Science 7–8

Chapter 1 — Nature and development of science

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

How scientific knowledge changes: models and theories revised when new evidence arrives — continental drift to plate tectonics, and the changing forms of the periodic table

What we teach here — `VC2S8H01` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"scientific knowledge, including models and theories, can change because of new evidence"* **This subtopic carries the whole code** — there is no partner subtopic; 1A owns `VC2S8H01` outright (§3). The five cases taught here are the ones the elaborations supply: the re-examining of how organisms are classified, aircraft design as the forces of flight came to be better understood, continental drift becoming plate tectonics, deep Earth imaging, and the changing forms of the periodic table. **In our words:** a model or theory is the best explanation science has *at the time*, built from all the evidence gathered so far. When new evidence arrives that the old explanation cannot account for, the explanation is revised or replaced. That is not science failing — it is science working. In this subtopic we follow five real cases and learn the habit: *what was the old idea, what new evidence arrived, and what changed?* **Achievement-standard extract served here (D13):** 1A owns the code, so the extract appears in full here: *"students explain how new evidence can lead to changes in scientific knowledge."* Every worked example and question in this subtopic practises that one move. **Elaborations drawn on:** `VC2S8H01.E01` (re-examining how organisms are classified as new information arrives — the fungi moved out of the plant group), `VC2S8H01.E03` (how aeronautical engineers' understanding of the forces acting in flight changed the design of aircraft), `VC2S8H01.E05` (the evidence that led to the acceptance of plate tectonics rather than continental drift), `VC2S8H01.E06` (how advances in deep Earth imaging find mineral, energy and water resources beneath surface sedimentary rock) and `VC2S8H01.E07` (reasons for different forms of the periodic table). **ICIP (D10):** no Aboriginal or Torres Strait Islander content is delivered here. `VC2S8H01.E02` and `VC2S8H01.E04` are reserved under the ICIP decision and are not taught; see the teacher-facing note at the foot of this subtopic. **Maths interlocks (D11):** none are listed for this subtopic — the work is reasoning about evidence. Where a measured value is quoted (Australia's 7 cm per year of plate motion; a winglet drag saving), it is taken from a named source and only read, never processed. **Authored from the CD text and the elaboration contexts (D12):** the CD states the principle — knowledge changes when new evidence arrives — and the five elaborations above supply the cases; the cycle diagram, the reasoning tables and every worked example here are authored fresh from those cases.

Word watch — *model*. A **model** is a stand-in for something that is hard to see, hold or test directly — a drawing, a physical copy, an arrangement of cards or boxes. A model shows some features of the real thing and leaves others out. The periodic table is a model of the elements; the jigsaw of continents in this subtopic is a model of the Earth's crust. When the evidence changes, the model changes too.

Word watch — *theory*. In everyday speech, "theory" can mean a guess. In science it means something much stronger: a **theory** is an explanation of a wide range of observations, built from many lines of evidence, that can be tested and that can be revised when new evidence arrives. *Plate tectonics* is a theory in this strong sense. This subtopic uses the word only in the scientific sense.

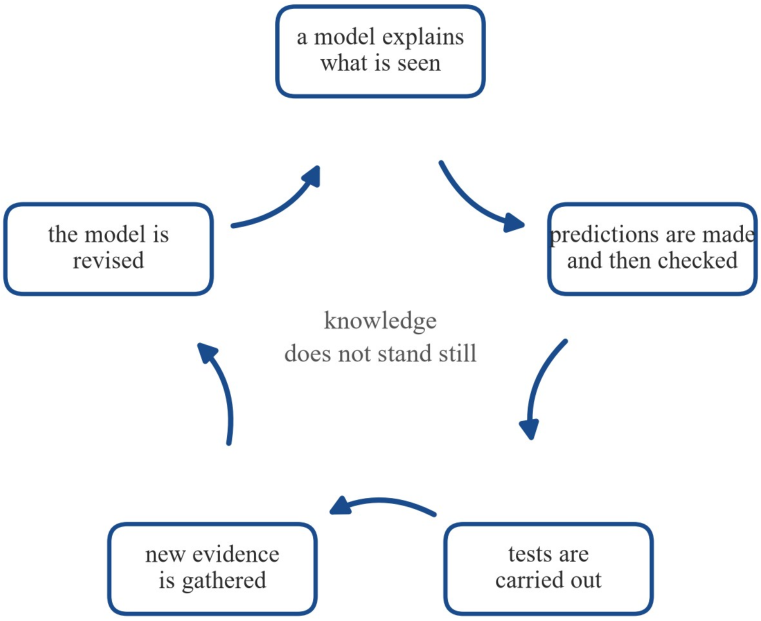
Word watch — *accepted*. When this subtopic says a theory is **accepted**, it means it is the explanation scientists currently use because it accounts for the evidence better than any rival. *Accepted* never means "proven forever" — the whole subtopic is about accepted ideas later being revised.

Theory

The engine of science — new evidence revises the explanation

Science does not collect facts the way a shelf collects dust. It builds **models** and **theories** — explanations of what is seen — and then tests them. A model explains what is seen; predictions are made from it and checked; tests are carried out; new evidence is gathered; and if the new evidence does not fit, **the model is revised**. The revised model then makes better predictions, and the cycle runs again.

How scientific knowledge changes



A cycle diagram titled "How scientific knowledge changes" with five boxes joined in a ring: a model explains what is seen; predictions are made and then checked; tests are carried out; new evidence is gathered; the model is revised; in the centre the words "knowledge does not stand still"

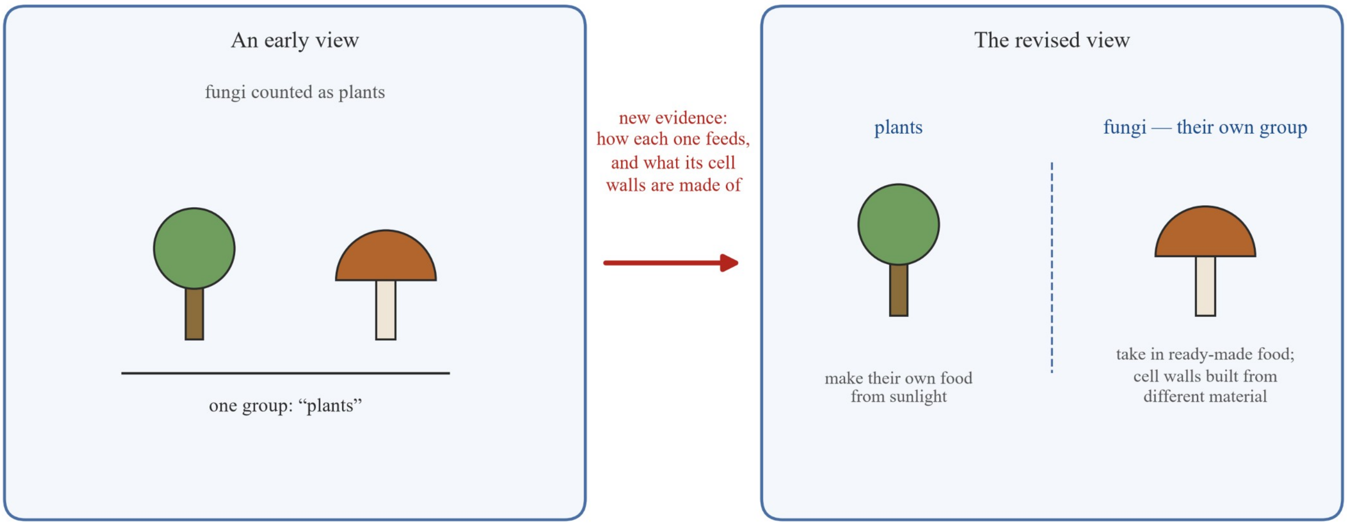
The five cases in this subtopic are that cycle run five times, in five different sciences. In each case we ask the same three questions: *what was the old idea? what new evidence arrived? what changed?*

Case 1 — Fungi: a group that moved (`VC2S8H01.E01`)

For a long time, fungi — mushrooms, moulds, yeasts — were classified with plants. Fungi grow in soil, they do not move from place to place, and they look plant-like, so they were filed under the plant group. That was the model, and it was reasonable on the evidence then gathered.

New evidence did not fit. Fungi do not make their own food from sunlight the way plants do — they take in ready-made food from their surroundings. Their cell walls are built from different material from plant cell walls. Later, fine comparisons of the chemistry inside cells confirmed what those differences suggested: fungi are not plants, and they belong in a group of their own. The classification was re-examined and revised — exactly as the elaboration describes, scientists are still re-examining the relationships between organisms as new information arrives.

Source: Whittaker, R.H., "New concepts of kingdoms of organisms", Science 166, 150–160, 1969.



Classification is re-examined as new information arrives — the fungi were moved out of the plant group.

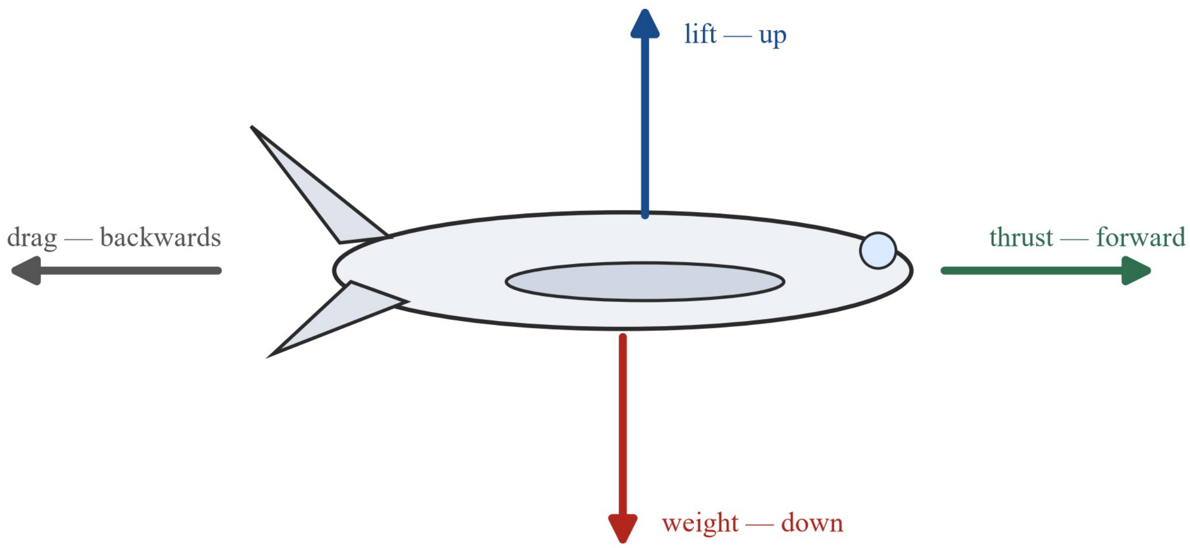
Two panels. Left, “An early view”: a tree and a mushroom drawn together above one label, “one group: plants”. Right, “The revised view”: the tree under “plants — make their own food from sunlight” and the mushroom under “fungi — their own group; take in ready-made food; cell walls built from different material”; between the panels a red arrow labelled “new evidence: how each one feeds, and what its cell walls are made of”

The lesson is not that the early classifiers were silly. On the evidence they had — shape, place, growth — grouping fungi with plants was sensible. The lesson is that **when better evidence arrived, the classification changed rather than being defended**.

Case 2 — Flight: aircraft designed on the evidence (`VC2S8H01.E03`)

An aeroplane in steady flight has four forces acting on it: **lift** (up), **weight** (down), **thrust** (forward) and **drag** (backwards). Every aircraft design is a set of answers about those four forces — and as the understanding of the forces grew, the designs changed.

The four forces on an aeroplane in steady flight



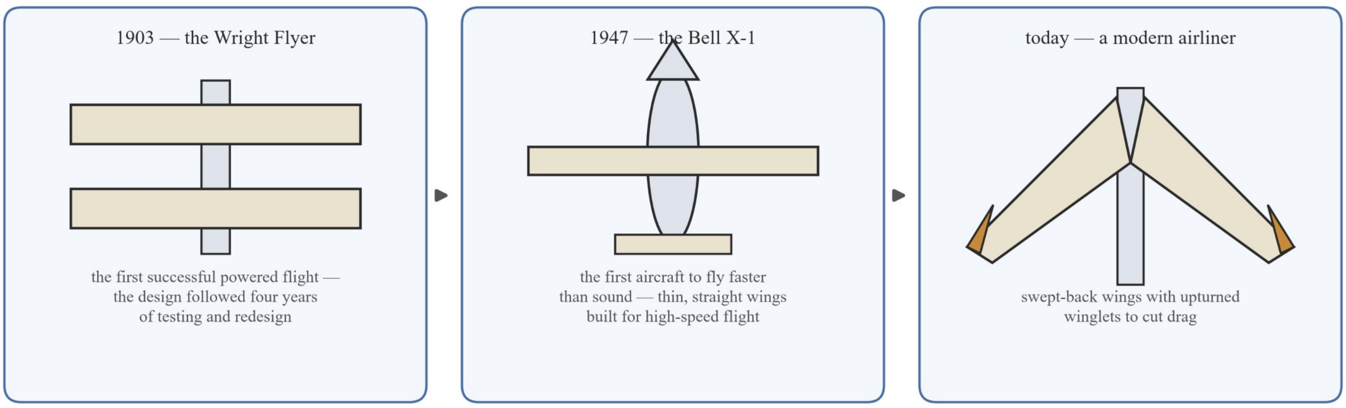
Aircraft designers work with all four forces: a change in the understanding of any one of them can change the design.

Side view of an aeroplane with four labelled arrows: lift pointing up from the wing, weight pointing down, thrust pointing forward from the nose, drag pointing backwards from the tail; a footer notes that a change in the understanding of any one force can change the design

Three generations of aircraft show the change. The Wright Flyer of 1903 made the first successful powered flight after the Wright brothers spent about four years testing gliders and revising their design on what each test showed. The Bell X-1, in 1947, was the first aircraft to fly faster than sound — its thin, straight wings were built on new high-speed knowledge of how air behaves near and past the speed of sound. Modern airliners carry swept-back wings with upturned tips called **winglets**, a design that arrived in the 1970s when new evidence about the swirl of air at a wing tip showed how to cut drag.

Source: US National Park Service, "Wright Brothers National Memorial", nps.gov/wrbr — retrieved 2026-08-21; Ayers, T.G., "NACA/NASA supersonic flight research", 1990, ntrs.nasa.gov — retrieved 2026-08-21.

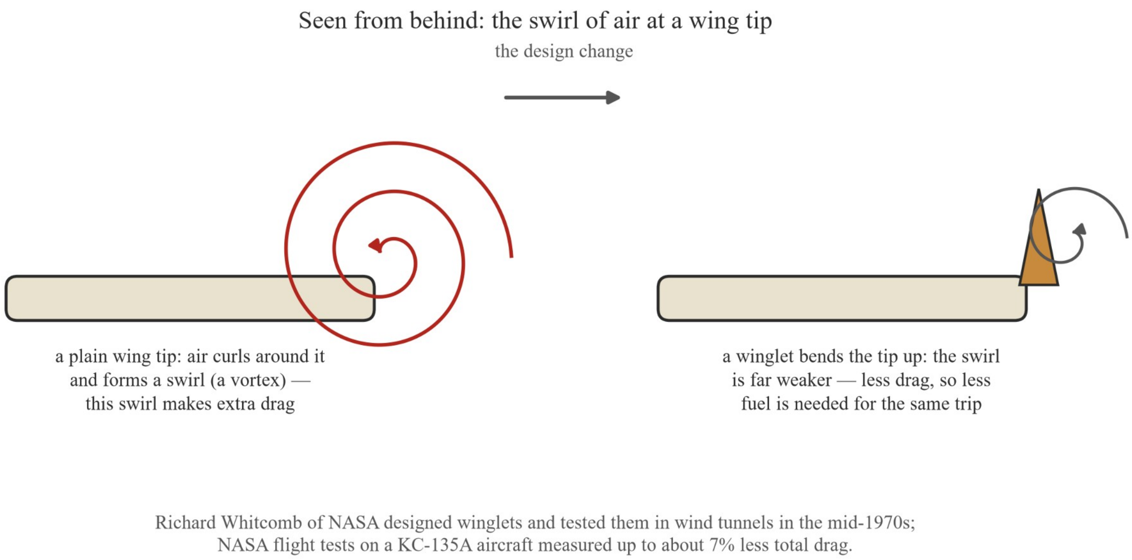
Aircraft wings changed as the understanding of flight forces grew



Each design follows from what engineers understood at the time about lift, drag and the air around the wing.

Three plan-view panels. Left: the Wright Flyer, two straight rectangular wings, captioned "the first successful powered flight — the design followed four years of testing and redesign". Middle: the Bell X-1, a slim bullet-shaped body with thin straight wings, captioned "the first aircraft to fly faster than sound — thin, straight wings built for *high-speed flight". Right: a modern airliner with swept-back wings and small upturned winglets at the tips, captioned "swept-back wings with upturned winglets to cut drag"*

Seen from behind, a plain wing tip lets high-pressure air below the wing curl around the tip toward the low-pressure air above it, forming a swirling tube of air — a **vortex** — that makes extra drag. A winglet bends the tip upward and stands in the way of that curl, so the vortex is far weaker and the drag is smaller.



Rear view of two wing tips. Left: a plain wing with a large red spiral of air curling around the tip, labelled as a vortex that makes extra drag. Right: the same wing with an upturned winglet at the tip and a much smaller grey spiral; a caption notes that the weaker swirl means less drag and less fuel for the same trip. The footer credits Richard Whitcomb of NASA for the mid-1970s wind-tunnel tests and NASA flight tests on a KC-135A aircraft that measured up to about 7% less total drag

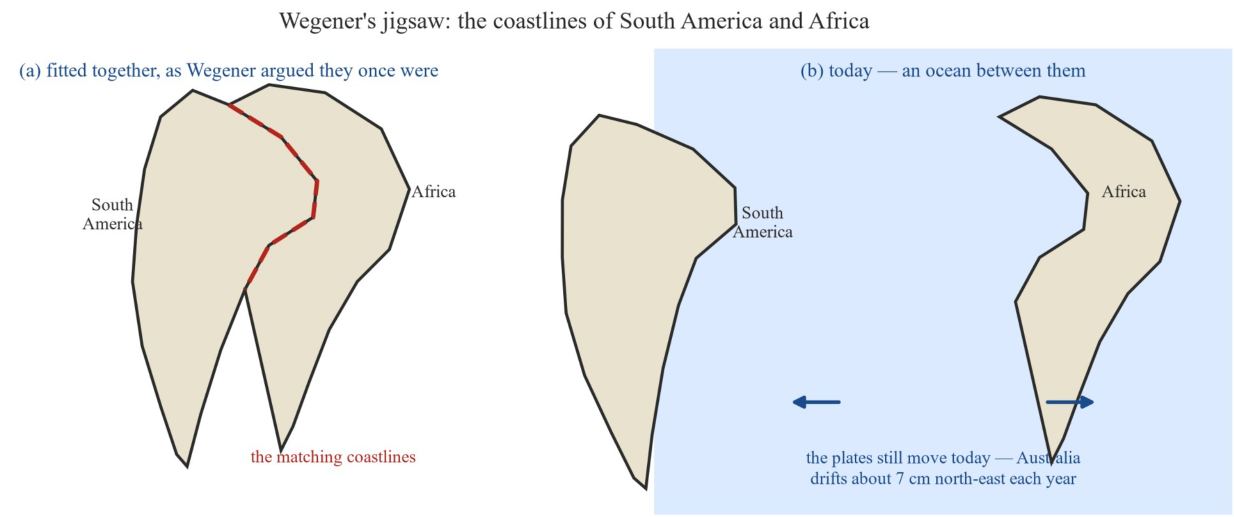
Richard Whitcomb of NASA designed winglets and tested them in wind tunnels in the mid-1970s; NASA flight tests on a KC-135A aircraft then measured up to about 7% less total drag with the winglets fitted. The design entered service because the evidence said it worked — engineers' understanding of the forces acting in flight had changed, and aircraft changed with it.

Source: Whitcomb, R.T., "A design approach and selected wind tunnel results at high subsonic speeds for wing-tip mounted winglets", NASA TN D-8260, 1976, ntrs.nasa.gov — retrieved 2026-08-21; Montoya, L.C., "KC-135 winglet flight results", 1981, ntrs.nasa.gov — retrieved 2026-08-21.

Case 3 — From continental drift to plate tectonics (`VC2S8H01.E05`)

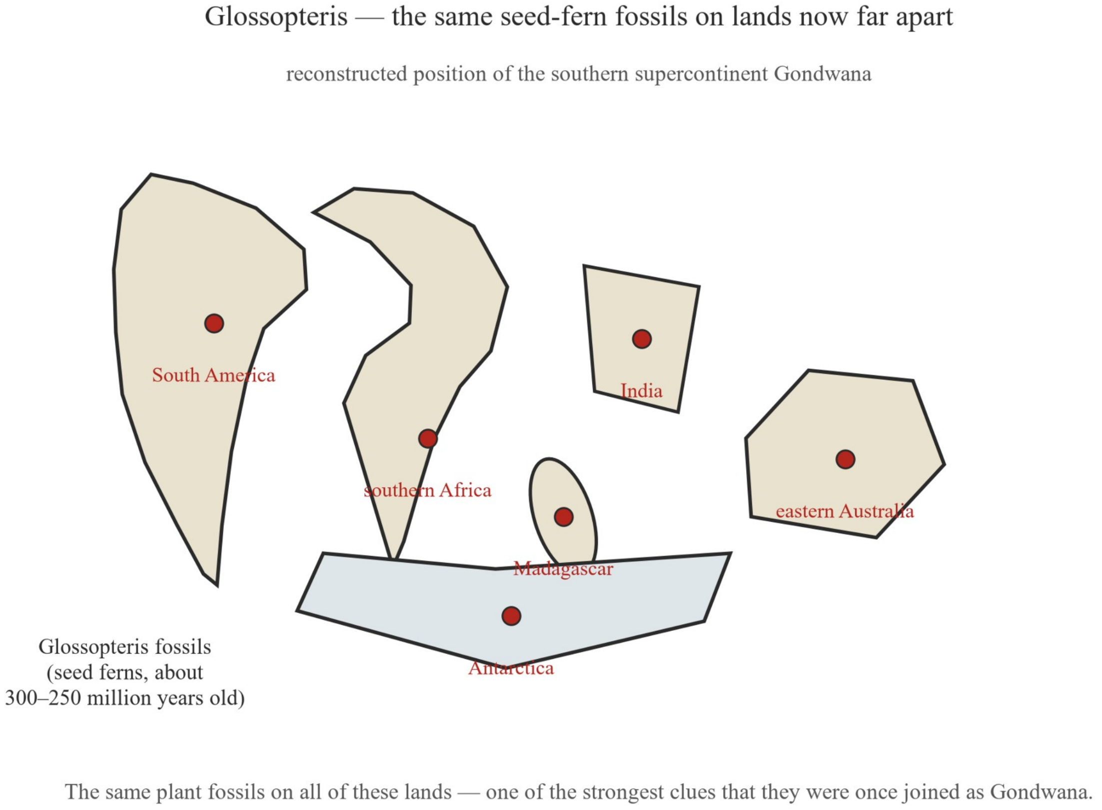
In 1912 the German weather scientist Alfred Wegener proposed that the continents had once been joined and had since drifted apart. His evidence was real and it was strong:

- **The fit of the coastlines** — the east coast of South America and the west coast of Africa fit together like two pieces of a jigsaw.
- **Matching fossils** — fossils of the seed fern *Glossopteris*, about 300–250 million years old, are found in South America, southern Africa, Madagascar, India, Antarctica and eastern Australia: lands now separated by whole oceans.
- **Traces of old climates** — marks of ancient ice sheets appear on lands that now sit in warm latitudes, as if those lands once stood somewhere else.



Two panels of stylised continents. Left: South America and Africa fitted together with the matching coastline edge drawn as a dashed red line. Right: the same two continents today with the Atlantic Ocean between them, arrows pointing apart, and a caption noting that the plates still move today — Australia drifts about 7 cm north-east each year

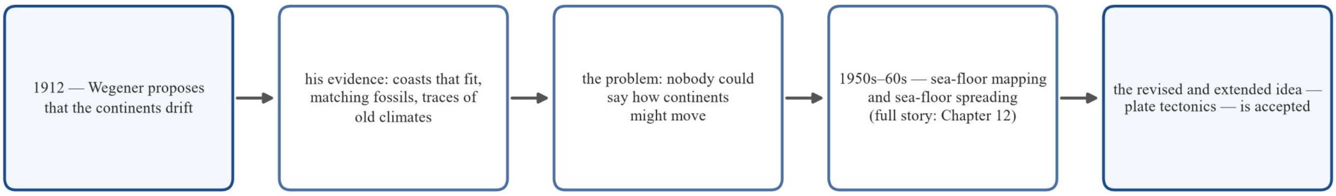
Source for the modern motion: Geoscience Australia, "Earthquake", 2025, ga.gov.au — retrieved 2026-08-21 (Australia's landmass moves north-east about 7 cm per year).



A stylised reconstruction of the southern supercontinent Gondwana, showing South America, southern Africa, Madagascar, India, Antarctica and eastern Australia joined, with red dots marking Glossopteris fossil finds on each land and a label noting the seed-fern fossils are about 300–250 million years old

Yet for forty years most geologists refused the idea, and they had a good reason: **nobody could say how continents might move.** Wegener's suggested driving force did not stand up to testing. A theory needs a mechanism that works, and his did not.

The idea only became accepted when new evidence arrived from the sea floor. From the 1950s, mapping of the ocean floor revealed great mountain ranges and deep trenches under the oceans; the pattern of magnetic stripes recorded in the sea-floor rock showed that new sea floor is made at the mid-ocean ridges and spreads outward — **sea-floor spreading**. The continents were not ploughing through the ocean crust; they were riding on moving **plates** of the Earth's outer shell. The revised and extended idea — **plate tectonics** — carried the old evidence *and* a working mechanism, and by the late 1960s it was the accepted theory. (The full story of the sea floor is told in Chapter 12.)



The core idea — that continents move — survived. It was tested, extended and given a mechanism, and so it changed from a contested proposal into the accepted theory of plate tectonics.

A five-stage flow: 1912 — Wegener proposes that the continents drift; his evidence — coasts that fit, matching fossils, traces of old climates; the problem — nobody could say how continents might move; 1950s–60s — sea-floor mapping and sea-floor spreading; the revised and extended idea — plate tectonics — is accepted

Sources: Wegener, A., "Die Entstehung der Kontinente", Petermanns Geographische Mitteilungen 58, 1912; Hess, H.H., "History of ocean basins", in Petrologic Studies: A Volume in Honor of A. F. Buddington, Geological Society of America, 1962; Vine, F.J. and Matthews, D.H., "Magnetic anomalies over oceanic ridges", Nature 199, 947–949, 1963; Heezen, B.C., Tharp, M. and Ewing, M., "The floors of the oceans, I: North Atlantic", Geological Society of America Special Paper 65, 1959.

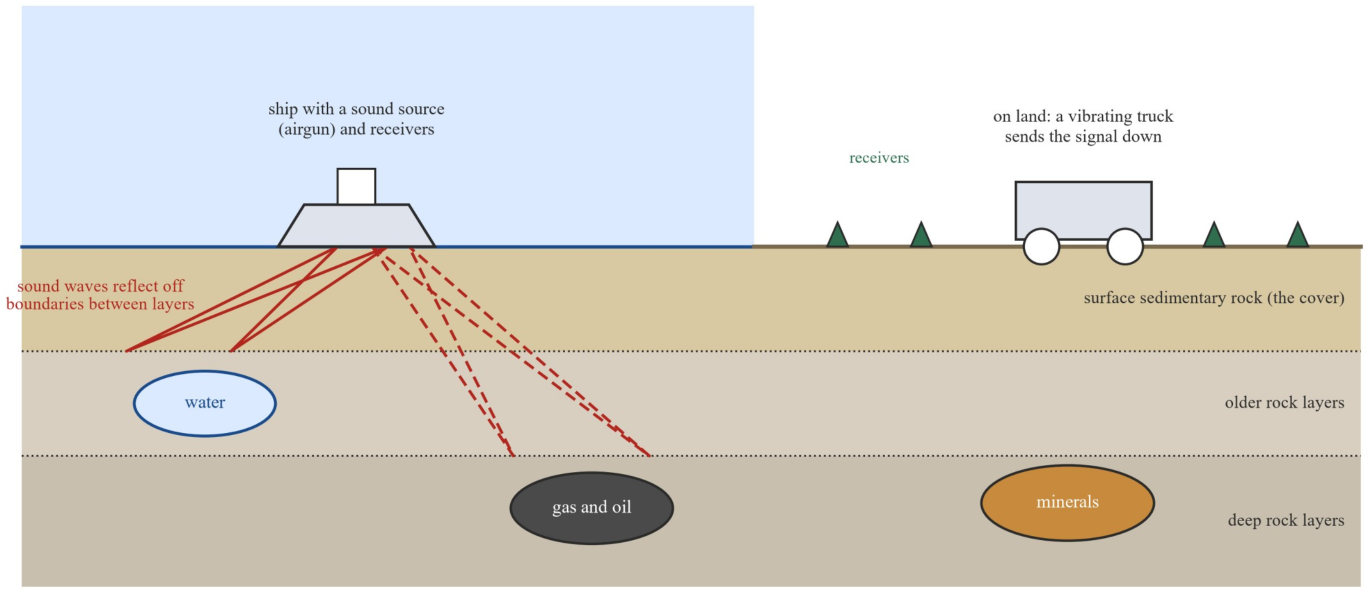
Notice what changed and what did not. The core claim — *the continents move* — survived from 1912 into the accepted theory. What changed was the explanation of how. That is the pattern of this whole subtopic: **the old idea is tested against the new evidence, and what survives is revised, extended or replaced.**

Case 4 — Seeing under the cover: deep Earth imaging (`VC2S8H01.E06`)

The same pattern runs in applied science. Much of Australia's mineral, energy and water wealth lies hidden beneath a cover of surface sedimentary rock. Geologists cannot see it directly, so they build a model of the underground from evidence — and the quality of the model depends on the quality of the imaging.

In a **sound-wave survey** — one form of deep Earth imaging — a sound source (an airgun at sea, a vibrating truck on land) sends sound waves down into the rock. The waves reflect off the boundaries between layers and return to receivers set out on land or towed behind the ship. The times and strengths of the returns let a computer build a picture of the layers below — and of what lies trapped in them: water, gas and oil, and mineral deposits.

Seeing underground: imaging with sound waves



Better imaging lets geologists find water, energy and mineral resources hidden beneath surface rock.

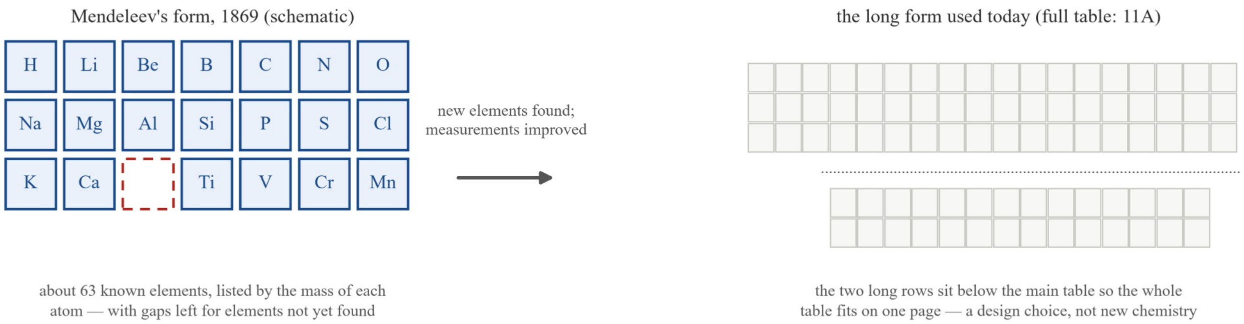
Cross-section of a sound-wave survey imaging the underground: at left a ship over the sea with a sound source and receivers, at right a vibrating truck on land with receivers set out around it; red ray paths travel down, reflect off boundaries between rock layers and return; beneath the surface sedimentary cover are labelled bodies of water, gas and oil, and minerals; the footer notes that better imaging lets geologists find water, energy and mineral resources hidden beneath surface rock

Each advance in deep Earth imaging — stronger sources, denser receivers, faster computing — has been new evidence in the same sense as the rest of this subtopic: the picture of what lies under the cover is revised, and resources that could not be identified before are identified. That is why the elaboration pairs this case with the changing of knowledge: better instruments, better evidence, better models.

Case 5 — The periodic table: the same knowledge in different forms (`VC2S8H01.E07`)

In 1869 the Russian chemist Dmitri Mendeleev published a table of the elements, listed in order of the mass of each atom. His table had a bold feature: **gaps**. Where the pattern of properties demanded an element that was not known, Mendeleev left an empty place and predicted what the missing element would be like.

Different forms of the same knowledge: the periodic table

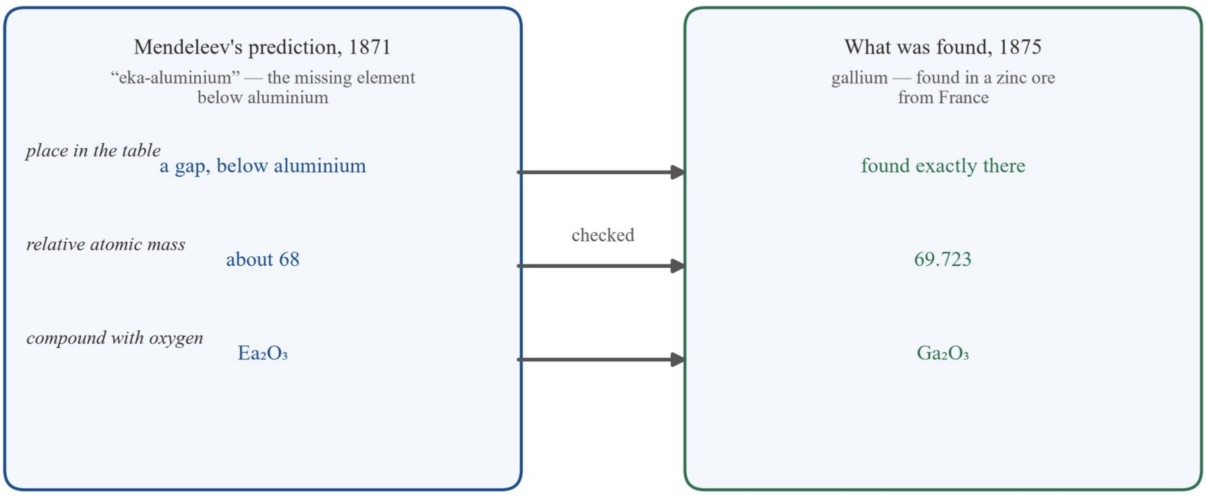


Tables changed shape as knowledge grew: gaps were filled, the order was refined, and the layout was redesigned for use — different forms exist for different reasons.

Two schematic tables. Left: Mendeleev's 1869 form — short rows of element symbols ordered by atomic mass with one dashed gap left in the third row. Right: the modern long form — a wide 18-column body with two long rows split out below the main table so the whole table fits on one page; a note says this is a design choice, not new chemistry, and the full table is taught in 11A

Four years later a predicted element turned up. In 1875 the French chemist Lecoq de Boisbaudran found **gallium** in a zinc ore. Mendeleev had predicted his "eka-aluminium" would sit below aluminium with a relative atomic mass of about 68 and a compound with oxygen of the form Ea_2O_3; gallium was found exactly there, with a relative atomic mass of 69.723 and a compound with oxygen Ga_2O_3. In 1886 a second predicted gap was filled the same way. When a model's predictions keep coming true, the model is trusted — the checked predictions were a large part of why chemists accepted the table.

A prediction checked: Mendeleev's "eka-aluminium" and gallium



Mendeleev left gaps in his table and predicted the properties of the missing elements. Gallium, found four years later, matched — one of the predictions that persuaded chemists to trust the table (full table: 11A).

Two panels. Left, "Mendeleev's prediction, 1871": eka-aluminium, the missing element below aluminium; place in the table — a gap below aluminium; relative atomic mass — about 68; compound with oxygen — Ea2O3. Right, "What was found, 1875": gallium, found in a zinc ore from France; found exactly there; 69.723; Ga2O3; arrows join each predicted property to the value found

Sources: Mendeleev, D., "Die periodische Gesetzmässigkeit der einfachen Körper", Annalen der Chemie und Pharmacie (supplement) 8, 133–229, 1871; Lecoq de Boisbaudran, P., "On a new metal, gallium" (in French), Comptes Rendus de l'Académie des Sciences 81, 493–495, 1875; Winkler, C., "A new element, similar to tin" (in

German), Journal für Praktische Chemie 34, 177–229, 1886; CIAAW (the IUPAC body that sets atomic weights), "Gallium", ciaaw.org — retrieved 2026-08-21.

The table has changed form since 1869 for two different reasons, and it is important to tell them apart:

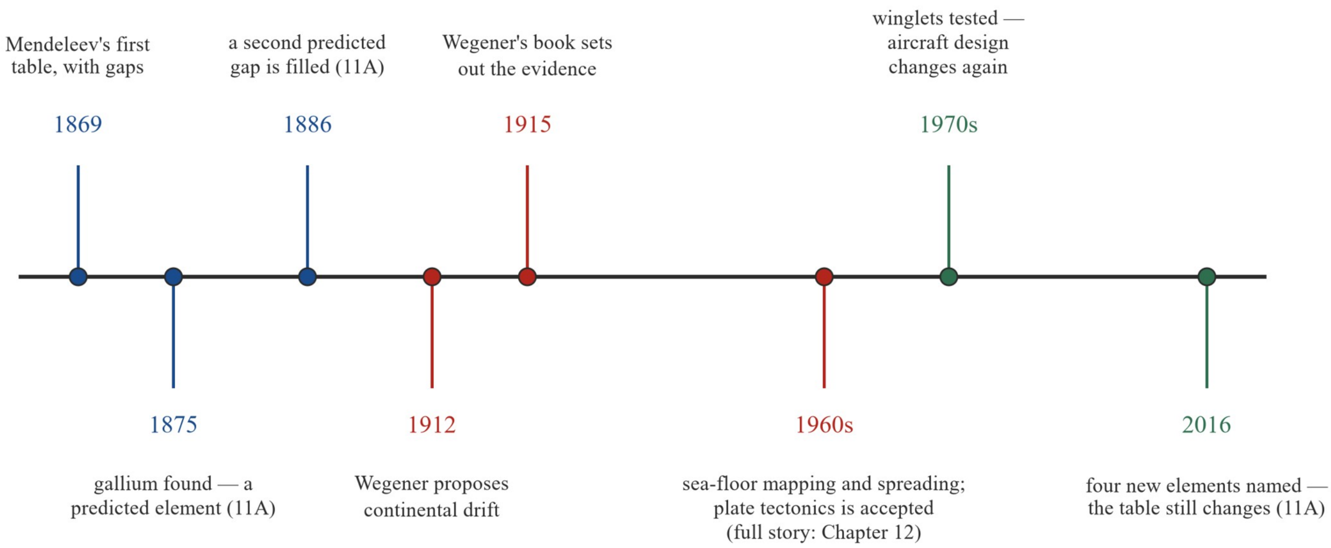
- **New knowledge changed the table.** Gaps were filled as new elements were found, and measurements of atomic masses were refined. As late as 2016 the table gained four newly named elements — nihonium, moscovium, tennessine and oganesson — the names being approved by IUPAC in November 2016.
- **Design choices changed the table.** The modern "long form" places two long rows below the main body so the whole table fits on one page; other forms arrange the same elements in other ways to bring out different patterns. Different forms exist for different reasons — the knowledge is the same, the arrangement serves the user.

Source: IUPAC, "Periodic Table of Elements", iupac.org — retrieved 2026-08-21 (element names approved 28 November 2016). The full periodic table — groups, periods and how to read it — is taught in 11A; here the table is used only as a case of knowledge changing form.

The pattern — five cases, one lesson

Set the five cases side by side on one line of time and the subtopic's single idea stands out.

Changes of knowledge in this section, on one line of time



In every case the earlier idea was not simply discarded — it was tested against new evidence and revised, extended or re-read. That is how scientific knowledge changes.

A horizontal timeline with eight events: 1869 Mendeleev's first table, with gaps; 1875 gallium found — a predicted element; 1886 a second predicted gap is filled; 1912 Wegener proposes continental drift; 1915 Wegener's book sets out the evidence; 1960s sea-floor mapping and spreading, plate tectonics accepted; 1970s winglets tested — aircraft design changes again; 2016 four new elements named — the table still changes

In every case the earlier idea was not simply thrown away. The fungi grouping, the drift idea, the 1869 table and the pre-winglet designs each explained what was seen at the time. New evidence — how fungi feed, the sea-floor record, the elements that turned up, the drag measured in flight tests — revised and extended those ideas into the ones accepted today. **That is how scientific knowledge changes: not by accident and not by opinion, but by evidence.**

Words to know in 1A

Word	What it means here
model	a stand-in for something hard to see or test directly; it shows some features and leaves others out
theory	(scientific sense) an explanation of a wide range of observations, built from many lines of evidence, that can be tested and revised
accepted	currently used by scientists because it accounts for the evidence best — not “proven forever”
evidence	observations or measurements that support or challenge an explanation
classification	placing living things into groups based on their features and relationships
fungi	the group containing mushrooms, moulds and yeasts; they take in ready-made food and are not plants
lift, weight, thrust, drag	the four forces on an aircraft in steady flight: up, down, forward, backwards
vortex	a swirling tube of air; at a plain wing tip it makes extra drag
winglet	the upturned tip on a modern wing that weakens the vortex and cuts drag
continental drift	Wegener’s 1912 proposal that the continents had once been joined and had moved apart
plate tectonics	the accepted theory that the Earth’s outer shell is divided into moving plates
Gondwana	the southern supercontinent in the reconstructions — the joined lands that now make up South America, Africa, Madagascar, India, Antarctica and Australia
sound-wave survey	imaging the underground by sending sound waves down and reading the reflections — one form of deep Earth imaging
periodic table	the arranged table of the elements; its forms have changed as knowledge grew

Worked examples

Example 1 — scaffolded

For each of Wegener’s observations, state what it suggested and why it counted as evidence for drift.

Working	Comment
(a) The east coast of South America and the west coast of Africa fit together like jigsaw pieces. → It suggests the two coasts were once joined; a fit that exact is unlikely by chance.	A fit alone is only a hint — but it is a testable hint: do the rocks match too?
(b) *Glossopteris* fossils, 300–250 million years old, occur on five southern lands now separated by oceans. → A seed fern cannot cross an ocean; the lands must have been joined when the fern grew.	One plant, many continents — the fossils are evidence the continents moved, not that the plant swam.

Example 2 — scaffolded

Fungi were once classified with plants. Use the two facts below to explain the change: fact 1 — plants make their own food from sunlight, fungi take in ready-made food; fact 2 — fungal cell walls are built from different material from plant cell walls.

Working	Comment
1. Groups in classification should contain things that are closely related, not things that just look alike.	The early grouping was based on looks: fixed in place, growing in soil.
2. Facts 1 and 2 show fungi are not closely related to plants — they feed in a different way and are built in a different way.	Each fact is new evidence the old grouping cannot account for.
3. ∴ the classification was revised: fungi were moved to a group of their own.	New evidence → revised model. The habit of the whole subtopic in one case.

Example 3 — unscaffolded

Mendeleev’s 1869 table contained gaps, and the modern long form places two long rows below the main body of the table. Explain why each of these features exists, and say which one is a change driven by new evidence and which is a design choice.

The gaps existed because the pattern of the table demanded elements that were not yet known — Mendeleev left a space and predicted the missing element’s properties, as with eka-aluminium (gallium). The gaps were closed by new evidence: the elements were found — gallium in 1875 and a second predicted element in 1886 — and their measured properties matched the predictions. The two long rows below the modern table are different in kind: they hold elements that were always going to sit there in the pattern, placed below the main body only so the whole table fits on one page. ∴ the filled gaps are knowledge changed by new evidence; the split-out rows are a design choice serving the user — two different reasons for the table to change form, which is exactly what the elaboration asks us to research.

Example 4 — unscaffolded

A textbook of 1950 describes “continental drift” as a rejected idea. A textbook of 1975 describes “plate tectonics” as the accepted theory. Explain what arrived between those dates to change the scientific knowledge, and say what part of Wegener’s idea survived.

Between about 1950 and the late 1960s, new evidence arrived from the sea floor: mapping showed mid-ocean mountain ranges and deep trenches (Heezen, Tharp and Ewing), the idea of sea-floor spreading gave the moving a mechanism (Hess), and the striped magnetic record over the ocean ridges showed new sea floor being made and spreading outward (Vine and Matthews). Wegener’s idea had failed acceptance chiefly because no working mechanism existed; the sea-floor evidence supplied one, with continents riding on plates rather than ploughing through ocean crust. ∴ the knowledge changed from drift to plate tectonics because new evidence supplied the missing mechanism — and what survived from 1912 was the core claim itself: the continents move.

Practice questions

Scaffolded

Q1. In this subtopic, *model* and *theory* are used in their scientific senses. State what a scientific theory is, in one sentence.

Q2. Name the four forces acting on an aeroplane in steady flight.

Q3. A winglet weakens one thing at the wing tip. Name it, and state what the weakening saves.

Q4. Name two of the lines of evidence Wegener used for continental drift in 1912.

Q5. State the main reason Wegener’s idea was not accepted when he proposed it.

Q6. In Mendeleev’s 1869 table, what did a gap mean?

Unscaffolded

Q7. Fungi were long classified with plants and are now in a group of their own. Explain what changed, and why this is an example of scientific knowledge changing with new evidence.

Q8. Explain why the discovery of gallium in 1875 made chemists trust Mendeleev’s table.

Q9. Different forms of the periodic table exist today. Give the two different reasons a form of the table can change, one sentence each.

Q10. Explain how a sound-wave survey builds a picture of what lies beneath surface sedimentary rock, and name two kinds of resource it can help identify.

Q11. A student writes: “A theory is only a guess, so plate tectonics is only a guess.” Using the scientific sense of *theory*, explain what is wrong with that sentence.

Q12. Explain why the accepted theory became plate tectonics rather than continental drift, naming the kind of evidence that made the difference.

Q13. Geoscience Australia reports that Australia’s landmass moves north-east about 7 cm per year. Explain what a measurement like this adds to the theory of plate tectonics today.

Q14. Choose two of the five cases in this subtopic and, for each, state: the old idea, the new evidence, and what changed.

Answers

Q1. A scientific theory is an explanation of a wide range of observations, built from many lines of evidence, that can be tested and revised. **Q2.** Lift (up), weight (down), thrust (forward), drag (backwards). **Q3.** It weakens the vortex (the swirl of air) at the wing tip; the weaker swirl means less drag, so less fuel is needed for the same trip. **Q4.** Any two of: the jigsaw fit of the South American and African coastlines; matching *Glossopteris* fossils on southern lands now separated by oceans; traces of old climates on lands now in warm latitudes. **Q5.** Nobody could say how continents might move — the idea had no working mechanism. **Q6.** A gap meant an element that the pattern said should exist but had not yet been found. **Q7.** New evidence — how fungi feed, what their cell walls are made of, and later the chemistry inside their cells — showed fungi are not closely related to plants, so they were moved to their own group; the classification changed because the evidence changed. **Q8.** Gallium matched what Mendeleev's table had predicted for the missing element below aluminium — place, relative atomic mass (about 68 predicted, 69.723 found) and the form of its compound with oxygen — so a model whose predictions came true earned trust. **Q9.** New knowledge (new elements found, measurements refined) changes the table; and design choices (such as placing two long rows below the main body so it fits on one page) change its form. **Q10.** A sound source sends waves down; the waves reflect off boundaries between layers and return to receivers; the returns are used to build a picture of the layers and what is trapped in them — for example water, gas and oil, or mineral deposits. **Q11.** In science a theory is not a guess: it is an explanation built from many lines of evidence that can be tested and revised. Plate tectonics rests on coastlines, fossils, sea-floor maps and magnetic stripes — a guess rests on none. **Q12.** Drift had the evidence but no working mechanism; sea-floor mapping, sea-floor spreading and the magnetic stripes supplied the mechanism (continents riding on moving plates), so the revised and extended theory — plate tectonics — was accepted. **Q13.** It is new, measured evidence that the plates are still moving now — the theory makes a prediction (present-day motion) and the measurement checks it. **Q14.** For example: (1) drift → plate tectonics: old idea, continents drift; new evidence, the sea-floor record and spreading; change, the revised theory with a mechanism. (2) pre-winglet wings: old idea, a plain tip is fine; new evidence, wind-tunnel and flight tests showed the vortex drag and the winglet saving; change, winglets on modern wings.

Fully-worked solutions

Q1. A scientific theory is an explanation of a wide range of observations, built from many lines of evidence *(1 mark)*, that can be tested and revised when new evidence arrives *(1 mark)*.

Q2. The four forces are **lift** (up) *(1 mark)*, **weight** (down) *(1 mark)*, **thrust** (forward) *(1 mark)* and **drag** (backwards) *(1 mark)*.

Q3. A winglet weakens the **vortex** — the swirl of air at the wing tip *(1 mark)*. The weaker vortex means less drag, so **less fuel is needed for the same trip** *(1 mark)*.

Q4. Two lines of evidence: **the coastlines of South America and Africa fit together** *(1 mark)*, and **the same *Glossopteris* fossils occur on southern lands now separated by oceans** *(1 mark)*.

Q5. The idea was not accepted because **nobody could say how continents might move** — it lacked a working mechanism *(1 mark)*, and a theory must have a mechanism that stands up to testing *(1 mark)*.

Q6. A gap meant **an element the pattern said should exist but that had not yet been found** *(1 mark)* — Mendeleev left the space and predicted the missing element's properties *(1 mark)*.

Q7. The early grouping put fungi with plants on looks — fixed in place, growing in soil *(1 mark)*. New evidence showed fungi feed in a different way (they take in ready-made food) and their cell walls are built from different material, so they are not closely related to plants *(1 mark)*. The classification was therefore revised, fungi gaining a group of their own — knowledge changed because the evidence changed *(1 mark)*.

Q8. Mendeleev's table had predicted a missing element below aluminium with a relative atomic mass of about 68 and a compound with oxygen of the form Ea_2O_3 *(1 mark)*. Gallium, found in 1875, sat exactly there with a relative atomic mass of 69.723 and a compound with oxygen Ga_2O_3 *(1 mark)*. A model whose predictions come true is trusted — so the checked prediction persuaded chemists to accept the table *(1 mark)*.

Q9. Reason 1: **new knowledge** — new elements found and measurements refined change what the table must hold *(1 mark)*. Reason 2: **design choice** — the same knowledge can be arranged in different ways to serve the user, as with the two long rows placed below the main body so the table fits on one page *(1 mark)*.

Q10. A sound source (airgun at sea, vibrating truck on land) sends sound waves into the rock *(1 mark)*; the waves reflect off boundaries between layers and return to receivers, and the returns build a picture of the layers below *(1 mark)*. Resources it can help identify: **water** and **gas and oil** (or **minerals**) *(1 mark)*.

Q11. The sentence uses the everyday sense of theory (a guess), not the scientific one *(1 mark)*. In science a theory is an explanation built from many lines of evidence, testable and revisable — and plate tectonics rests on coastlines, fossils, sea-floor maps and magnetic stripes *(1 mark)*. A guess rests on no evidence at all, so calling the theory "only a guess" misnames it *(1 mark)*.

Q12. Continental drift carried strong evidence (coastline fit, matching fossils, old climate traces) but no working mechanism, which is why it was refused *(1 mark)*. From the 1950s, sea-floor mapping, sea-floor spreading and the magnetic stripes over the ridges supplied the mechanism — continents riding on moving plates *(1 mark)*. The revised and extended theory, plate tectonics, accounted for the old evidence and the new, so it was accepted *(1 mark)*.

Q13. The theory predicts that the plates are still moving now *(1 mark)*. A measured rate — Australia drifting north-east about 7 cm per year — is new evidence checking that prediction in the present day *(1 mark)*. Each such measurement that matches the prediction strengthens the accepted theory *(1 mark)*.

Q14. Case 1: old idea — continents fixed; new evidence — coastline fit, fossils, then the sea-floor record; change — drift revised and extended into plate tectonics *(1–2 marks)*. Case 2: old idea — plain wing tips; new evidence — wind-tunnel and KC-135A flight tests showed the vortex drag and about 7% less drag with winglets; change — winglets adopted on modern aircraft *(1–2 marks)*. (Any two cases correctly given as old idea → new evidence → change earn full marks; the fungi case, the deep Earth imaging case and the periodic table case are equally acceptable.)

Sources

Web sources below were retrieved 2026-08-21.

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Elaboration contexts used: `VC2S8H01.E01` (re-examining classification as new information arrives — fungi), `VC2S8H01.E03` (flight forces and aircraft design), `VC2S8H01.E05` (plate tectonics over continental drift), `VC2S8H01.E06` (deep Earth imaging and resources beneath sedimentary cover) and `VC2S8H01.E07` (reasons for different forms of the periodic table).

Teacher-facing note — reserved elaborations (not student text). `VC2S8H01.E02` (Aboriginal and Torres Strait Islander traditional ecological knowledge informing sustainable harvesting) and `VC2S8H01.E04` (changing interpretations of Deep Time cultural sites, including Cloggs Cave on Gunaikurnai Country and Budj Bim Cultural Landscape on Gunditjmara Country) are reserved under the ICIP decision (D10; CONTENT_POLICY rule 1): no Aboriginal or Torres Strait Islander content is delivered in this book. The case-study method they would have illustrated — interpretation revised as new evidence and new voices arrive — is taught here in general scientific cases only.

Who does science: multidisciplinary teams, and how different skills, perspectives and worldviews shape the questions asked and the answers found

What we teach here — `VC2S8H02` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"Multidisciplinary endeavours to advance scientific knowledge make use of people's different perspectives and worldviews."* **This section owns the whole content description** (TOC §4: `VC2S8H02` sits entire in 1B): who does science — teams that mix skills and fields, and the way people's perspectives and worldviews shape the questions science asks and the answers it finds. **In our words:** science is not a lone genius in a lab. It is teams of different people with different skills — and deeper than skills, different points of view. Who does science decides which questions get asked, which methods get used, and which answers get found. **Achievement-standard extract served here (D13):** *"They discuss how people with different understandings, skills, perspectives and worldviews have worked in multidisciplinary teams to develop scientific knowledge."* **Elaborations drawn on (contexts, not a checklist — D12):** `VC2S8H02.E01` (Levins and Rotblat: worldviews influencing what scientists choose to study and do), `VC2S8H02.E02` (Patterson's curse as useful plant or weed, depending on perspective), `VC2S8H02.E03` (David Unaipon's boomerang aerodynamics and his 1914 vertical-lift flying machine), `VC2S8H02.E04` (seasonal calendars informing botany, zoology, ecology and meteorology), `VC2S8H02.E05` (bamboo houses and earthquake-resistant structures) and `VC2S8H02.E07` (fairness in sport and rapid drug tests). `VC2S8H02.E06` is not drawn on here — see the teacher-facing note in Sources. **Authored from the CD text and the elaboration contexts (D12):** the CD names "perspectives and worldviews" without saying whose; the six elaboration contexts above supply the cases, and the bionic ear supplies the team. **ICIP (D10):** the Aboriginal content in this section (E03, E04) is delivered only from named published sources — the published historical record of David Unaipon, and the Gariwerd seasonal calendar published by the Bureau of Meteorology with the permission of the Elders. The calendar itself is the Indigenous Cultural and Intellectual Property of its owners and is never reproduced or redrawn here; the figure shows the bridge the calendar builds, not the calendar. See the teacher-facing note in Sources.

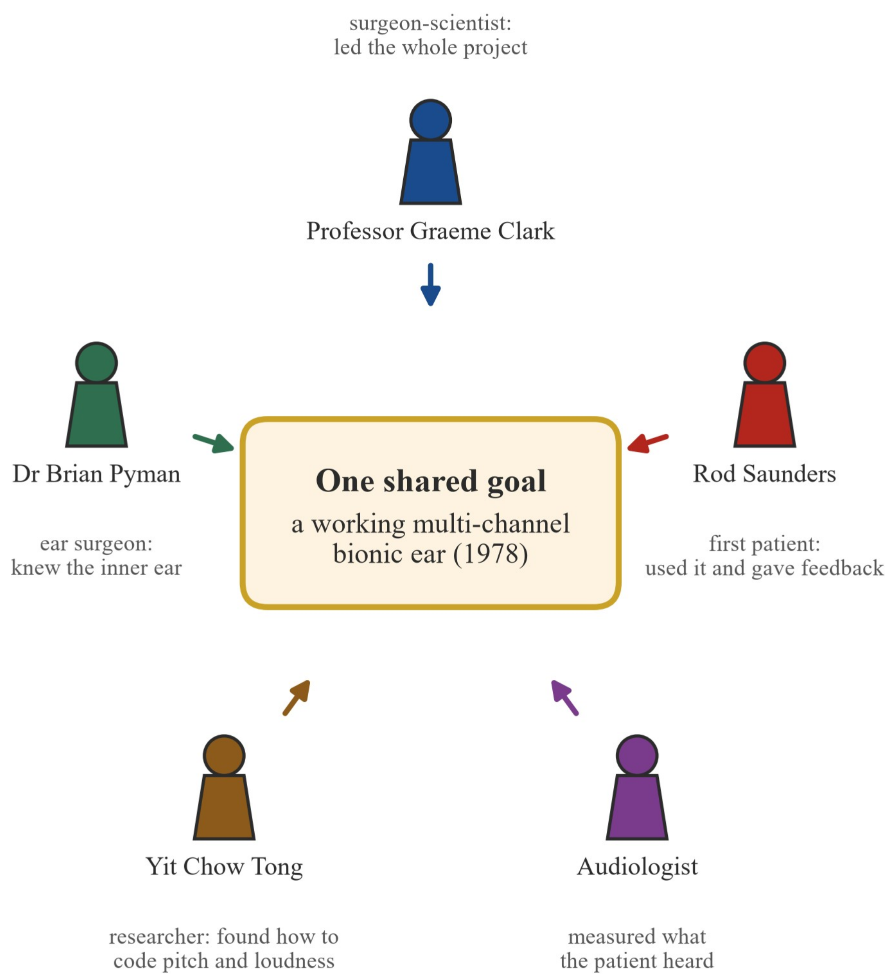
Word watch — *multidisciplinary*, *perspective* and *worldview*. A **multidisciplinary** effort is one that mixes several fields of knowledge and work — surgery and engineering and measurement, not just one. A **perspective** is the angle a person sees a question from, shaped by who they are and what they need; two people can look at one plant and see a weed and a rescue. A **worldview** is bigger: a person's whole picture of how the world works and what matters in it. In this section those three words always carry these meanings.

Theory

Science is a team effort

The stock picture of science is a lone genius having a flash of insight. The real picture is a team. Some of the biggest steps in science are multidisciplinary endeavours: people from several fields bring different skills, different knowledge and different points of view to one shared problem, and the problem gets solved because all of those pieces are at the table.

Five parts of one team — the bionic ear, Melbourne (1978)



First implanted at the Royal Victorian Eye and Ear Hospital. No one person could build it alone.

Five members of the bionic ear team drawn around their one shared goal, a working multi-channel bionic ear

In 1978, a team in Melbourne gave the world its first working multi-channel bionic ear — an implant that let a person who had lost their hearing hear speech again. No one person could have built it.

- **Professor Graeme Clark**, a surgeon-scientist at the University of Melbourne, led the whole project.
- **Dr Brian Pyman**, an ear surgeon, brought the surgeon's knowledge of the inner ear.
- **Yit Chow Tong**, a researcher, helped work out how pulses of electricity could carry **pitch** (how high or low a sound is) and **loudness** to the brain.
- An **audiologist** — a health professional who measures hearing — tested what the patient actually heard.
- **Rod Saunders**, who had lost his hearing at 46, was the first person to receive the implant. He used the ear and gave the team the feedback that made it better.

The first surgery was done at the Royal Victorian Eye and Ear Hospital. Surgery, anatomy, engineering, measurement and lived experience: five different kinds of knowing, one device.

Source: Wikipedia, "Graeme Clark (doctor)", 2026. en.wikipedia.org — retrieved 2026-08-21.

Source: Wikipedia, "Royal Victorian Eye and Ear Hospital", 2026. en.wikipedia.org — retrieved 2026-08-21.

Try it — build a team of your own

You will need: a group of four, and a plan for a fair test of "which brand of paper towel soaks up the most water". List the jobs the investigation needs — designing the fair test; measuring carefully; recording and graphing the results; double-checking the reasoning. Hand each job to the person whose strengths fit it, then answer:

1. Which job went to which strength, and why?
2. What would your investigation lose if one person did all four jobs alone?
3. Match your four jobs to the bionic ear team: which of their five roles is like each of yours?

Worldviews choose the work (`VC2S8H02.E01`)

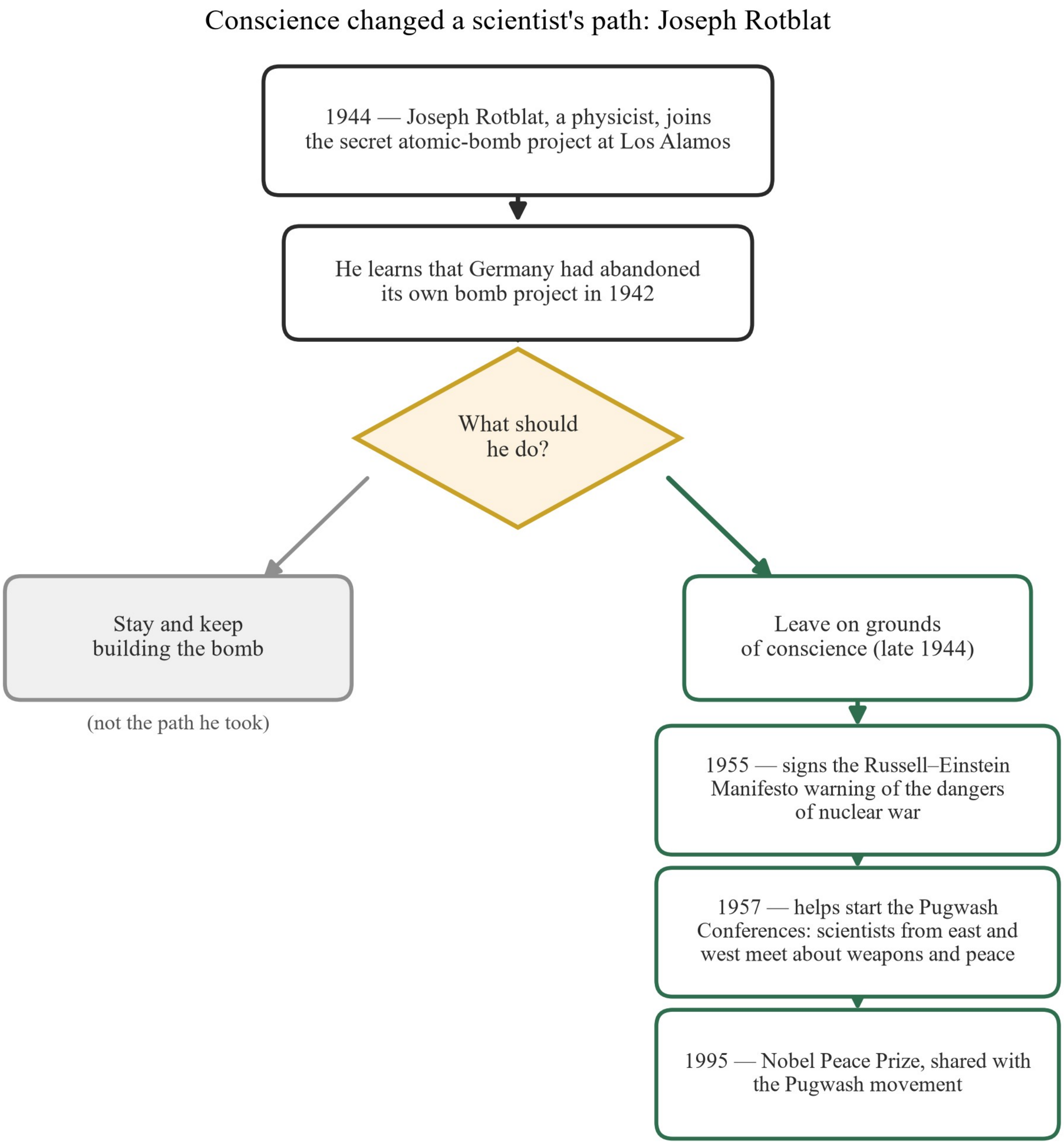
Team members bring skills. They also bring something deeper: a **worldview** — a picture of how the world works and what matters in it. A scientist's worldview shapes what they choose to study, and what they refuse to do.

Richard Levins (1930–2016) was an American biologist with strong political beliefs about fairness for ordinary people. Those beliefs chose his science: he studied farming, hunger and disease — science in the service of communities. They also chose *how* he did biology. Instead of looking at single organisms on their own, he studied whole populations of living things and how they change in a changing environment, and he built new mathematics to do it. His worldview picked his questions.

Joseph Rotblat (1908–2005), a Polish-born physicist, made an even starker choice. In 1944 he joined the secret project at Los Alamos in the United States to build the first nuclear bombs, because he feared that Germany would build one first. Then he learned that Germany had given up its own bomb project in 1942. The reason for his work was gone. Late in 1944, Rotblat left the project because he could no longer justify the work — the only scientist to leave before the bomb was used. Afterwards he pointed his science at peace: in 1955 he signed the Russell–Einstein Manifesto, a public warning about nuclear war; in 1957 he helped start the Pugwash Conferences, where scientists from east and west met to talk about weapons and peace; and in 1995 he shared the Nobel Peace Prize with the Pugwash movement. Same training as his colleagues; different choices. The difference was his worldview.

Source: NobelPrize.org, "Joseph Rotblat – Biographical", n.d. nobelprize.org — retrieved 2026-08-21.

Source: Wikipedia, "Richard Levins", 2026. en.wikipedia.org — retrieved 2026-08-21.



Decision diagram of Joseph Rotblat at Los Alamos in 1944, the path of conscience he took, and the peace work that followed to the 1995 Nobel Peace Prize

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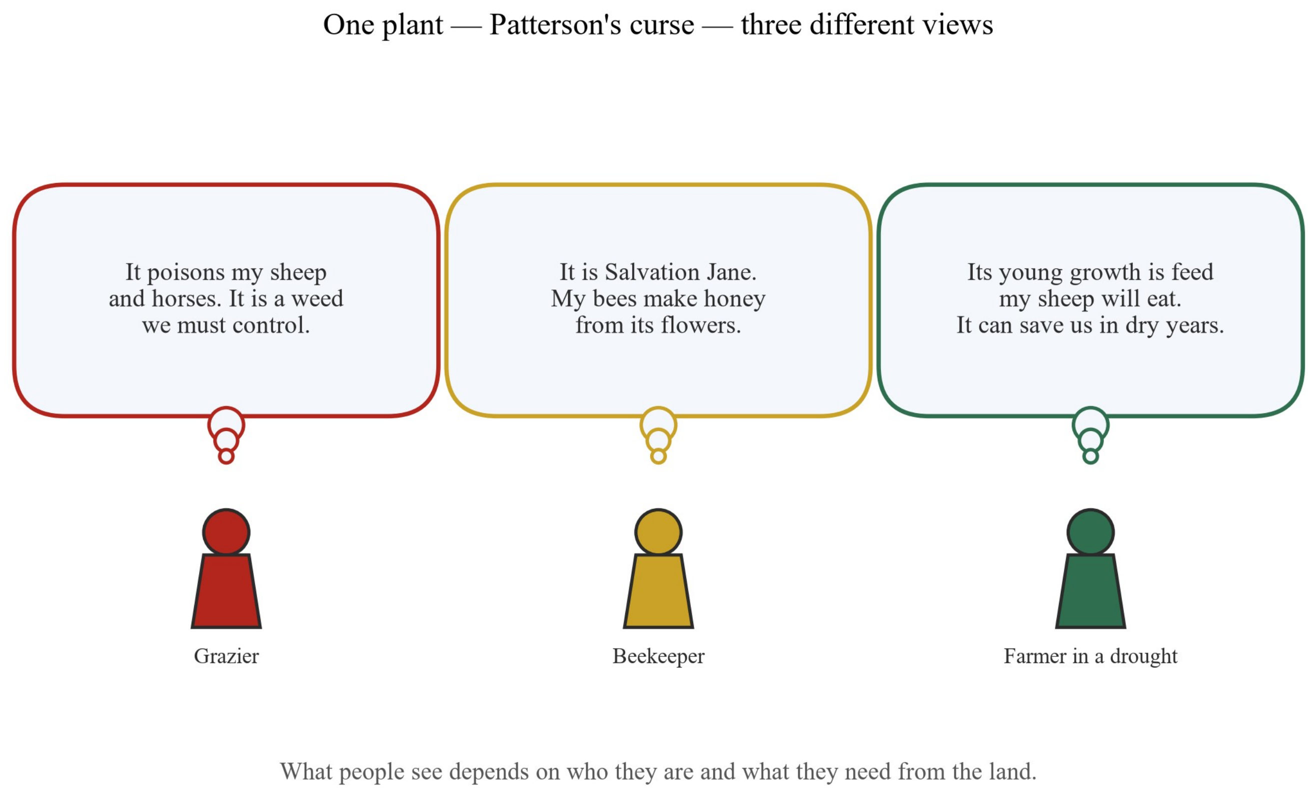
One plant, many views (`VC2S8H02.E02`)

Perspectives are not only a scientists' affair. Who asks the question decides what counts as a problem — and whether something is a problem at all. Look at one wildflower.

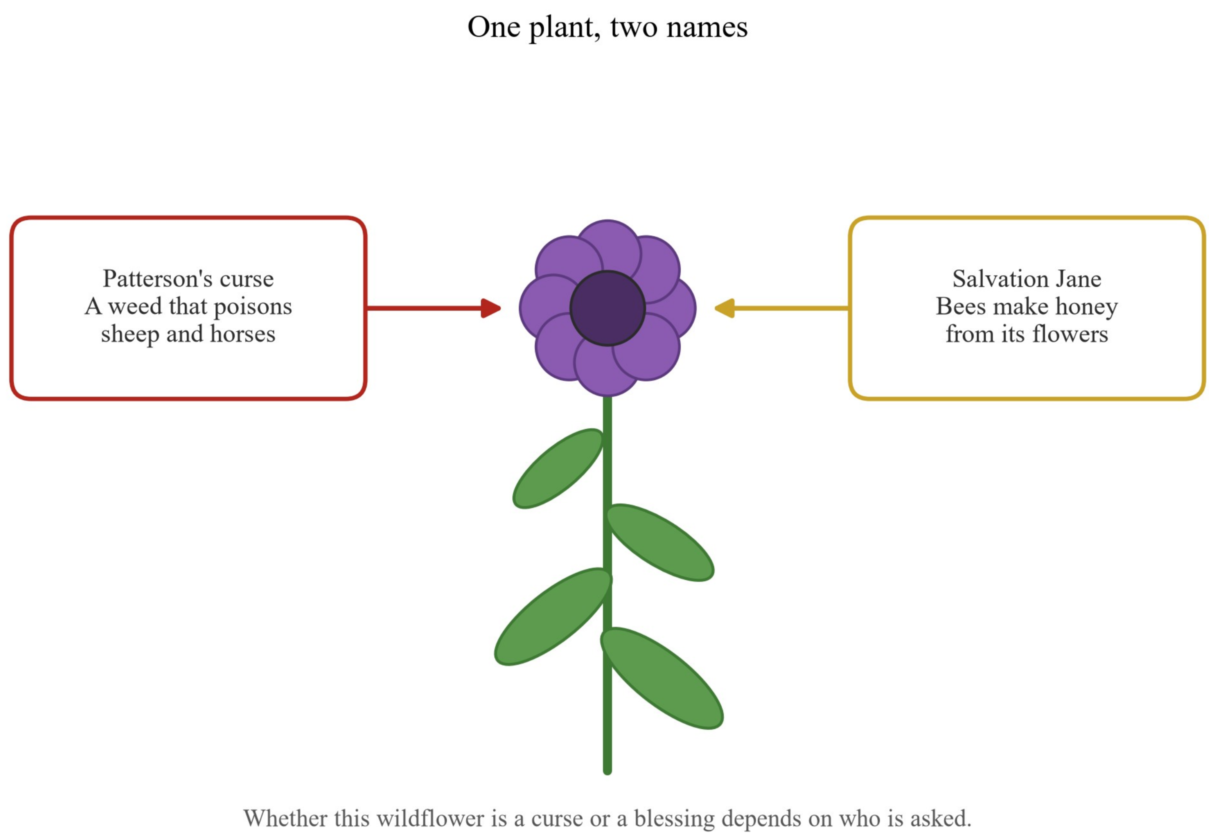
Patterson's curse is a purple-flowered plant that came to Australia from Europe and spread over huge areas. To a grazier it is a weed: the plant carries poisons that build up in the liver of an animal that eats it, and stock have sickened and died after grazing on it heavily. To a beekeeper it is Salvation Jane: bees work its flowers, and the honey they make is blended with other honeys to dilute the small amount of poison the nectar carries, then sold. To a farmer in a dry year, its young growth is feed the stock will eat when little else is green. One plant — a curse and a salvation at the same time. What people see depends on who they are and what they need from the land.

Source: Wikipedia, "Echium plantagineum", 2026. en.wikipedia.org — retrieved 2026-08-21.

Source: Weeds Australia, "Paterson's Curse", n.d. weeds.org.au — retrieved 2026-08-21.



A grazier, a beekeeper and a farmer in a drought each describing the same plant, Patterson's curse, in a different way



One purple-flowered plant labelled Patterson's curse on one side and Salvation Jane on the other

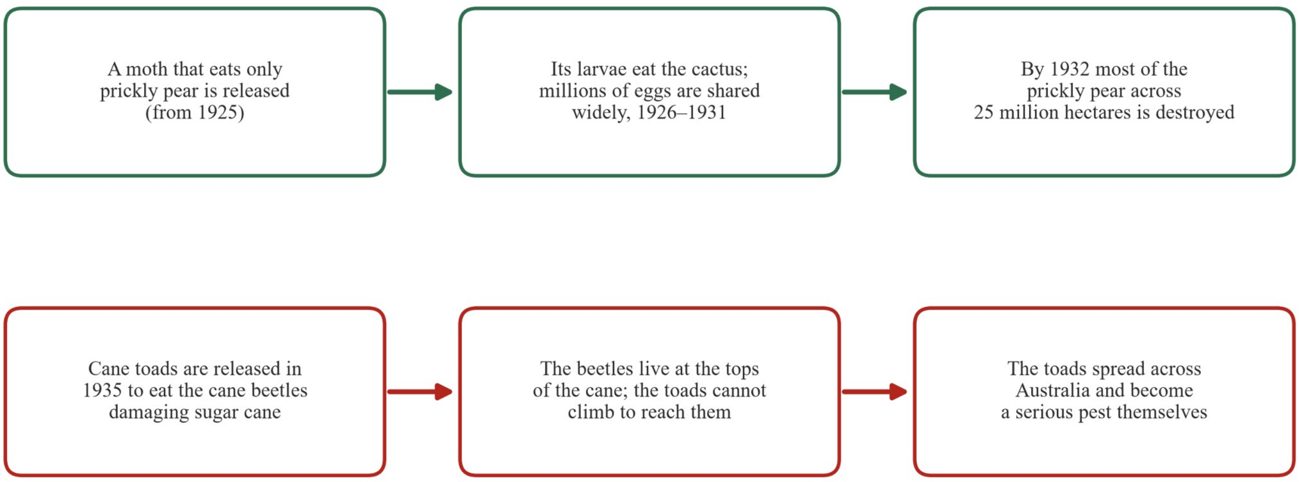
Science has to carry all those views at once when it is asked to act. In the early twentieth century, Australia asked science to deal with another introduced plant that was smothering farmland: prickly pear, a cactus that had spread over about 25 million hectares by 1920, advancing by about 1 million hectares a year. Digging, burning and crushing had all failed. The answer science found is one of the great successes of **biological control** — using one living thing to check another. The moth *Cactoblastis cactorum*, brought from South America and released from 1925, eats almost only prickly pear. Between 1926 and 1931, tens of millions of the moth's eggs were shared around Queensland, and by 1932 most of the prickly pear had been destroyed. The **specialist** worked.

The opposite choice shows why the weighing-up matters. In 1935, cane toads were released in Queensland to eat the cane beetles that were damaging sugar cane. The toads are **generalists**: they eat almost anything. And the beetles live at the tops of the cane, where the toads cannot climb. The toads failed to control the beetles — then spread across Australia and became a serious pest themselves, poisoning the native animals that try to eat them. Choosing what science should do meant carrying many perspectives and risks. It still does.

Source: Wikipedia, "Biological pest control", 2026. en.wikipedia.org — retrieved 2026-08-21.

Source: Wikipedia, "Cane toad", 2026. en.wikipedia.org — retrieved 2026-08-21.

Choosing a biological control agent: specialist or generalist?



An agent that eats only the pest (a specialist) worked; one that eats almost anything (a generalist) failed and caused harm.

Two flow charts comparing the successful control of prickly pear by the specialist Cactoblastis moth with the failed release of the generalist cane toad

Try it — three views of one thing

Find one thing in your school that people see in different ways — a clover patch on the oval, the canteen menu, the bell. In a group of three, take the parts of three different people (for the clover: the groundskeeper, a beekeeper, a student lying in the sun at lunch). Each says one sentence starting "To me, this is …". Then answer: if the school asked science, "Should we remove the clover?", whose views would have to be carried? Why can chemistry alone not answer the question?

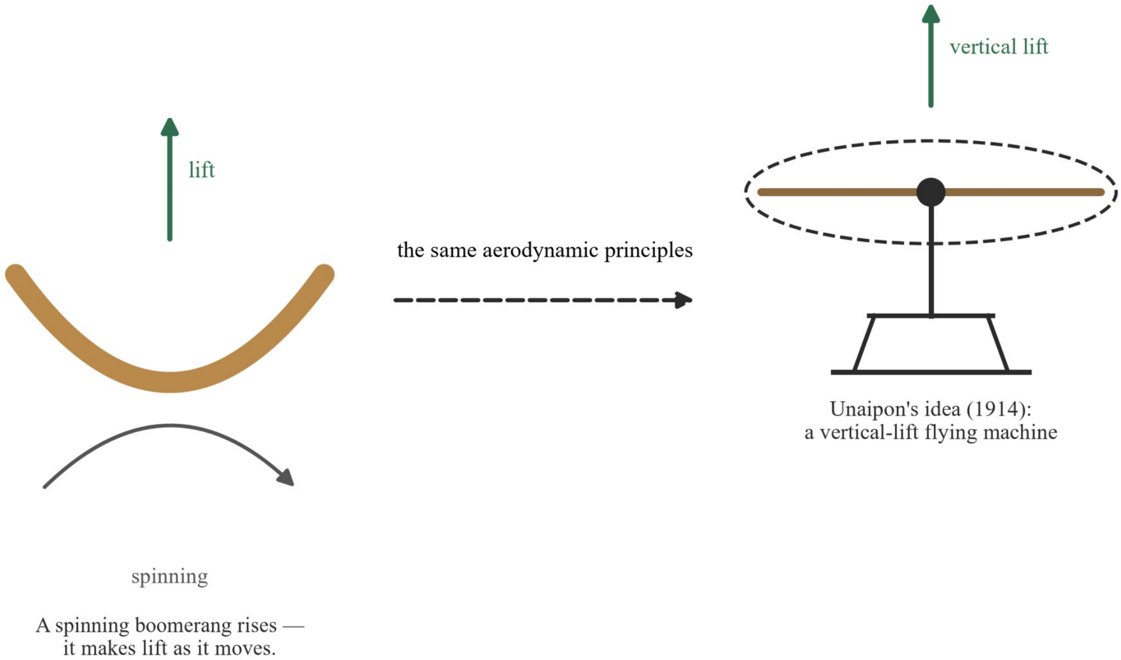
Knowledge from many cultures: Unaipon's flight idea (`VC2S8H02.E03`)

Science also advances when it listens to knowledge from many cultures, including the knowledge of Aboriginal and Torres Strait Islander Peoples.

David Unaipon (1872–1967) was a Ngarrindjeri man, born at Point McLeay mission in South Australia — he is the man on the Australian fifty-dollar note. He was a preacher, a writer and an inventor who registered ten patents between 1909 and 1944. In 1914 he put forward a striking idea: a flying machine could be built on the same aerodynamic principles as a spinning boomerang — a machine that makes vertical lift the way a boomerang's spin makes lift. **Aerodynamics** is the study of how air moves around objects. Unaipon drew the idea from deep knowledge of how a boomerang flies — knowledge grown on Country over thousands of years — and aimed it at a brand-new machine. His 1914 design was an idea on paper, not a built craft; but the leap itself, from an old technology of Country to the aerodynamics of flight, is exactly the kind of cross-cultural thinking that moves science forward.

Source: Wikipedia, "David Unaipon", 2026. en.wikipedia.org — retrieved 2026-08-21.

David Unaipon, 1914: from a spinning boomerang to a vertical-lift flying machine



Conceptual sketch of the idea Unaipon described in 1914; not a drawing of a built machine.

A spinning boomerang making lift, linked by an arrow to Unaipon's 1914 idea of a vertical-lift flying machine using the same aerodynamic principles

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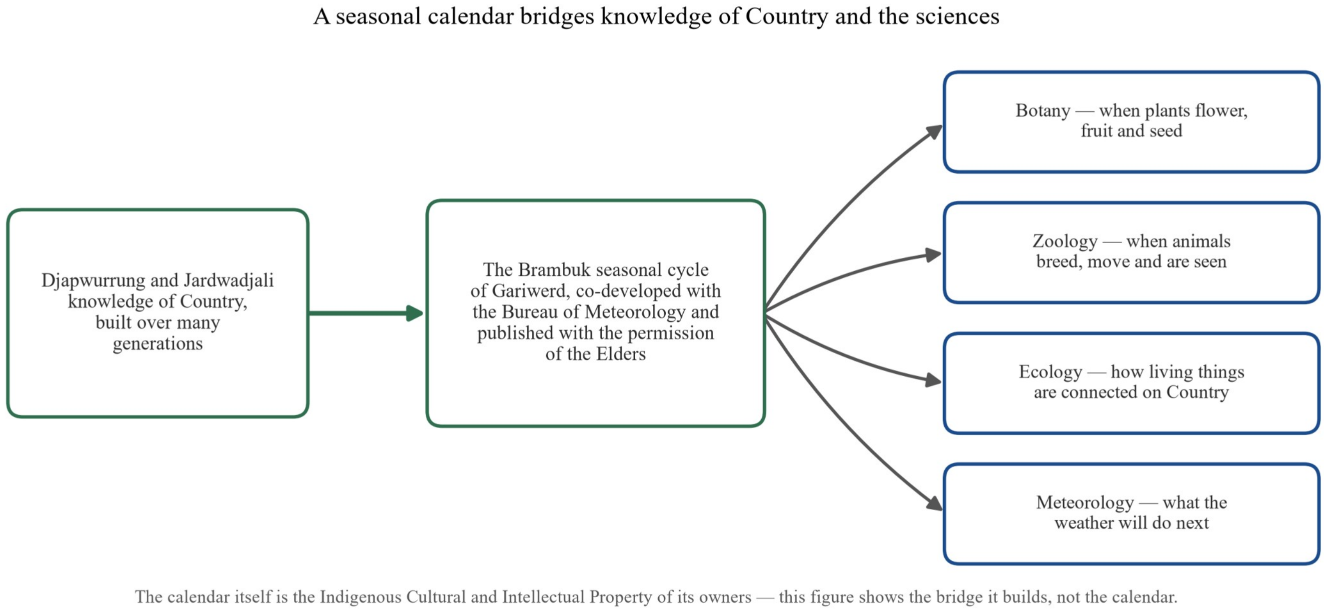
Seasonal calendars as bridges to science (`VC2S8H02.E04`)

Another bridge from cultural knowledge to science is the seasonal calendar. Across Australia, Aboriginal and Torres Strait Islander Peoples have built deep knowledge of Country: when the eels run, when the bees appear, when the birds nest, what the sky and the weather will do next. A seasonal calendar ties those signs together into a year.

In Victoria, the Brambuk seasonal cycle of Gariwerd (the Grampians) records the knowledge of the Djapwurrung and Jardwadjali Peoples. The Bureau of Meteorology co-developed the published calendar with the Brambuk community, and it is published with the permission of the Elders. Reading it, a scientist sees four sciences at once: **botany** (when plants flower, fruit and seed), **zoology** (when animals breed and move), **ecology** (how the living things of Country are connected) and **meteorology** (what the weather will do next). It is a long, careful record of how a whole landscape turns through the year — and it informs each of those sciences.

The calendar itself is the Indigenous Cultural and Intellectual Property (ICIP) of its owners. This section names what the calendar informs; it never reproduces the calendar. The figure below shows the bridge, not the calendar. See the teacher-facing note in Sources.

Source: Bureau of Meteorology, "Gariwerd calendar", Indigenous Weather Knowledge, n.d. bom.gov.au — retrieved 2026-08-20.



Flow diagram of the Brambuk seasonal cycle of Gariwerd, co-developed with the Bureau of Meteorology and published with the permission of the Elders, bridging knowledge of Country to botany, zoology, ecology and meteorology

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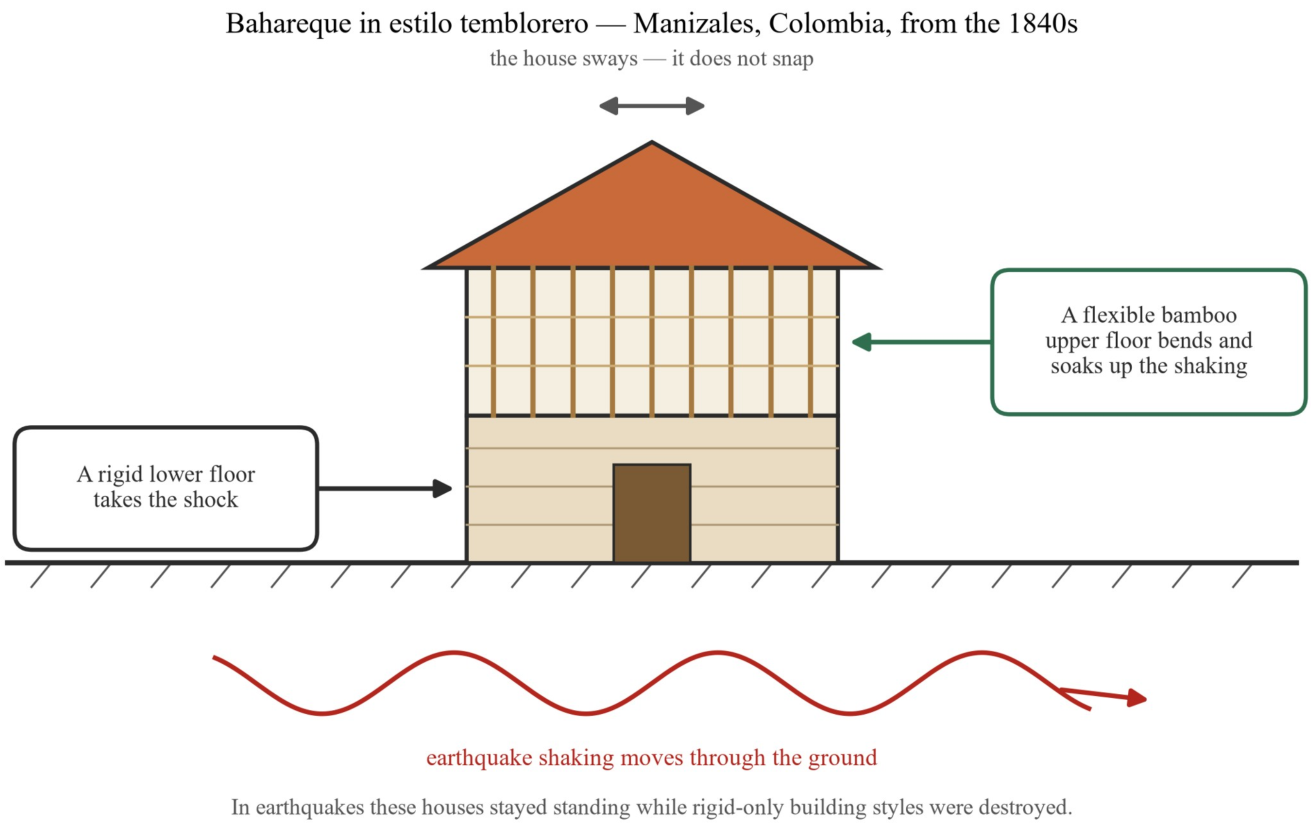
Bamboo houses that ride out earthquakes (`VC2S8H02.E05`)

Engineering advances when it learns from builders in other places. In Manizales, Colombia, settlers built two-storey houses from the 1840s in a style later named *estilo temblorero* — “earthquake-shaking style”. The lower floor was rigid, made of packed earth; the upper floor was **bahareque**, a light frame of bamboo packed with earth and plastered. When earthquakes shook the town, the rigid lower floor took the shock and the flexible bamboo upper floor bent and soaked up the shaking — the house swayed instead of snapping. People watched houses built in stiffer styles fall while the *estilo temblorero* houses stayed standing, and the style spread. Modern earthquake engineering teaches the same idea: a building that can bend and soak up shaking survives. The builders of 1840s Colombia got there first, and today their local knowledge is part of the world’s engineering knowledge for building in earthquake country.

Source: Wikipedia, “Bahareque”, 2026. en.wikipedia.org — retrieved 2026-08-21.



Cross-section of a bahareque house in estilo temblorero during earthquake shaking, with a rigid lower floor taking the shock and a flexible bamboo upper floor bending to soak up the shaking

Try it — bend, don't break

You will need: a dry biscuit and a slice of soft bread. Bend each slowly. The biscuit snaps; the bread bends and holds. In an earthquake it is the ground that does the bending. A house that can bend a little — like the bamboo upper floor — soaks up the shaking; a house that is only stiff can snap like the biscuit. Which part of the *estilo temblorero* house is the bread? State one way the biscuit-and-bread model falls short of a real house in a real quake.

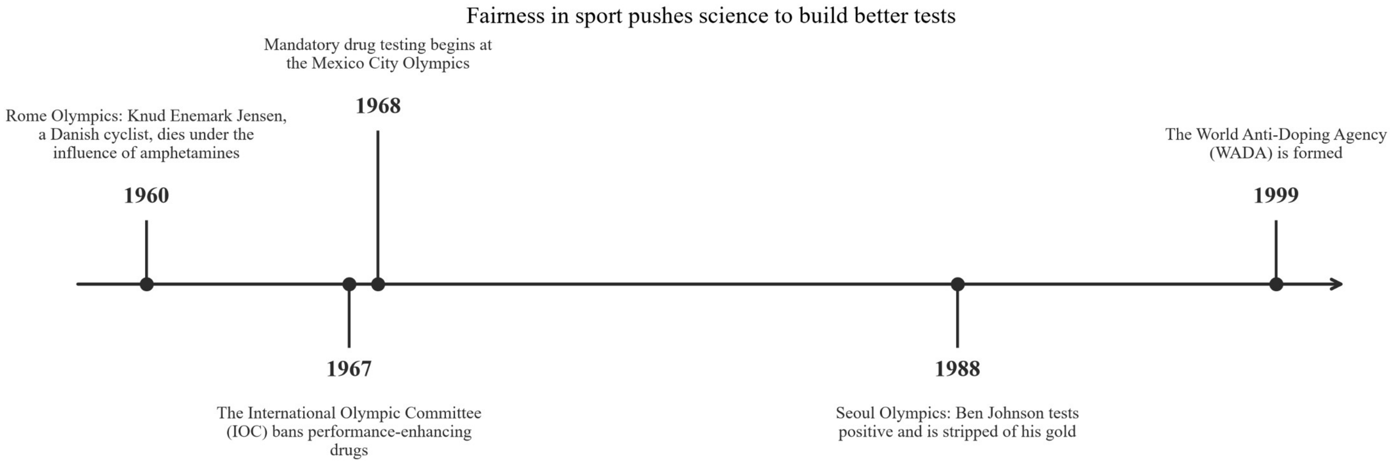
Fairness drives the tests: sport (`VC2S8H02.E07`)

Sometimes a whole community's sense of what is fair sets science its problem. Sport is one of those cases: a race only means something if everyone runs it on the same terms. When some athletes began taking drugs to perform better, that fairness was broken — and science was asked to build the tests that protect it.

In 1960, at the Rome Olympics, the Danish cyclist Knud Enemark Jensen fell during the road race and later died; a coroner found he had been under the influence of a stimulant drug. His death showed the world how common drug use in top sport had become. In 1967 the International Olympic Committee (IOC) banned performance-enhancing drugs, set up a medical commission and wrote a list of banned substances. In 1968, at the Mexico City Olympics, mandatory testing began. In 1988, at the Seoul Olympics, the 100 m winner Ben Johnson tested positive for a banned drug and was stripped of his gold medal in front of the world. In 1999 the World Anti-Doping Agency (WADA) was formed, backed by many governments and the IOC, to drive the science and the rules. Every step of that timeline asked chemists for better, faster tests: a test that can find a trace of a banned substance in an athlete's sample is the chemistry of fairness in action.

Source: Wikipedia, "Doping at the Olympic Games", 2026. en.wikipedia.org — retrieved 2026-08-21.

Source: Wikipedia, "World Anti-Doping Agency", 2026. en.wikipedia.org — retrieved 2026-08-21.



Timeline from 1960 to 1999 showing the events — Jensen's death, the IOC ban, mandatory testing, Ben Johnson's positive test and the founding of WADA — that pushed science to build better drug tests

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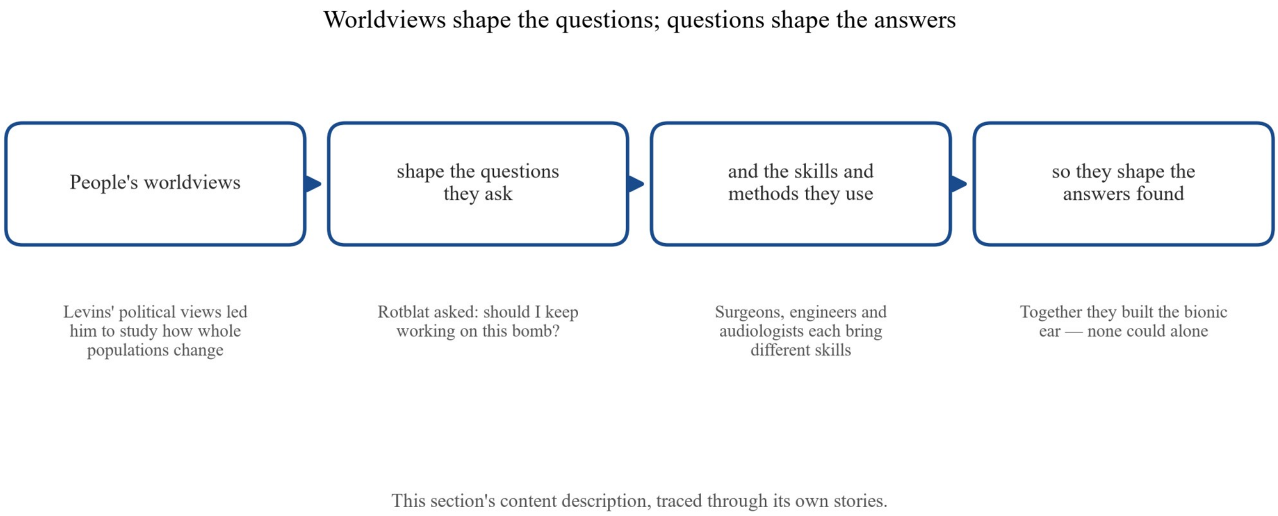
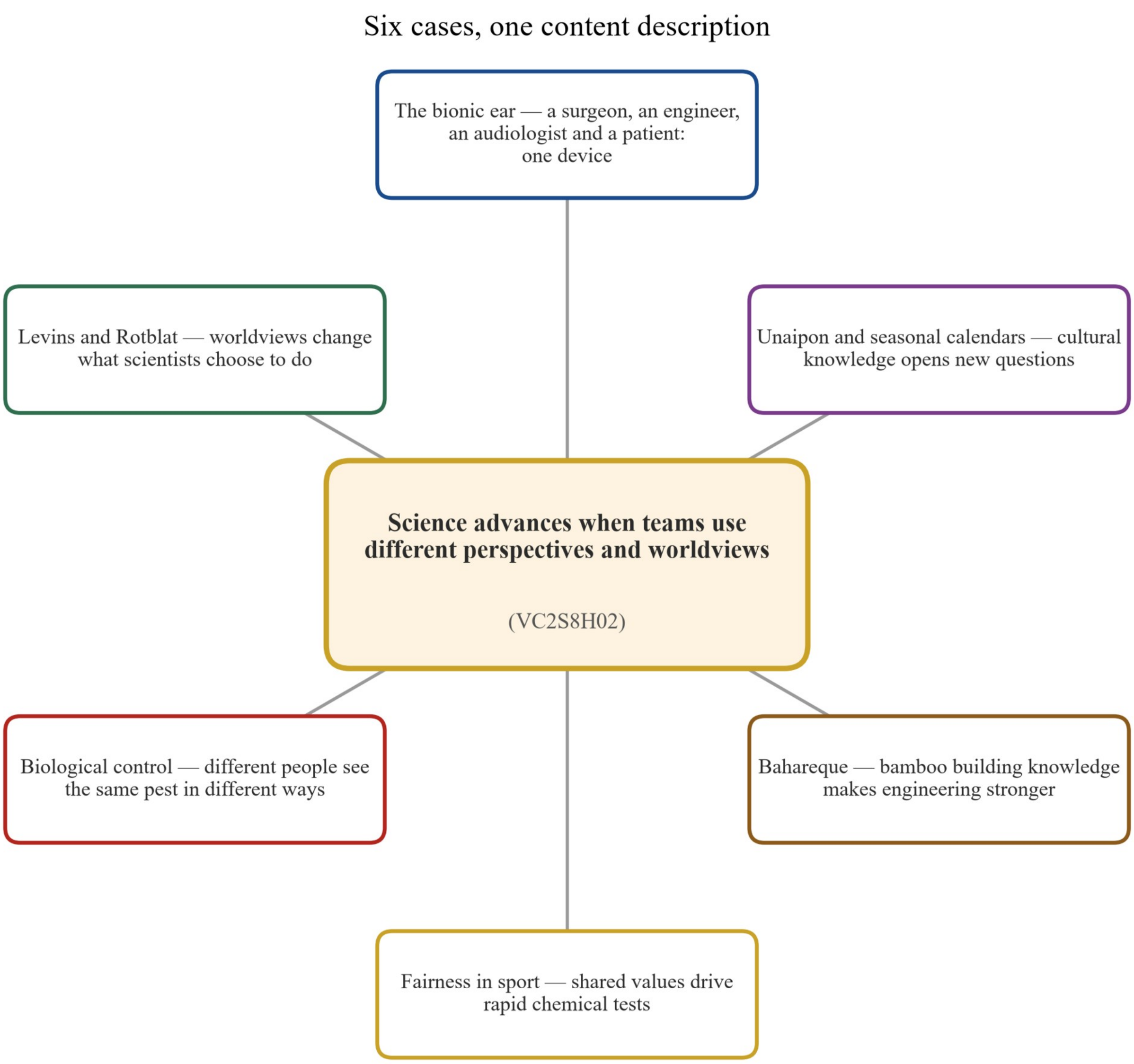
The whole picture

Pull the cases together and the content description is exactly what you see.



Flow diagram reading: people's worldviews shape the questions they ask, the questions shape the skills and methods they use, and these shape the answers found — each stage illustrated with a case from this section

People's worldviews shape the questions they ask; the questions shape the skills and methods they bring; and the answers found are the answers a team like that can find.



Concept map joining the six cases of this section — the bionic ear team, Levins and Rotblat, biological control, Unaipon and the seasonal calendars, bahareque building, and fairness in sport — to the one content description VC2S8H02

Six cases: a team that built one device; two scientists whose worldviews chose their work; one plant seen three ways; an inventor and a calendar carrying cultural knowledge into science; builders whose bamboo houses taught engineering; and a sporting world whose sense of fairness drove new chemistry. *Multidisciplinary endeavours to advance scientific knowledge make use of people's different perspectives and worldviews* — that is not only the curriculum's sentence. It is the story of every case in this section.

Worked examples

Example 1 — scaffolded

The table summarises the 1978 bionic ear team from the Theory section.

Person	What they brought
Professor Graeme Clark	surgeon-scientist; led the whole project
Dr Brian Pyman	ear surgeon; the surgeon's knowledge of the inner ear
Yit Chow Tong	researcher; how to code pitch and loudness
Audiologist	measured what the patient heard
Rod Saunders	first patient; used the ear and gave feedback

Person	What they brought

(a) Name two different kinds of knowledge the team needed besides surgery.
(b) Why was Rod Saunders, the patient, a working part of the team and not just a receiver of it?
(c) Why is the bionic ear project a multidisciplinary endeavour?

Working	Comment
(a) Any two of: engineering (coding pitch and loudness with electrical pulses); measurement of hearing (the audiologist's tests); the lived experience of hearing loss (Saunders' feedback).	Read down the "What they brought" column and pick kinds of knowledge that are not surgery.
(b) Only Saunders could report what the ear actually sounded like from the inside. His feedback told the team what to fix, so the device improved because of him.	A team can use knowledge that only a user has.
(c) It mixed several fields — surgery, anatomy, engineering, hearing measurement — and no single field could build the device alone.	Multidisciplinary means several fields of knowledge and work, one shared goal.

Example 2 — scaffolded

The table summarises three views of the one plant, *Echium plantagineum*.

Person	What they see	Why
Grazier	A weed, Patterson's curse	The plant carries poisons that build up in stock
Beekeeper	Salvation Jane	Bees make honey from its flowers
Farmer in a dry year	Feed	Its young growth is eaten when little else is green

(a) Who sees the plant as a curse, and on what evidence?
(b) Who sees it as a salvation, and on what evidence?
(c) The plant never changed. What did change, from row to row?

Working	Comment
(a) The grazier, because the plant's poisons build up in the liver of animals that eat it and stock have died after grazing on it heavily.	A curse is a harm to what the person needs — here, stock.
(b) The beekeeper (honey from the nectar) and the farmer in a dry year (young growth as feed when little else is green).	A salvation is a use that serves what the person needs.
(c) The person asking — who they are and what they need from the land. The plant is one plant; the perspective changes, so the judgement changes.	This is exactly what the elaboration's "useful plant or weed" question points at.

Example 3 — unscaffolded

Joseph Rotblat joined the Los Alamos project to build nuclear bombs in 1944 and left it late in the same year. Explain how his worldview changed the path of his science, using two dated events from his later life.

Rotblat joined the project for a reason his worldview supplied: a fear that Germany would build the bomb first. When he learned that Germany had abandoned its own bomb project in 1942, that reason vanished, and the same worldview made him leave late in 1944 because he could no longer justify the work — his beliefs decided what he would and would not put his science towards. Afterwards they chose his work positively: in 1955 he signed the Russell–Einstein Manifesto warning of the dangers of nuclear war, in 1957 he helped start the Pugwash Conferences that brought eastern and western scientists together to talk about weapons and peace, and in 1995 he shared the Nobel Peace Prize with the Pugwash movement. ∴ the same training led to bomb-building or to peace work depending on the worldview steering it — worldview chose the questions his science worked on.

Example 4 — unscaffolded

A builder says: *"Old bamboo houses are not engineering — engineering is what modern experts do."* Use the story of the *estilo temblorero* houses and one other case from this section to argue against that claim.

The claim fails on the evidence. In Manizales from the 1840s, *estilo temblorero* houses paired a rigid lower floor that took the shock with a flexible bahareque upper floor that bent and soaked up the shaking, so the houses swayed instead of snapping; people watched stiffer-styled buildings fall in earthquakes while these houses stayed standing — that is testing against observation, the heart of engineering, done by builders a century before modern earthquake codes taught the same idea. The same pattern appears with David Unaipon: his 1914 design for a vertical-lift flying machine drew the aerodynamic principles of a spinning boomerang — knowledge grown on Country — and aimed them at a new machine, so cultural knowledge supplied the engineering idea. ∴ engineering knowledge has more than one source: local builders and cultural knowledge can produce working, tested design ideas that modern engineering later confirms and adopts.

Practice questions

Scaffolded

Q1. Answer the following about the bionic ear team. (a) Who led the bionic ear project, and from which university? (b) What did the audiologist on the team do? (c) What does the team case show about who does science?

Q2. Answer the following about Levins and Rotblat. (a) State one way Richard Levins' worldview shaped his science. (b) What did Joseph Rotblat learn in 1944 that removed his reason for staying at Los Alamos? (c) What prize did Rotblat share in 1995, and with whom?

Q3. Answer the following about Patterson's curse / Salvation Jane. (a) Why does a grazier call the plant a curse? (b) Why does a beekeeper call it Salvation Jane? (c) Neither name is the one a scientist uses. Give the plant's scientific name and say why science prefers it.

Q4. Answer the following about David Unaipon. (a) What cultural knowledge did Unaipon draw on for his flight idea? (b) What did he put forward in 1914? (c) Why does his story matter for the question "who does science?"

Q5. Answer the following about the *estilo temblorero* houses. (a) Name the two floors of the house and say how each behaved in an earthquake. (b) What did people observe after earthquakes in Manizales? (c) What modern engineering idea matches the builders' design?

Q6. Answer the following about fairness in sport. (a) What event at the 1960 Rome Olympics showed how dangerous drug use in sport had become? (b) What began at the 1968 Mexico City Olympics? (c) Which agency was formed in 1999 to drive the science and the rules against doping?

Unscaffolded

Q7. "No single person could have built the 1978 bionic ear." Explain this claim using two named members of the team and the different knowledge each brought. *(2 marks)*

Q8. Patterson's curse and Salvation Jane are two names for the one plant. Explain how a single plant can carry two opposite names. *(2 marks)*

Q9. Richard Levins studied whole populations of living things rather than single organisms on their own. Explain how a worldview can shape the *questions* a scientist asks, not just the answers they find. *(2 marks)*

Q10. Compare the *Cactoblastis cactorum* moth and the cane toad as biological control agents. Explain what the pair teaches a team that must choose an agent. *(3 marks)*

Q11. Explain how cultural knowledge and new engineering met in David Unaipon's 1914 flying machine idea. *(2 marks)*

Q12. Name two of the four sciences the Gariwerd seasonal calendar informs, and for one of them, state what the calendar's knowledge adds. *(2 marks)*

Q13. An engineer is designing a house for a town in earthquake country. Using the *estilo temblorero* story, advise the engineer about rigid and flexible parts of the building. *(3 marks)*

Q14. "Who does science affects the questions asked and the answers found." Discuss this claim using two different cases from this section. *(4 marks)*

Answers

Q1. (a) Professor Graeme Clark, at the University of Melbourne. (b) Measured what the patient actually heard. (c) Big science is a team effort mixing several fields — surgery, engineering, measurement and lived experience — and no one field could do it alone. **Q2.** (a) Any one of: his beliefs about fairness led him to study farming, hunger and disease; they led him to study whole populations rather than single organisms. (b) That Germany had given up its own bomb project in 1942. (c) The Nobel Peace Prize, shared with the Pugwash movement. **Q3.** (a) The plant carries poisons that build up in the liver of stock that eat it. (b) Bees make honey from its flowers. (c) *Echium plantagineum* — the scientific name carries no point of view, so all sides can use the same name. **Q4.** (a) Knowledge of how a boomerang flies — knowledge grown on Country. (b) That a flying machine could be built on the same aerodynamic principles as a spinning boomerang, making vertical lift. (c) It shows scientific ideas can grow from cultural knowledge as well as from laboratories — who does science includes many cultures. **Q5.** (a) A rigid lower floor of packed earth that took the shock, and a flexible bamboo (bahareque) upper floor that bent and soaked up the shaking. (b) Houses built in stiffer styles fell while the *estilo temblorero* houses stayed standing. (c) A building that can bend and soak up shaking survives an earthquake. **Q6.** (a) Knud Enemark Jensen, a Danish cyclist, fell during the road race and later died, having been under the influence of a stimulant drug. (b) Mandatory drug testing. (c) The World Anti-Doping Agency (WADA). **Q7.** Any two named members with their distinct knowledge, e.g. Clark led as a surgeon-scientist while Tong worked out how electrical pulses code pitch and loudness; neither skill set includes the other, so the device needed both (and the surgeon's, the audiologist's and the patient's knowledge too). **Q8.** The names carry points of view, not just botany: "curse" records the harm to stock, "salvation" records the use (honey, or feed in dry years). One plant, different needs, opposite judgements. **Q9.** A worldview is a picture of what matters and how the world works; Levins' led him to ask "how do whole populations change and survive?" instead of "how does one organism work?" — the question itself comes from the worldview, before any data is collected. **Q10.** The moth eats almost only prickly pear and destroyed most of the infestation by 1932 — a specialist worked. The toad eats almost anything, could not reach the beetles at the tops of the cane, failed, and became a pest itself — a generalist caused harm. A team choosing an agent must weigh up how narrowly the agent feeds, and the risk if it escapes the job it was given. **Q11.** He drew the aerodynamic principles of a spinning boomerang — knowledge grown on Country over thousands of years — and applied them to a brand-new machine, a vertical-lift flying machine; cultural knowledge supplied the engineering idea. **Q12.** Any two of botany, zoology, ecology, meteorology; e.g. meteorology gains a long record of what the sky and weather do next as the seasons turn, built from many generations of observation. **Q13.** Advise a mix: a rigid part low down to take the shock and a flexible part above (like the bamboo upper floor) to bend and soak up the shaking, because the 1840s houses swayed instead of snapping and stayed standing while stiffer styles fell. **Q14.** Any two cases correctly discussed, e.g. the bionic ear (different skills at one table produce an answer none could produce alone) and Patterson's curse (whose perspective is carried decides which question science is asked — control the weed, or use the plant).

Fully-worked solutions

Q1. (a) The project was led by **Professor Graeme Clark**, a surgeon-scientist at the **University of Melbourne**. (b) The **audiologist measured what the patient actually heard** — the team needed data about real hearing, not just a working device. (c) The case shows that big science is a **team effort mixing several fields** — surgery, anatomy, engineering, hearing measurement and the patient's lived experience — and that **no single field could have built the device alone**.

Q2. (a) Levins' political beliefs about fairness for ordinary people led him to study **farming, hunger and disease**, and to study **whole populations** of living things and how they change, rather than single organisms on their own. (b) He learned that **Germany had given up its own bomb project in 1942**, so the fear that had justified his work was gone. (c) In 1995 he shared the **Nobel Peace Prize with the Pugwash movement**.

Q3. (a) The grazier calls it a curse because **the plant carries poisons that build up in the liver of stock that eat it**, and animals have sickened and died after grazing on it heavily. (b) The beekeeper calls it Salvation Jane because **bees work its flowers and make honey from the nectar**. (c) Science uses ***Echium plantagineum***: the scientific name **carries no point of view**, so a grazier, a beekeeper and a botanist all mean the same organism when they say it.

Q4. (a) Unaipon drew on **knowledge of how a boomerang flies — knowledge grown on Country** over thousands of years. (b) In 1914 he put forward the idea that **a flying machine could be built on the same aerodynamic principles**

as a spinning boomerang, making **vertical lift**. (c) His story matters because it shows that **scientific ideas can grow from cultural knowledge as well as from laboratories** — "who does science" includes people and knowledge from many cultures.

Q5. (a) The house had a **rigid lower floor of packed earth that took the shock**, and a **flexible bahareque (bamboo) upper floor that bent and soaked up the shaking**. (b) After earthquakes, people observed that **houses built in stiffer styles were destroyed while the *estilo temblorero* houses stayed standing**. (c) Modern engineering teaches the same idea: **a building that can bend and soak up shaking survives**.

Q6. (a) **Knud Enemark Jensen, a Danish cyclist, fell during the road race and later died; a coroner found he had been under the influence of a stimulant drug.** (b) **Mandatory drug testing** began at the 1968 Mexico City Olympics. (c) The **World Anti-Doping Agency (WADA)** was formed in 1999.

Q7. The claim is right because the members brought knowledge the others did not have *(1 mark)*: for example, **Clark** led as a surgeon-scientist and **Pyman** brought the surgeon's knowledge of the inner ear, while **Tong** worked out how electrical pulses carry pitch and loudness and the **audiologist** measured real hearing — surgery cannot do engineering's job and engineering cannot do surgery's, so the device needed them all *(1 mark)*.

Q8. The two names record **points of view, not just botany** *(1 mark)*: "Patterson's curse" records the harm the plant does to stock, while "Salvation Jane" records the use people get from it — honey for beekeepers, feed in dry years — so one plant carries opposite names because different people need different things from the land *(1 mark)*.

Q9. A worldview is a person's picture of how the world works and what matters in it, and it acts before any data is collected *(1 mark)*: Levins' beliefs about communities and fairness led him to ask "how do whole populations change and survive in a changing environment?" rather than "how does one organism work?", so the worldview chose the questions his mathematics and biology then had to answer *(1 mark)*.

Q10. The moth is a **specialist** — it eats almost only prickly pear — and between 1926 and 1931 its eggs were shared widely, so that **by 1932 most of the prickly pear was destroyed** *(1 mark)*. The toad is a **generalist** — it eats almost anything, the beetles live at the tops of the cane where toads cannot climb, so the toads **failed and became a serious pest themselves** *(1 mark)*. The pair teaches a choosing team to weigh up **how narrowly the agent feeds and what harm it could do if it escapes its job** — the specialist's narrow diet was the source of both successes *(1 mark)*.

Q11. Unaipon's idea joined two knowledge streams: **the aerodynamic principles of a spinning boomerang — knowledge grown on Country over thousands of years** *(1 mark)* — and **a brand-new engineering goal, a vertical-lift flying machine**, so that cultural knowledge supplied the idea that modern aerodynamics would later study *(1 mark)*.

Q12. Any two of **botany, zoology, ecology and meteorology** *(1 mark)*; e.g. for meteorology, the calendar adds **a long, multi-generational record of what the sky and weather do next as the seasons turn** — data no short instrument record can match *(1 mark)*.

Q13. Advise the engineer to **combine a rigid part with a flexible part**, as the 1840s houses did *(1 mark)*: a rigid lower floor takes the shock while **a flexible upper part (like the bamboo bahareque floor) bends and soaks up the shaking, so the building sways instead of snapping** *(1 mark)*; the advice is evidence-based, because in real earthquakes **the flexible houses stayed standing while stiffer styles were destroyed** *(1 mark)*.

Q14. The claim is supported by the cases. **Case 1 — the bionic ear**: the answer found (a working multi-channel implant) required **different skills and knowledge at one table** — surgery, engineering, hearing measurement, the patient's feedback — and the question "can hearing be restored?" only became answerable when a multidisciplinary team existed to ask it well *(2 marks)*. **Case 2 — Patterson's curse**: the question science is asked depends on **whose perspective is carried** — a grazier's view asks "how do we control this weed?" while a beekeeper's or drought-struck farmer's view asks "how do we keep and use this plant?", so the perspectives in the room choose the question and therefore the answers pursued *(2 marks)*. (Other cases — Levins/Rotblat's worldviews choosing their work, Unaipon and the calendars bringing cultural knowledge in, the bamboo builders teaching engineering, fairness driving drug tests — argue the same way.)

Sources

Web sources below were retrieved 2026-08-21 unless stated.

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The tables in Worked Examples 1 and 2 **summarise the real cases taught in the Theory section**; no simulated data is used in this section.

Elaboration contexts used: `VC2S8H02.E01` (Levins and Rotblat), `VC2S8H02.E02` (Patterson's curse as useful plant or weed), `VC2S8H02.E03` (David Unaipon's boomerang aerodynamics and 1914 flying machine), `VC2S8H02.E04` (seasonal calendars informing botany, zoology, ecology and meteorology), `VC2S8H02.E05` (bamboo houses and earthquake-resistant structures) and `VC2S8H02.E07` (fairness in sport and rapid drug tests). `VC2S8H02.E06` is not drawn on.

Teacher-facing note — ICIP delivery in E03/E04 (not student text). Under the TOC's D10 decision, Aboriginal and Torres Strait Islander content is delivered here only from named published sources. For E03, that source is the published historical record of David Unaipon (Ngarrindjeri; Point McLeay mission, South Australia; ten patents 1909–1944; the 1914 vertical-lift flying machine idea drawn from boomerang aerodynamics), summarised above under the Wikipedia source line. For E04, the source is the Bureau of Meteorology's published Gariwerd seasonal calendar — the Brambuk seasonal cycle recording Djapwurrung and Jardwadjali knowledge of Country — which the BOM states is hosted with permission: "Permission to host the Gariwerd seasonal calendar and related information is given by the Elders/Directors of Gariwerd, which include the Gunditjmara, Winda Mara (Kerrup Jamara), Goolum Goolum, Kirrae Whurrong and Framlingham peoples." Per CONTENT_POLICY rule 1, the calendar itself is the Indigenous Cultural and Intellectual Property (ICIP) of its owners and is **not reproduced or redrawn** in this section: the student text names what the calendar informs, and the figure shows the bridge to the four sciences, not the calendar.

Teacher-facing note — E06 not drawn on (not student text). `VC2S8H02.E06` (Tesla and Vivekananda) is not developed in this section: the elaborations are a context bank, not a checklist (D12), and six contexts already carry the content description. If a teacher chooses to use E06, the TOC's §6 rule binds: teach it strictly as the documented encounter between the two men, never assert a physical result of it, and keep $E = mc^2$ and all other out-of-band physics out of the discussion (D9).