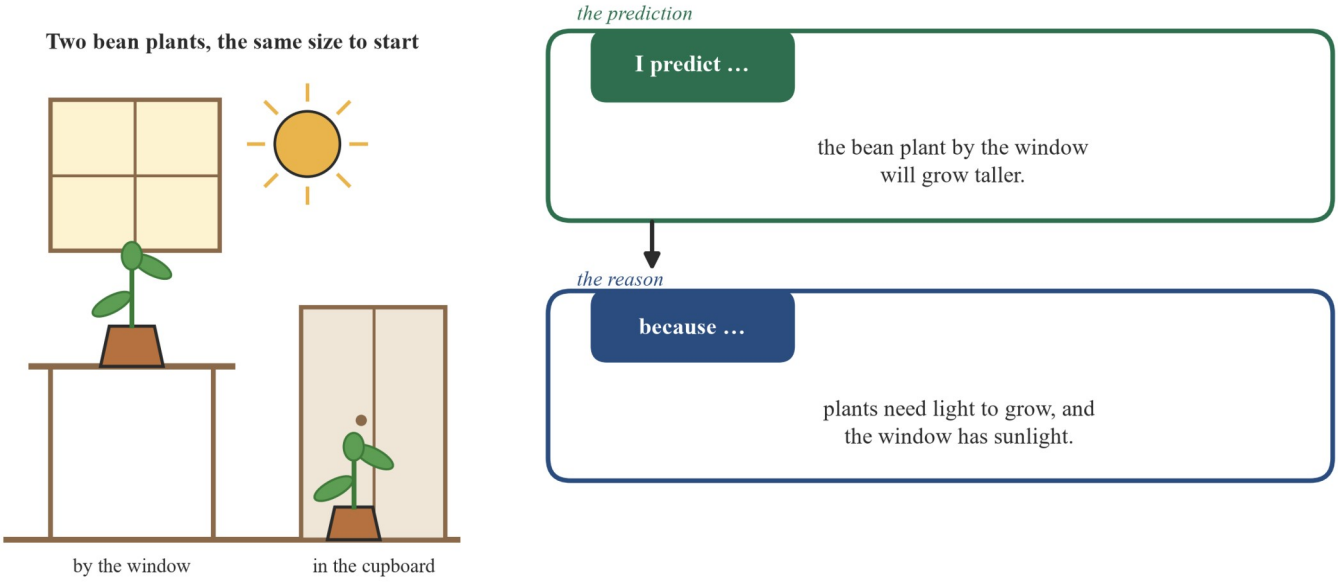


A clipboard titled "Is my question investigable?" with four ticked boxes: Is it about things we can observe or measure? Can we test it with the equipment and time we have? Does it have one clear focus? Is the answer still unknown? The caption reads: Four yeses — you have an investigable question.

If any check fails, the question needs fixing. "Which is nicer, a cat or a dog?" fails the first check — niceness cannot be observed or measured. "How many planets are in our solar system?" fails the last check — the answer is already known.

Reasoned predictions

A **prediction** is a statement of what we think will happen in a test, made *before* the test is done. A **reasoned prediction** goes further: it gives a **reason** for the prediction, using what we already know. The frame is "I predict … because …".

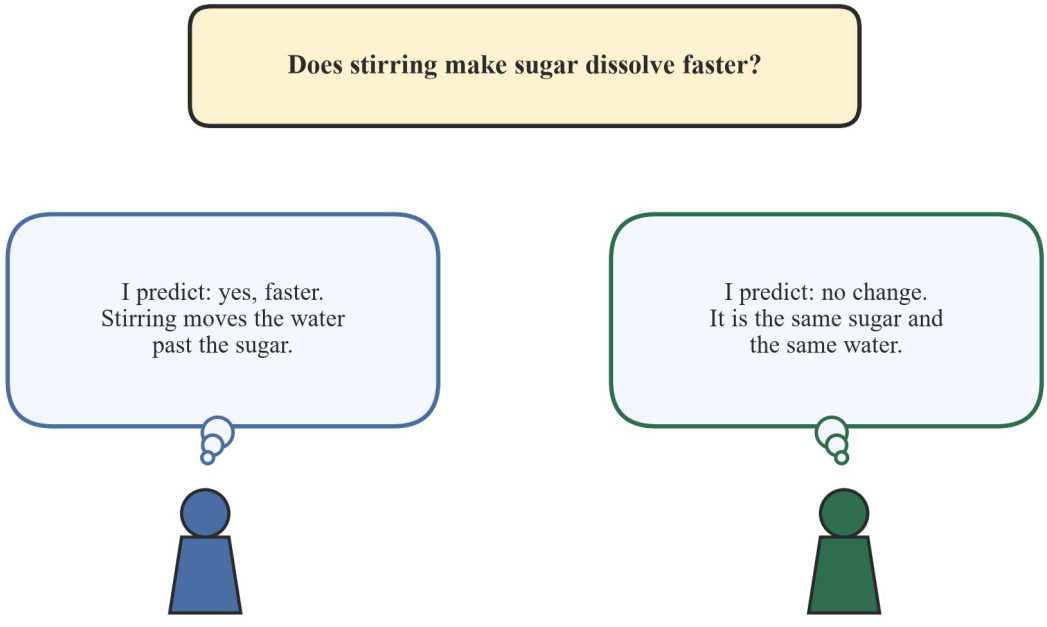


On the left, two bean plants the same size to start: one on a bench by a sunny window and one inside a cupboard. On the right, two writing frames joined by an arrow: the green frame begins "I predict …" and is completed with "the bean plant by the window will grow taller"; the blue frame begins "because …" and is completed with "plants need light to grow, and the window has sunlight".

The *because* is what makes the prediction reasoned. "I predict the window plant will grow taller" is a plain prediction. Adding "because plants need light to grow" links the prediction to something we already know, and makes it worth testing.

Two people can look at the same question and make different reasoned predictions. That is fine — good science does not mean agreeing. It means giving a reason, then letting the test decide.

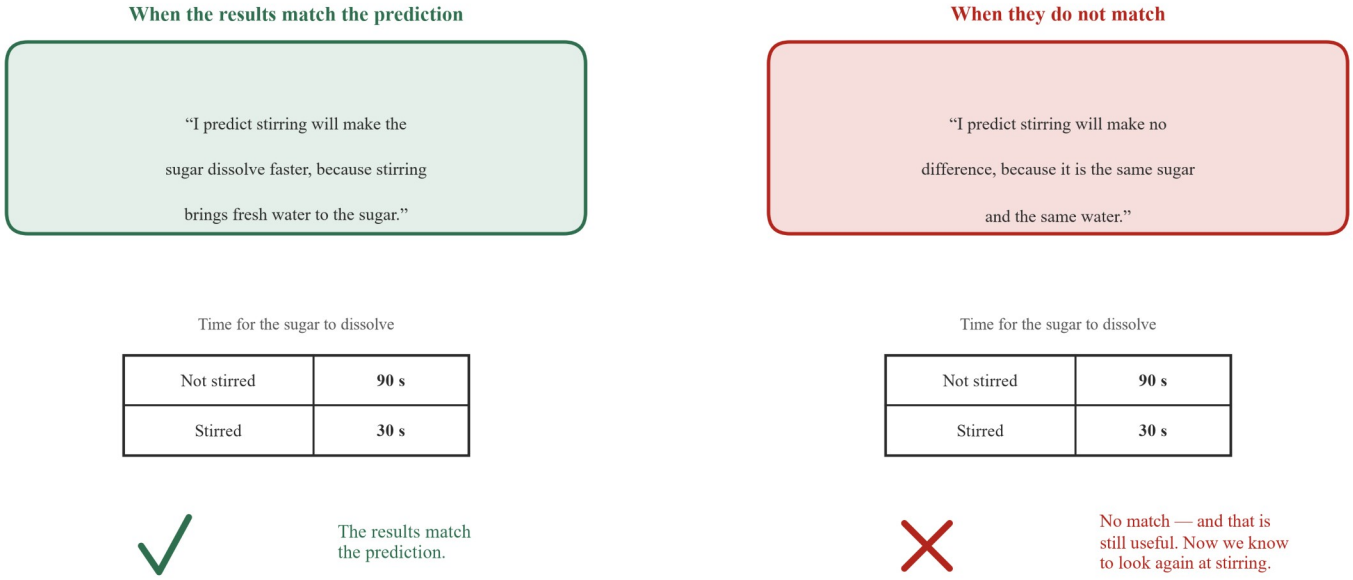
The same question — two reasoned predictions



Both predictions give a reason. The test will decide between them.

A banner holds the question "Does stirring make sugar dissolve faster?" Below, Mia's thought bubble reads "I predict: yes, faster. Stirring moves the water past the sugar." and Noah's thought bubble reads "I predict: no change. It is the same sugar and the same water." The caption reads: Both predictions give a reason. The test will decide between them.

After the test, we check the prediction against the results. The results are the **evidence**. Sometimes the evidence matches the prediction, and sometimes it does not — and both outcomes teach us something. A prediction that does not match is not a failure; it tells us our first idea needs another look.



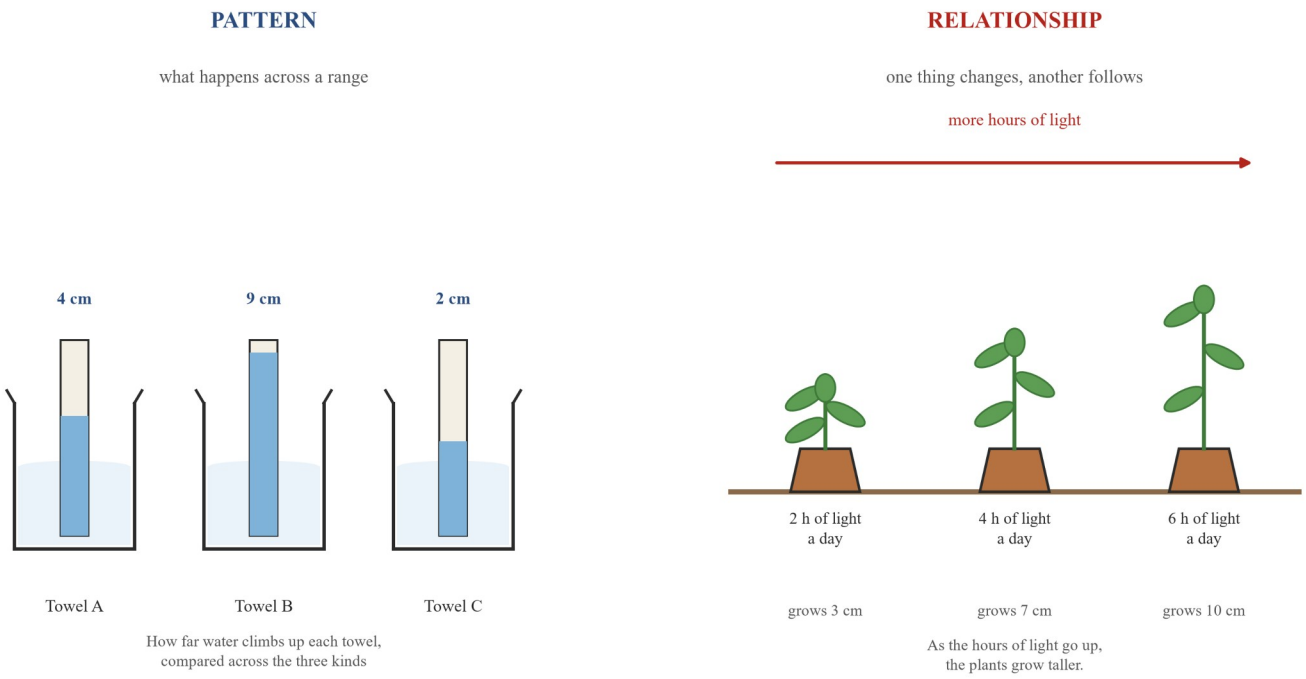
Two panels. The left panel, headed "When the results match the prediction", shows the prediction "I predict stirring will make the sugar dissolve faster, because stirring brings fresh water to the sugar" above a table of results (not stirred: 90 s; stirred: 30 s) and a tick with the words "The results match the prediction." The right panel, headed "When they do not match", shows the prediction "I predict stirring will make no difference, because it is the same sugar and the same water" above the same results table and a cross with the words "No match — and that is still useful. Now we know to look again at stirring."

Patterns and relationships

Investigable questions often ask about a **pattern** or a **relationship**.

A **pattern** is what happens across a range of things or groups. "Which kind of paper towel soaks up the most water?" asks about a pattern: we test several kinds and compare what happens across them.

A **relationship** is what happens to one thing when another thing is changed. "How does the number of hours of light change how tall a bean plant grows?" asks about a relationship: we change the hours of light and follow what the height does.

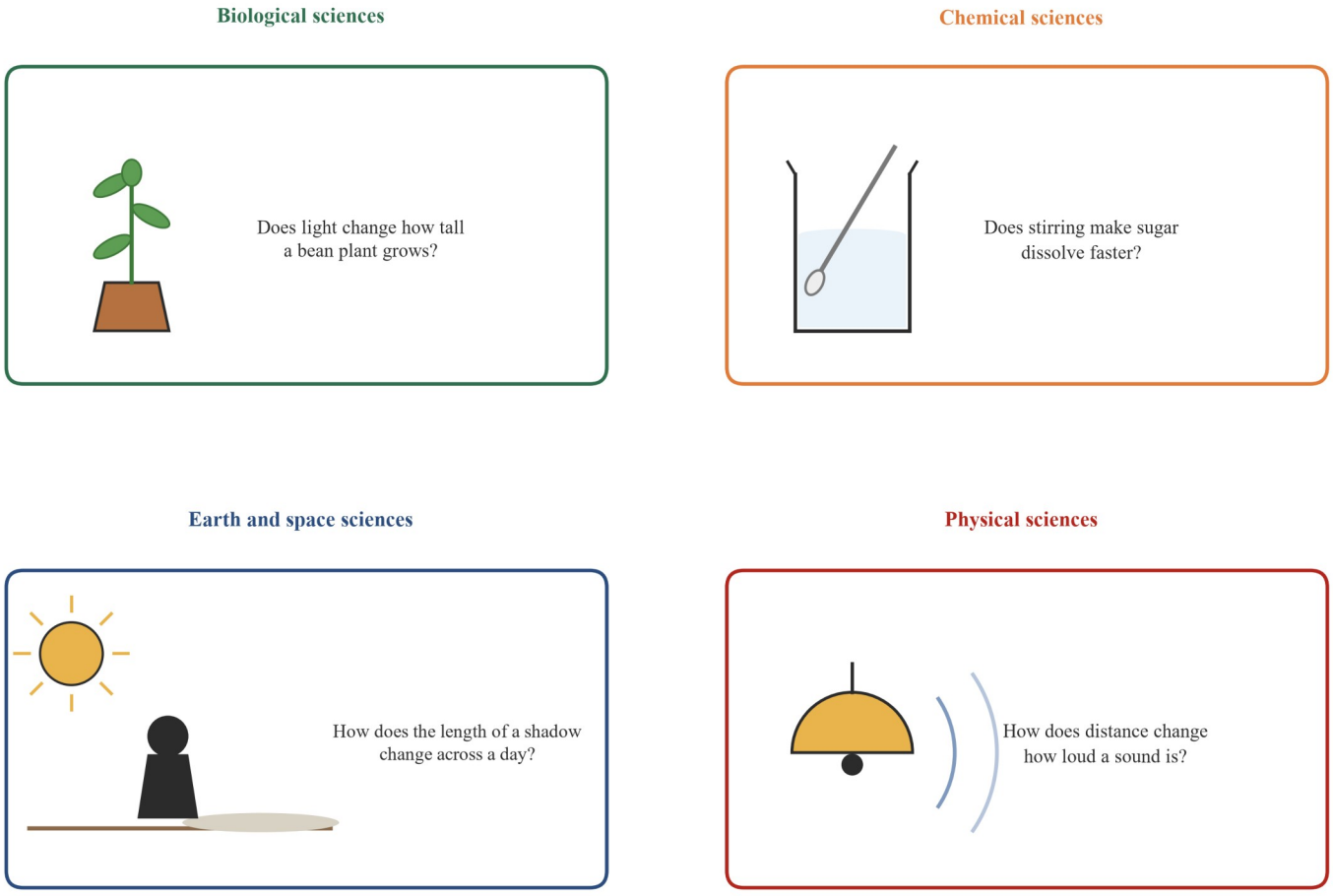


Two panels. The left panel is headed PATTERN — what happens across a range, and shows three paper towels standing in beakers of water; the water has climbed 4 cm up Towel A, 9 cm up Towel B and 2 cm up Towel C. The right panel is headed RELATIONSHIP — one thing changes, another follows, and shows three bean plants given 2 h, 4 h and 6 h of light a day, growing 3 cm, 7 cm and 10 cm tall, with an arrow labelled "more hours of light".

A reasoned prediction can be about either. For the towels: "I predict Towel B will soak up the most, because it feels the thickest and thickest towels hold more water." For the plants: "I predict that as the hours of light go up, the plants will grow taller, because plants need light to grow."

Investigable questions in every strand

Science has four big topic areas, called **strands**: the biological sciences (the study of living things), the chemical sciences (substances and how they change), the Earth and space sciences (our planet and the sky), and the physical sciences (light, sound, heat and forces). Investigable questions turn up in all four.



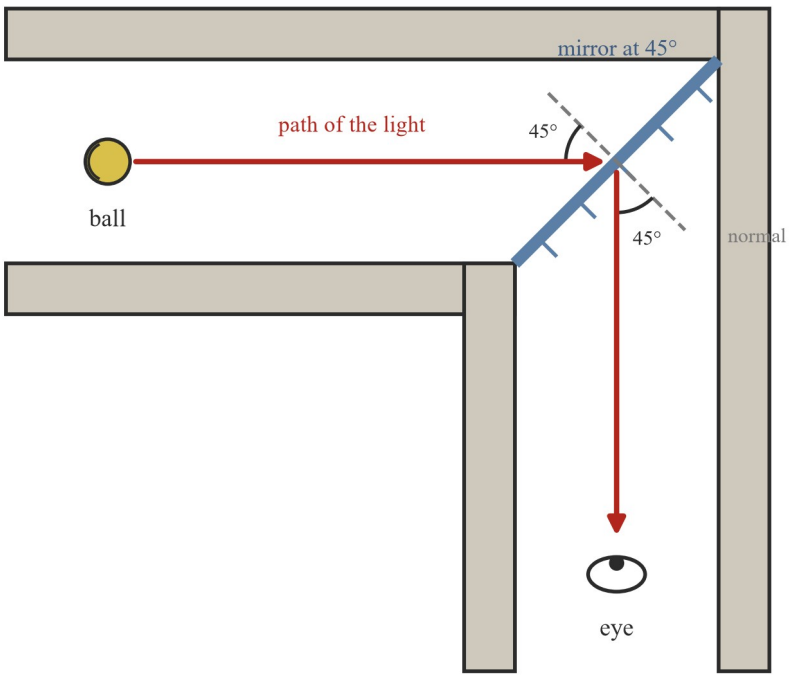
A grid of four panels, one per strand. Biological sciences shows a potted bean plant and asks "Does light change how tall a bean plant grows?" Chemical sciences shows a beaker with a spoon and asks "Does stirring make sugar dissolve faster?" Earth and space sciences shows the Sun, a student and a long shadow, and asks "How does the length of a shadow change across a day?" Physical sciences shows a ringing bell with sound waves and asks "How does distance change how loud a sound is?"

Predicting with what we already know

A reasoned prediction leans on things we have already learned. Three examples.

Seeing around a corner. Light travels in straight lines and bounces off a mirror. In the diagram below, light from the ball hits the mirror at the corner and bounces down the other corridor to the eye. The two angles marked at the mirror are equal. Because we know light bounces off mirrors, we can predict whether a mirror will let us see around a corner — before we build anything.

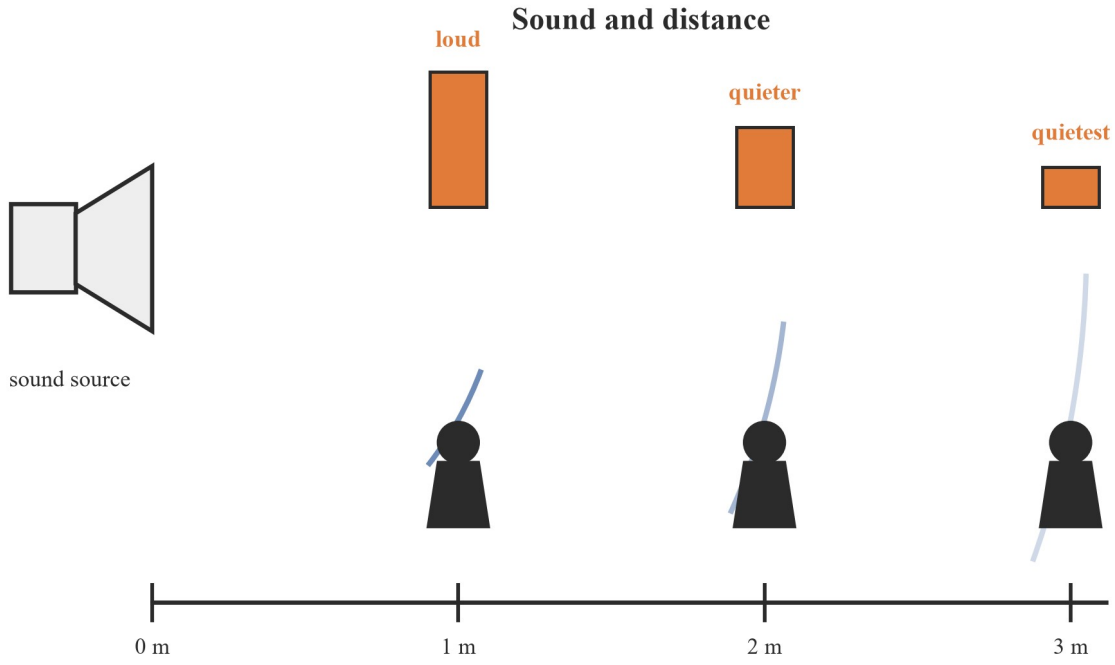
Seeing around a corner



Light bounces off the mirror, and the two angles are equal.
This is how the eye sees the ball around the corner.

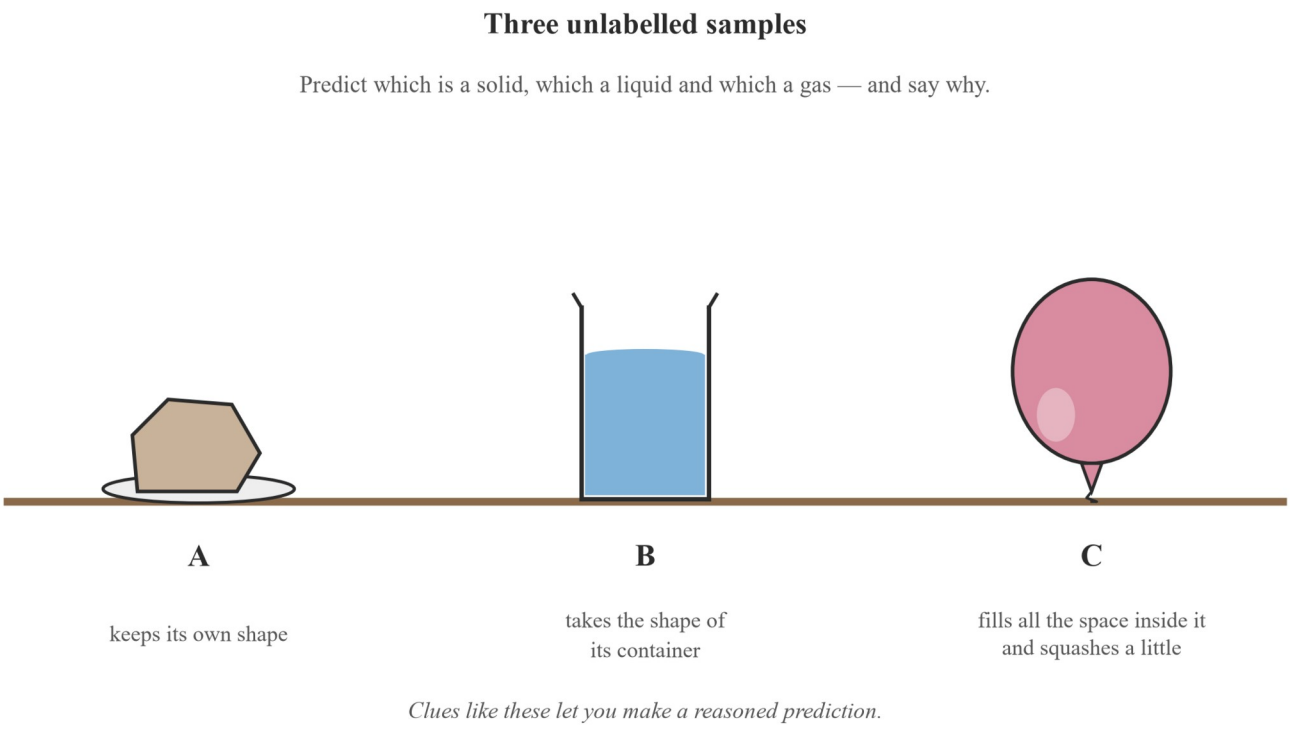
A top view of two corridors meeting at a corner. A ball sits in one corridor and an eye in the other. A mirror placed at 45 degrees across the corner sends a red ray from the ball to the mirror and then along the other corridor to the eye; a dashed normal is drawn at the mirror, and the angle between the ray and the normal is marked 45 degrees on both sides. The caption reads: Light bounces off the mirror, and the two angles are equal. This is how the eye sees the ball around the corner.

Sound and distance. Sound spreads out from its source. The further a listener is from the source, the quieter the sound seems. Knowing this, we can make a reasoned prediction: “I predict the listener at 3 m will hear the quietest sound, because the sound has spread out the most by the time it reaches them.”



A sound source on the left sends out wave fronts that fade with distance. Three listeners stand at 1 m, 2 m and 3 m on a ruler; above them, loudness bars shrink and are labelled loud, quieter and quietest.

Unknown samples. Here are three samples with no labels. Sample A keeps its own shape on the plate. Sample B takes the shape of its beaker and sits in the bottom. Sample C fills all the space inside the balloon and squashes a little. What we already know about solids, liquids and gases lets us make a reasoned prediction about each sample — that is Example 2 below.



Three samples on a bench. Sample A is a lump on a plate, captioned "keeps its own shape". Sample B is water in a beaker, captioned "takes the shape of its container". Sample C is a balloon, captioned "fills all the space inside it and squashes a little". The heading asks the reader to predict which is a solid, which a liquid and which a gas, and say why.

Worked examples

Example 1 — with support

Mia wonders, "I wonder if plants need light to grow?" Turn this wondering into an investigable question.

Working	Comment
Start: "I wonder if plants need light to grow?"	A wondering is broad — not yet a question we can test.
The one thing to change: where the plant grows — sunlight, or a dark cupboard.	Naming the change gives the question one clear focus.
The one thing to measure: how tall each plant grows, in cm, after two weeks.	Height can be observed and measured with a ruler.
∴ "Do bean plants grow taller in sunlight than in a dark cupboard?"	The question passes all four checks, so it is investigable.

Example 2 — with support

Look again at the three unlabelled samples in the diagram above. Make a reasoned prediction about each: which is a solid, which is a liquid and which is a gas?

Working	Comment
Sample A keeps its own shape on the plate.	Solids keep their own shape.
∴ I predict A is a solid, because it keeps its own shape.	The reason uses what we know about solids.
Sample B takes the shape of the beaker and sits in the bottom.	Liquids take the shape of their container and can be poured.
∴ I predict B is a liquid, because it takes the shape of its container.	The reason uses what we know about liquids.
Sample C fills all the space in the balloon and squashes a little.	Gases fill all the space available and are easy to squash.
∴ I predict C is a gas, because it fills its container and squashes.	The reason uses what we know about gases.

Example 3 — by yourself

Sam rings a bell on the bench. Priya stands 1 m away, and Noah stands 3 m away. Write (a) an investigable question about the loudness of the bell, and (b) a reasoned prediction for it, using the frame "I predict … because …".

Practice questions

With support

Q1. Sort these questions into three groups: investigable; not answerable by a test; already settled. *(3 marks)* (a) Which is nicer, chips or salad? (b) How many legs does a spider have? (c) Which towel soaks up the most water: paper, cloth or sponge?

Q2. Tom wonders, "I wonder about soil and plants?" Write an investigable question that names the one thing Tom will change and the one thing he will measure. *(2 marks)*

Q3. Only one of these is a *reasoned* prediction. Choose it and state the reason it gives. *(2 marks)* (a) "I predict the plant will grow." (b) "I predict the plant by the window will grow taller, because plants need light to grow." (c) "Maybe the plant will do something."

Q4. Say whether each question asks about a pattern or a relationship. *(2 marks)* (a) Which brand of paper towel soaks up the most water? (b) How does the number of hours of light change how tall a bean plant grows?

Q5. Complete this writing frame for the question "Does stirring make sugar dissolve faster?" *(2 marks)* - I predict _____ - because _____

Q6. A student predicts, “Stirring will make the sugar dissolve faster.” The results are: not stirred, 90 s; stirred, 30 s. Does the evidence match the prediction? How can you tell? *(2 marks)*

By yourself

Q7. “Which ice-cream flavour is the best?” *(2 marks)* (a) Explain why this question is not investigable as it stands. (b) Rewrite it as an investigable question about how fast each flavour melts.

Q8. A student asks, “Do plants grow taller?” *(2 marks)* (a) Which of the four checks does this question fail? (b) Fix the question so it passes all four checks.

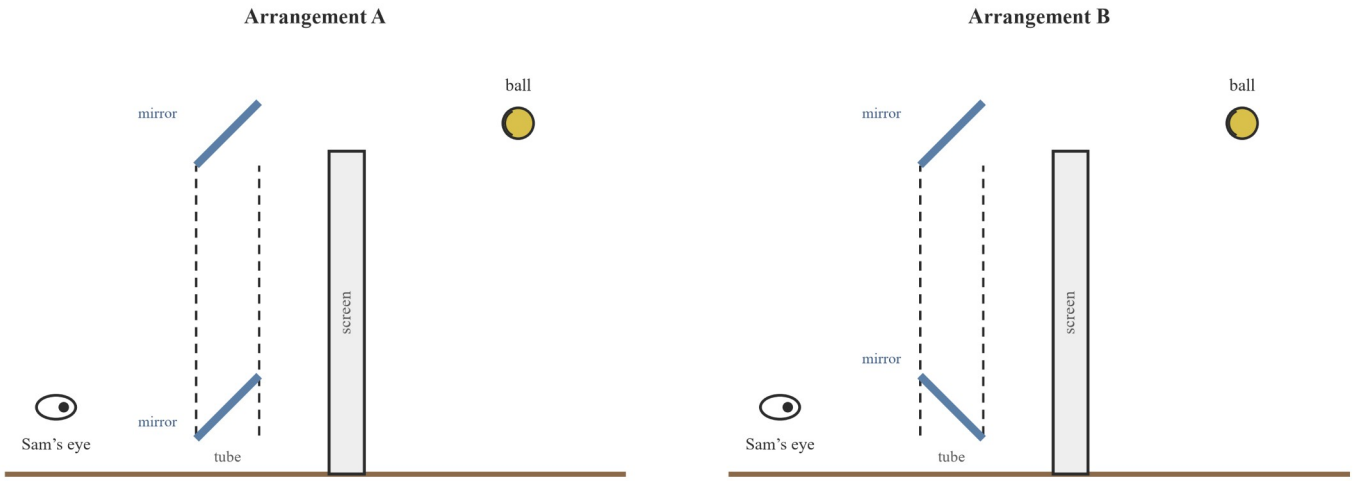
Q9. Three samples have no labels. Sample D keeps its own shape. Sample E pours and takes the shape of its container. Sample F fills the whole bottle and squashes when the bottle is squeezed. Make a reasoned prediction about each sample, using “I predict … because …”. *(3 marks)*

Q10. Say whether each question asks about a pattern or a relationship, and give a reason for your choice. *(2 marks)* (a) How far does water climb up four different kinds of towel? (b) How does the distance from a bell change how loud the sound is?

Q11. Two students make different reasoned predictions for the same question, as in the diagram of Mia and Noah. Explain why both predictions are good science even though they disagree. *(2 marks)*

Q12. Look at the diagram of the ball, the mirror and the eye at the corner. Sam predicts, “I will see the ball in the mirror, because light bounces off the mirror into my eye.” State whether this is a reasoned prediction, and name the piece of knowledge the reason leans on. *(2 marks)*

Q13. Sam wants to see the ball over the screen while his eye stays low to the ground. He builds a tube with two mirrors, one at each end. Two arrangements are shown below. Predict which arrangement will let Sam see the ball, and give your reason. *(3 marks)*



Two side views labelled Arrangement A and Arrangement B. In both, Sam’s eye is at the lower left, a tall screen stands in the middle, and a ball floats above and beyond the screen. Each arrangement has a tube holding two mirrors at 45 degrees. In Arrangement A both mirrors tilt the same way; in Arrangement B the bottom mirror tilts the other way.

Q14. A class waters three bean plants with different amounts of water each day for two weeks, then measures how tall each plant grows. *(3 marks)*

Water each day	Height grown
10 mL	4 cm
30 mL	9 cm
50 mL	7 cm

(a) Describe the pattern in the results.

(b) Which amount of water gave the tallest plant?

Q15. A class rings a bell and asks listeners how loud it seems at three distances. The results are: 1 m, loud; 2 m, quieter; 3 m, quietest. A student had predicted, "The further the listener is from the bell, the quieter the sound will seem." *(3 marks)* (a) Describe the relationship in the results. (b) Does the evidence match the prediction? Explain.

Q16. Your teacher gives your group three cups: one of dry beach sand, one of garden soil and one of potting mix, plus a jug of water and three funnels with filter paper. *(5 marks)* (a) Write an investigable question about how well each cup's contents hold water. (b) Write a reasoned prediction for your question, using "I predict … because …". (c) Does your question ask about a pattern or a relationship? Say how you know. (d) Name the one thing you will change, the one thing you will measure, and two things you will keep the same. (e) After the test, how will you check your prediction against the evidence?

Practical — does stirring make sugar dissolve faster?

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

Question: Does stirring make sugar dissolve faster?

Equipment: two clear plastic cups of the same size; water; two spoons of sugar (one per cup); a spoon for stirring; a timer or stopwatch; a paper towel; a marker pen for labelling the cups.

Safety: Wipe spills straight away so the floor is not slippery. Use plastic cups, not glass. Do not taste anything in the science room.

Risk	How we stay safe
Water or sugar spilled on the bench or floor	Wipe spills up straight away with the paper towel.
Cups knocked over	Keep cups in the middle of the bench, away from edges.
Splashing while stirring hard	Stir gently and keep the spoon in the cup.

The things we change, measure and keep the same:

Thing	Choice
The one we change	whether the water is stirred or not stirred
The one we measure	the time for the sugar to dissolve (s)
The ones we keep the same	the same amount of water in each cup; the same one spoon of sugar in each cup; the same cups; water from the same jug

Method:

1. Pour the same amount of water into each cup, from the same jug.
2. Label one cup "stirred" and one cup "not stirred".
3. Add one spoon of sugar to each cup at the same time, and start the timer.
4. Stir the "stirred" cup gently. Do not stir the other cup.
5. Stop the timer when the sugar in a cup can no longer be seen. Record the time.
6. Repeat steps 1–5 until you have three trials for each cup.

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

Trial	Not stirred (s)	Stirred (s)
1		
2		
3		

Compare your three trials for each cup. Do the readings agree with each other?

Thinking about the results:

1. Describe what happened in each cup. Which cup's sugar dissolved faster?
2. Compare your results with your prediction. Did the evidence match?
3. If your prediction did not match, write what you would now look at again.

Make a claim and give your reasons. Finish this writing frame in full sentences:

- I claim that stirring _____ .
- My evidence is _____ .
- My reason is _____ .
- If my prediction did not match the results, I would _____ .

Answers

Q1 (a) Not answerable by a test (opinion). (b) Already settled (look it up). (c) Investigable (we can test it). **Q2** Any question naming one change and one measure, e.g. “Do bean plants grow taller in rich soil than in sand?” **Q3** (b). The reason is “plants need light to grow”. **Q4** (a) Pattern — it compares across a range of kinds. (b) Relationship — one thing is changed (hours of light) and another follows (height). **Q5** Any prediction with a matching reason, e.g. “I predict stirring will make the sugar dissolve faster, because stirring moves the water past the sugar.” **Q6** Yes. 30 s is a much shorter time than 90 s, so stirring did make the sugar dissolve faster, as predicted. **Q7** (a) “Best” is an opinion — no test can decide it. (b) e.g. “Which ice-cream flavour melts the fastest?” **Q8** (a) It fails “one clear focus” — nothing is named to change or compare. (b) e.g. “Do bean plants grow taller in sunlight than in a dark cupboard?” **Q9** D: solid, because it keeps its own shape. E: liquid, because it takes the shape of its container. F: gas, because it fills all the space and squashes. **Q10** (a) Pattern — several kinds of towel are compared across a range. (b) Relationship — the distance is changed and the loudness follows. **Q11** Both give a reason from what they already know, and both can be tested — the test decides between them. **Q12** Yes, it is reasoned. The reason leans on the knowledge that light bounces off a mirror. **Q13** Arrangement A. With both mirrors tilted the same way, light from the ball bounces off the top mirror, straight down the tube, and off the bottom mirror into Sam’s eye. In B the bottom mirror sends the light the wrong way. **Q14** (a) The height grown goes up from 10 mL to 30 mL, then down at 50 mL. (b) 30 mL (9 cm). **Q15** (a) As the distance goes up, the loudness goes down. (b) Yes — the prediction said the further the listener, the quieter the sound, and that is what the results show. **Q16** (a) e.g. “Which holds water the best: beach sand, garden soil or potting mix?” (b) Any reasoned prediction, e.g. “I predict potting mix will hold water the best, because it feels the softest and holds moisture in pots.” (c) Pattern — three kinds are compared across a range. (d) Change: the kind of material in the cup. Measure: how much water drips through (or how long the material stays wet). Keep the same: the same amount of material; the same amount of water poured. (e) Compare the results with the prediction and say whether they match.

Worked solutions

Q1 *(3 marks: 1 each)* (a) “Which is nicer?” is a matter of opinion, so no test can decide it — not answerable by a test. *1 mark* (b) The number of spider legs is already known, so we look it up — already settled. *1 mark* (c) We can soak the three materials and measure the water each holds — investigable. *1 mark*

Q2 *(2 marks)* Any investigable question that names one thing to change and one thing to measure. *1 mark* Example: “Do bean plants grow taller in rich soil than in sand?” — the change is the kind of soil and the measure is the height grown. *1 mark*

Q3 *(2 marks)* (b) is the reasoned prediction. *1 mark* Its reason is “because plants need light to grow” — it links the prediction to something already known. *1 mark* (a) and (c) are plain guesses with no reason.

Q4 *(2 marks: 1 each)* (a) Pattern — several kinds of towel are tested and compared across the range. (b) Relationship — the hours of light are changed and the height follows.

Q5 *(2 marks: 1 for the prediction, 1 for a reason that matches it)* Example: “I predict stirring will make the sugar dissolve faster” *1 mark* “because stirring moves the water past the sugar.” *1 mark* The reason must support the prediction.

Q6 *(2 marks)* Yes, the evidence matches the prediction. *1 mark* The stirred cup dissolved in 30 s and the unstirred cup took 90 s, so stirring made the sugar dissolve faster, which is what the prediction said. *1 mark*

Q7 *(2 marks: 1 each)* (a) “Best” is an opinion; different people prefer different flavours, and no test can prove one answer right. (b) “Which ice-cream flavour melts the fastest?” — melting time can be observed and measured, so it is investigable.

Q8 *(2 marks: 1 each)* (a) It has no clear focus: nothing is named to change, and nothing to compare or measure. (b) Any fixed question that passes the checks, e.g. “Do bean plants grow taller in sunlight than in a dark cupboard?”

Q9 *(3 marks: 1 each)* D: “I predict D is a solid, because it keeps its own shape.” E: “I predict E is a liquid, because it pours and takes the shape of its container.” F: “I predict F is a gas, because it fills all the space in the bottle and squashes.” Each mark needs the prediction and its reason.

Q10 *(2 marks: 1 each)* (a) Pattern — the question compares what happens across a range of four kinds of towel. (b) Relationship — one thing (distance) is changed and another (loudness) follows.

Q11 *(2 marks)* Each prediction gives a reason drawn from what the student already knows, so each is reasoned rather than a guess. *1 mark* Both predictions can be tested by the same test, and the results decide between them — disagreeing is fine in science. *1 mark*

Q12 *(2 marks)* Yes — it predicts and gives a reason, so it is a reasoned prediction. *1 mark* The reason leans on the knowledge that light travels in straight lines and bounces off a mirror. *1 mark*

Q13 *(3 marks)* Arrangement A. *1 mark* Light from the ball hits the top mirror and bounces straight down the tube; the bottom mirror, tilted the same way, bounces it again into Sam's eye. *1 mark* In Arrangement B the bottom mirror tilts the other way, so the light bouncing down the tube is sent away from Sam's eye and he does not see the ball. *1 mark*

Q14 *(3 marks: 2 for (a), 1 for (b))* (a) From 10 mL to 30 mL of water, the height grown goes up (4 cm to 9 cm); *1 mark* at 50 mL the height grown goes back down to 7 cm, so the tallest plant is in the middle of the range. *1 mark* (b) 30 mL of water a day gave the tallest plant (9 cm). *1 mark*

Q15 *(3 marks)* (a) As the distance from the bell goes up (1 m, 2 m, 3 m), the loudness goes down (loud, quieter, quietest). *1 mark* (b) Yes, the evidence matches the prediction. *1 mark* The prediction said the further the listener, the quieter the sound, and the results show exactly that. *1 mark*

Q16 *(5 marks: 1 each)* (a) An investigable question, e.g. "Which holds water the best: beach sand, garden soil or potting mix?" *1 mark* (b) A reasoned prediction with a matching reason, e.g. "I predict potting mix will hold water the best, because it holds moisture in plant pots." *1 mark* (c) Pattern — three kinds of material are tested and compared across the range; nothing is changed step by step. *1 mark* (d) Change: the kind of material. Measure: how much water drips through. Keep the same: the same amount of material and the same amount of water poured. *1 mark* (e) Put the results and the prediction side by side and say whether they match; if they do not match, say what to look at again. *1 mark*