Science

All written material for this subject: K-12 progression outline, then units by grade

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Proposed K–12 Science Progression (Draft Framework)

Status: written framework (not lessons); unreviewed AI draft; CC0 1.0
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> **Important:** this maps a proposed sequence of science topics. A topic listed here is **not** a written unit unless it is marked **Unit written** with a link. It is not aligned to any official standard (NGSS, the English National Curriculum, or others). A teacher should check it against their own requirements before using it.

Principles

1. **Doing before naming.** Students handle, sort, measure and grow things before they learn the technical word. For example, they watch bread go mouldy before they hear "decomposer".
2. **Spiral, not one-and-done.** Big ideas (living things, matter, energy, forces, Earth and space) come back every band at a deeper level. Each return should build on the earlier one, not repeat it.
3. **Fair tests early, numbers gradually.** From grade 3, students change one thing and keep the rest the same. Measurement, tables and graphs grow alongside the maths progression in this repository.
4. **Safety is content.** Each unit teaches why a rule exists (sealed mould bags, never tasting, eye protection), not only the rule.
5. **Honest uncertainty.** Students learn to say what their evidence does and does not show, and that scientific models are simplifications.

Strands

Strand	Short name
Living things, ecosystems and the human body	Life
Materials, matter and chemical change	Matter
Energy, forces, light, sound and electricity	Physics
Earth, weather, climate and space	Earth & space
Working scientifically (questions, fair tests, data, argument)	Inquiry (runs through every unit)

Band 1: Grades K–2 (ages 5–8) — Noticing and sorting

- **Kindergarten:** Unit written: using our senses and watching the weather. Unit written: pushes and pulls. Unit written: what living things need, growing cress and a minibeast hunt. Living vs non-living (sorting cards and real objects); the five senses as observation tools; weather each day on a class chart; pushes and pulls with toy cars.

- **Grade 1:** Unit written: what do plants need?. Unit written: sound and light (vibrations make sound; seeing needs light; materials in a beam; a signal device). Unit written: patterns in the sky (the Sun's path and moving shadows; the Moon's patterns; stars at night; less daylight in winter). Plants need light and water (growing beans in a window vs a cupboard); animal body parts and what they do; day and night, shadows; materials that bend, stretch, float or sink.
- **Grade 2:** Unit written: solids, liquids and melting ice. Unit written: land and water, fast and slow (where water is found, a model and map of land and water, erosion by water and wind, fast and slow Earth changes, comparing ways to protect land). Unit written: habitats, seeds and helpers (counting kinds of living things in different habitats, a planned cress test changing light or water, model seeds that stick to fur, a model bee carrying pollen). Habitats and simple food chains; life cycles (butterfly or frog, from pictures or a class kit); solids and liquids, melting ice; sound comes from vibration (rubber bands, drums; first met in the grade 1 sound and light unit, so grade 2 can revisit it through pitch and loudness).

Band 2: Grades 3–5 (ages 8–11) — First fair tests

- **Grade 3:** Unit written: magnets. Unit written: weather over a season. Unit written: life cycles and traits. Plant parts and seed dispersal; rocks and soils (sorting, simple scratch tests); magnets and which materials they attract; first fair test with one changed variable.
- **Grade 4:** Unit written: electric circuits. Electric circuits with bulbs, buzzers and switches (conductors vs insulators); the water cycle and evaporation; teeth, digestion and healthy eating (no tasting experiments); fossils as evidence of past life.
- **Grade 5:** Unit written: dissolving and changes that cannot be undone. Earth, Sun and Moon (models of phases and seasons); reversible vs irreversible changes (dissolving vs burning, demonstrated by an adult); classification keys for animals; forces including friction and air resistance (paper spinners, ramps).

Band 3: Grades 6–8 (ages 11–14) — Systems and evidence

- **Grade 6:**
- **Fungi and decomposition — Unit written:** units/science/6-fungi-decomposition/. What fungi are, decomposers and the nutrient cycle, a sealed bread-mould fair test, a yeast balloon test with a control, and fungi in human life.
- Cells under a microscope (onion skin, cheek-cell images); particles model of solids, liquids and gases; light travelling in straight lines, reflection.
- **Grade 7:**
- **Photosynthesis and respiration — Unit written:** units/science/7-photosynthesis-respiration/. Van Helmont's willow and the iodine starch test, floating leaf discs in light and dark, a lamp-distance fair test with a line graph, bromothymol blue tubes showing respiration day and night, and a simple carbon cycle.
- Elements, compounds and mixtures (separating salt and sand); energy stores and transfers; the rock cycle and plate tectonics.
- **Grade 8:**
- **Acids, alkalis and indicators — Unit written:** units/science/8-acids-alkalis-indicators/. A red cabbage indicator for everyday liquids, the pH scale with universal indicator and litmus, neutralisation by counting drops (a repeated comparison with medians), and neutralisation in soils, antacids and the ocean.
- Genetics basics and variation; speed, distance and time graphs; weather vs climate and the evidence for a changing climate.

Band 4: Grades 9–12 (ages 14–18) — Models, quantities and choices

- **Grade 9:** Unit written: forces and Newton's laws. Biology: cell division, DNA and inheritance; chemistry: atomic structure and the periodic table; physics: forces and Newton's laws with measured data.
- **Grade 10:** Unit written: ecology field sampling. Ecology with field sampling (quadrats, population estimates); chemical reactions, conservation of mass and balancing equations; electricity (current, voltage, resistance) with real meters.
- **Grade 11:** Unit written: rates of reaction. Evolution by natural selection and the evidence for it; rates of reaction; waves, the electromagnetic spectrum and radiation safety.
- **Grade 12:** Unit written: the extended investigation (planning, uncertainty, reporting and peer review, practised on a pendulum). Choice pathways (for example biology, chemistry, physics, Earth science, or applied science), plus an extended independent investigation with a written report and peer review.

Connections to other subjects in this repository

- **Mathematics:** fair-test tables and line graphs in grade 6 use the ratio and rate ideas in the grade 6 ratios unit (for example, mould growth in squares per day).
- **Computing:** data logging and simple simulations can link to the computing progression.

Known gaps and open questions

- Twenty-one science units are written so far (kindergarten senses and weather, kindergarten pushes and pulls, kindergarten living things and their needs, grade 1 plants, grade 1 sound and light, grade 1 patterns in the sky, grade 2 solids and liquids, grade 2 land and water, grade 2 habitats, seeds and helpers, grade 3 magnets, grade 3 weather over a season, grade 3 life cycles and traits, grade 4 circuits, grade 5 dissolving and changes, grade 6 fungi, grade 7 photosynthesis and respiration, grade 8 acids and alkalis, grade 9 forces and Newton's laws, grade 10 ecology, grade 11 rates of reaction, grade 12 extended investigation), at least one per band. Everything else is a plan.
- Topic placement is a judgement call. Many systems teach circuits, cells or the Earth–Moon system in different years.
- Practical work assumes basic classroom equipment (hand lenses, sealed bags, balloons, simple circuits; a microscope from grade 6). Schools without these will need alternatives.
- No human educator has reviewed this progression. Its status will stay "written framework" until one does.

Contributions welcome: claim a grade or topic first, following CONTRIBUTING.md.

Kindergarten Science: Using Our Senses and Watching the Weather (5 lessons, about 2 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 6 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules. Text-checked by one other agent (Gemini 4 Argon); see Known gaps.

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Big idea

Scientists find things out by noticing carefully. We notice with our senses: looking, touching, listening and smelling (and tasting, but only food a grown-up gives us). If we notice the same thing every day and write it down, such as the weather, we can start to see patterns.

This is the first science unit of the kindergarten year (term 1). It starts a class weather chart that keeps going every day for the rest of the year; the term 3 science unit comes back to it.

Outcomes

By the end of the unit a student can:

1. Describe an object (a leaf, stone or shell) using at least two words about how it looks or feels (for example colour, size, shape, rough, smooth).
2. Say which sense they used: "I saw...", "I felt...", "I heard...", "I smelled...".
3. Follow the class rule: we only taste food a grown-up has given us to eat.
4. Describe today's weather with words such as sunny, cloudy, rainy, windy, warm and cool, and add a picture card to the class weather chart.
5. Count how many sunny (or cloudy, or rainy) days the chart shows so far, and say which kind of day we have had the most of.

Prior knowledge

- None needed beyond everyday talk. Counting to 10 helps in lesson 5 (it is being learned in mathematics at the same time; count together).
- No reading is needed; the weather chart uses picture cards.

Lessons

Lessons are short (20-25 minutes). Leave a day or two between lessons. From lesson 4 on, the weather chart takes about 2 minutes every day, at the same time each day (for example straight after the register).

Lesson	Title	Main activity
1	Looking closely	Describe leaves, stones and shells by how they look

Lesson	Title	Main activity
2	Feeling and listening	Feely bag and a listening walk
3	Smelling, and the tasting rule	Smell pots; why we never taste unknown things
4	What is the weather today?	Look outside and start the class weather chart
5	What has the weather been like?	Count the chart so far; end-of-unit check

Materials (whole class unless noted)

- A "nature tray" for each table: a few leaves of different shapes and colours, smooth and rough stones (none smaller than a ping-pong ball, so nothing can be swallowed), and a few clean shells of a similar size.
- Simple hand lenses (one per pair if possible).
- A cloth bag or box with a hand hole ("feely bag") and objects with clearly different textures: a pine cone, a smooth stone, a sponge, a feather, a wooden block, a piece of fabric.
- Three to five "smell pots": small lidded pots with holes in the lid, each holding something the school has approved (for example lemon peel, an orange slice, a mint leaf, a cinnamon stick, coffee grounds). Nothing sprayed or chemical.
- A large wall chart: one row per school day, with space for a picture card. Picture cards for sunny, cloudy, rainy, windy, snowy (if it snows where you live), foggy, and "warm" / "cool" cards. Lots of copies of each.
- A ribbon or paper streamer on a stick, or a windsock, to see the wind.
- Lesson 1: a large sheet and a marker for the class "describing words" list.
- Lesson 3: picture cards of what is in each smell pot (for matching); a picture of a tongue or a mouth; four tasting-rule cards (an apple on a plate, a berry on a bush, a mushroom on the grass, a bottle with no label).
- Lesson 4: three photos of different weather for the closing check (for example a sunny beach, a rainy street, a windy day with leaves blowing).
- Lesson 5: interlocking cubes in two or three colours; small base cards with the weather picture symbols (sun, cloud, raindrop) to stand each tower on; a five-day practice chart on a large sheet (3 sunny, 1 cloudy, 1 rainy, mixed order, drawn with the picture symbols); check cards (an eye, an ear, a hand, a nose; a rainy-day photo; the four tasting-rule cards).

Assessment

- Lessons 1-3: the teacher notes each child's describing words and "I saw / I felt / I heard / I smelled" sentences during table work (observe; no writing needed).
- Lesson 4 on: children take turns choosing the weather card; note who can explain their choice ("I chose cloudy because I can't see the sun").
- Lesson 5: a 5-question picture/talk check with an answer guide. Plan an extra small-group or one-to-one slot in the week to finish per-child checks; 20-25 minutes is not enough for the whole class.

⚠ Safety (read before lesson 1)

- Check the school's allergy list before lessons 1 and 3 (plants, nuts, shellfish, citrus, spices). Leave out anything a child in the class reacts to.
- Shells and stones: wash before use; check for sharp edges. Nothing small enough to swallow.

- Leaves: use only leaves the school knows are safe to handle. Wash hands after handling natural objects.
- Smell pots: children waft the smell towards their nose with a hand; they do not put their nose in the pot, and nothing comes out of the pot.
- No tasting in this unit. Lesson 3 teaches the tasting rule instead.
- Outside: stay in a supervised area; never look at the Sun, even quickly.

Access and taking part

- Every activity can be done with more than one sense: a child who cannot see well can describe by touch and sound; a child who cannot hear well can describe by looking and touch. Describing words can be spoken, signed, or chosen from picture cards.
- Feely bag, smell pots and closing eyes are all opt-in. A child can watch, use a picture choice, or describe an object that is in front of them.
- Children who find a busy listening walk hard can listen from a quiet spot or wear ear defenders and report what they saw instead.

Sources

- Next Generation Science Standards, kindergarten "Weather and Climate" topic page, K-ESS2-1: "Use and share observations of local weather conditions to describe patterns over time." The page's clarification statement gives sunny, cloudy, rainy and warm as examples of describing the weather, counting sunny, windy and rainy days in a month as examples of counting, and "usually cooler in the morning than in the afternoon" as an example of a pattern. Its assessment boundary limits counting to whole numbers and relative words like warmer/cooler. It also defines weather as "the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time." https://www.nextgenscience.org/topic-arrangement/kweather-and-climate
- Wikipedia, "Sense" (introduction): five senses (sight, smell, touch, taste and hearing) were traditionally named in some cultures, but many more are now recognised. https://en.wikipedia.org/wiki/Sense
- Wikipedia, "Weather" (introduction): weather is day-to-day conditions; climate is the average over longer periods. https://en.wikipedia.org/wiki/Weather

Known gaps

- The order of lessons and the choice of objects are mine, not from a source.
- "Five senses" is a simplification; the unit says "senses" and names the ones children use, and lesson 3's teacher note says there are more.
- Weather words depend on where you live. Add local words (for example drizzle, frost, monsoon, haze) and leave out snow if it never snows.
- One week of chart data shows very little. The pattern talk in lesson 5 is a start; the real pattern-spotting happens in term 3, after months of data.
- Peer check: Gemini 4 Argon did a bounded text, timing and answer-key check at d18fb8c (not an educator, safety or accessibility review). Its notes (missing materials; symbol labels and low-vision routes for the cube towers, photos and charts) were fixed in the follow-up commit e8f0b52 and e1d9472 (see PEERCHECKS.md), which Argon also diff-checked the same day.

Lesson 1: Looking closely

Goal: Children describe a leaf, stone or shell using at least two words about how it looks, and say "I saw...".

Length: about 20 minutes.

Materials

- A nature tray per table (leaves, stones, shells; see the unit materials).
- Hand lenses, one per pair if possible.
- A large sheet of paper for a class "describing words" list (the teacher writes; children draw a small picture next to each word if they like).

Steps

✎ Opening (5 min)

Hold up one leaf. "I am going to be a scientist. Scientists notice things very carefully." Model: "I see that it is green. I see that it has a pointy end. I see little lines on it." Ask: "What do you notice?" Take three or four answers and write the describing words on the class list (green, pointy, lines, big, small, shiny...).

✎ Main activity: notice and describe (10 min)

1. Each pair chooses one object from their tray.
2. They look at it with their eyes, then with the hand lens.
3. Each child tells their partner two things they notice, starting "I saw...".
4. Walk round and ask: "What colour is it? Is it bigger or smaller than your hand? What shape is it? What did you see with the lens that you didn't see before?"
5. Note each child's describing words (see assessment).

✓ Discussion questions (3 min)

- "Did the hand lens help? What did it show you?" (Answer guide: accept anything they actually saw, such as tiny lines on a leaf, sparkly bits in a stone, rings on a shell.)
- "Were all the leaves the same?" (Answer guide: no; they are different colours, shapes and sizes. Praise any child who compares two objects.)

✓ Closing check (2 min)

Hold up a stone. "Tell me one thing you see." Then a shell, then a leaf. Children answer together or show a thumbs-up when they have a word. (Answer guide: any true describing word: colour, size, shape, shiny/dull, spotty, stripy.)

Vocabulary

notice, describe, colour, shape, size, hand lens, scientist

Differentiation

- Support: offer a choice ("Is it big or small? Is it green or brown?").
- Stretch: describe the object so a partner can guess which one it is without seeing it.

⚠ Safety

- Check allergies before handing out leaves (see unit safety notes).
- Hand lenses are for looking at objects; never look at the Sun through one.
- Wash hands after the lesson.

Access

- A child who cannot see well can describe by touch; words can be spoken, signed or chosen from picture cards.

Teacher notes

- Timing: 5 + 10 + 3 + 2 = 20 minutes.
- Children may want to touch too; that is fine, and lesson 2 is about touch. Today, gently steer the words towards how things look.
- Keep the describing-words list on the wall; it grows over the unit.

Lesson 2: Feeling and listening

Goal: Children describe an object by how it feels, notice sounds around them, and say "I felt..." and "I heard...".

Length: about 25 minutes.

Materials

- The feely bag with 5-6 objects of different textures (pine cone, smooth stone, sponge, feather, wooden block, fabric).
- The nature trays from lesson 1.
- The class describing-words list.

Steps

✎ Opening (3 min)

"Last time we used our eyes. Today we use our hands and our ears." Show the class list and read two words from lesson 1 together.

✎ Main activity 1: the feely bag (10 min)

1. Sit in a circle. A child who wants a turn puts a hand in the bag (no looking) and feels one object.
2. They say one word about how it feels: rough, smooth, soft, hard, spiky, bumpy, squashy. The teacher adds new words to the class list.
3. Then they guess what it is and pull it out to check.
4. Give about six turns; others can feel objects from the nature trays and pass them round, saying "I felt..." to a neighbour.

✎ Main activity 2: listening walk (8 min)

1. Walk quietly around the classroom, the corridor or a safe outside area.
2. Stop three times. Everyone stands still and listens for about 20 seconds. Children who want to can close their eyes; others look at the floor.
3. After each stop, whisper to a partner one thing you heard.

✓ Discussion questions (2 min)

- "What did you hear on our walk?" (Answer guide: accept real sounds, such as footsteps, birds, a door, cars, wind, someone talking.)

- "Which did you use to find out the pine cone was spiky, your eyes or your hands?" (Answer guide: hands, by touch; some may say eyes too, since it looks spiky. Both are fine.)

✓ Closing check (2 min)

The teacher names a sense and children point to the body part they use: "Seeing" (eyes), "Hearing" (ears), "Touching" (hands or fingers; any skin is also right).

Vocabulary

feel, touch, rough, smooth, soft, hard, hear, listen, sound

Differentiation

- Support: offer two textures to compare side by side ("Which one is soft?").
- Stretch: sort the feely objects into soft and hard, or rough and smooth.

⚠ Safety

- Check the feely-bag objects for sharp edges and anything small enough to swallow.
- Listening walk: stay together in a supervised area.

Access

- The feely bag is opt-in; a child can choose an object they can see and describe how it feels.
- Closing eyes is opt-in.
- A child who cannot hear well can report what they saw or felt on the walk (for example the floor shaking from footsteps, a door moving).

Teacher notes

- Timing: 3 + 10 + 8 + 2 + 2 = 25 minutes.

Lesson 3: Smelling, and the tasting rule

Goal: Children describe smells and say "I smelled...", and know the class rule: we only taste food a grown-up has given us to eat.

Length: about 20 minutes.

Materials

- 3-5 smell pots (school-approved contents; see the unit materials and safety notes). Number the pots; keep a list of what is in each.
- Picture cards of what is in each pot (lemon, orange, mint, cinnamon, coffee), for matching.
- A picture of a tongue or a mouth, and picture cards of: an apple on a plate, a berry on a bush, a mushroom on the grass, a bottle with no label.

Steps

✎ Opening (3 min)

"We have used our eyes, hands and ears. What else can tell us about the world?" Point to your nose. "Our noses!" Show how to smell safely: hold the pot a little away and wave the air towards your nose with your other hand. Everyone practises the "waft" with an empty hand.

✎ Main activity: smell pots (8 min)

1. Pass one pot round the circle at a time. Children who want to waft and smell; anyone can pass.
2. Ask: "Do you like this smell? Is it strong or gentle? What does it remind you of?" Collect words (sweet, strong, fresh, like a cake, like my grandma's kitchen).
3. After each pot, children guess which picture card matches. Open the pot and show what is inside.

✎ Main activity: the tasting rule (5 min)

1. "We have one more sense in our mouths: tasting. But tasting is special, because some things can make us very ill."
2. Show the four picture cards one at a time. For each, ask: "Is it safe to taste?"
3. Teach the rule and say it together: **"We only taste food a grown-up has given us to eat."**

✓ Discussion question (2 min)

- "You find a berry in the park. It looks yummy. What do you do?" (Answer guide: don't taste it; show a grown-up. Praise any version of the rule.)

✓ Closing check (2 min)

Point to body parts and ask: "What does this sense do?" Eyes (see), ears (hear), hands (touch, feel), nose (smell), mouth/tongue (taste, only food a grown-up gives us).

Answer guide: the four tasting cards

- Apple on a plate: a grown-up gave it to us to eat, so yes.
- Berry on a bush: no; ask a grown-up first.
- Mushroom on the grass: no; never taste it. Show a grown-up.
- Bottle with no label: no; never taste or drink it. Tell a grown-up.

Vocabulary

smell, nose, waft, strong, gentle, taste, tongue, safe

Differentiation

- Support: offer two words to choose from ("Is it strong or gentle?").
- Stretch: match each smell pot to its picture card without help.

⚠ Safety

- Check allergies (citrus, spices, coffee, plants) before choosing pots.
- Waft only; noses do not go into the pot. Lids stay on; contents stay in.
- No tasting in this lesson.

Access

- Smelling is opt-in. Some children dislike strong smells or have a weak sense of smell; they can match the pictures, look at what is inside, or describe how the pot looks and feels.

Teacher notes

- Timing: 3 + 8 + 5 + 2 + 2 = 20 minutes.
- "Five senses" is a simple way to start. Scientists know there are more, such as sensing balance and knowing where your arms are with your eyes closed. If a child asks, say so.
- Link the tasting rule to your school's food and medicine rules.

Lesson 4: What is the weather today?

Goal: Children use their senses to describe today's weather, and start the class weather chart that will run all year.

Length: about 25 minutes (including going outside).

Materials

- Coats as needed; a ribbon or paper streamer on a stick, or a windsock.
- The class weather chart and picture cards (sunny, cloudy, rainy, windy, snowy, foggy, warm, cool). Use local words too.

Steps

✎ Opening (3 min)

"Weather is what the sky and the air are like outside right now. We can find out the weather with our senses!" Ask: "Which senses could help?" (Answer guide: eyes to see the sky and rain, skin to feel warm or cool and the wind, ears to hear rain or wind.)

✎ Main activity 1: weather detectives outside (10 min)

1. Go outside to a safe spot (or look out of a window if the weather is bad).
2. **Look:** "Is the sky blue or grey? Can you see clouds? Is anything wet?" Remind everyone: never look at the Sun.
3. **Feel:** "Is the air warm or cool on your face and hands? Can you feel wind?"
4. **Wind check:** hold up the streamer. "Is it hanging down, or moving?"
5. **Listen:** "Can you hear rain or wind?"

✎ Main activity 2: start the chart (8 min)

1. Back inside, show the chart and the picture cards. Name each one together.
2. Ask the class: "Which cards show today's weather?" Choose one sky card (sunny, cloudy, rainy, snowy or foggy), add "windy" if the streamer moved, and "warm" or "cool".
3. A child sticks the cards on today's row. Ask them to explain: "I chose cloudy because..."

✓ Closing check (4 min)

Show three photos of different weather (for example a sunny beach, a rainy street, a windy day with leaves blowing). For each: "What is the weather? How do you know?" (Answer guide: sunny: bright, blue sky, shadows; rainy: wet, umbrellas, puddles; windy: leaves or hair blowing. Accept any sensible clue from the picture.)

Every day from now on (about 2 minutes)

At the same time each day, one or two children check the weather (window or door is fine) and add cards to the chart, saying why. Keep the chart going for the whole year; term 3 science uses it.

Vocabulary

weather, sunny, cloudy, rainy, windy, warm, cool, sky, chart

Differentiation

- Support: offer two cards to choose from.
- Stretch: "Is it the same as yesterday? What changed?"

⚠ Safety

- Never look at the Sun, even quickly or through sunglasses.
- Dress for the weather; stay in a supervised area.

Access

- Children who cannot go outside can use the window, a door, or a photo taken that morning.
- Choosing a card, pointing or signing all count as describing.
- The weather picture cards carry symbols (sun, cloud, raindrop), not only colours. For the closing-check photos, a child with low vision can hear each photo described aloud ("leaves are flying, a girl's hair is blowing") or handle real clues (a damp cloth, sunglasses, a streamer) and say which weather it shows.

Teacher notes

- Timing: 3 + 10 + 8 + 4 = 25 minutes.
- Some days are two things at once (sunny and cloudy, or rain then sun). That is fine: let children add two cards, or choose what most of the sky looks like right now.
- Weather means right now in this place. If a child talks about weather on holiday, that is a good chance to say weather is different in different places.

Lesson 5: What has the weather been like?

Goal: Children count the kinds of weather on the class chart so far, say which kind we have had most, and show what they learned about the senses.

Length: about 25 minutes. Teach it after the chart has run for at least four or five school days.

Materials

- The class weather chart.
- Interlocking cubes in two or three colours (for example yellow for sunny, white for cloudy, blue for rainy), and a base card for each tower showing the weather symbol (sun, cloud, raindrop), so the towers can be told apart without colour.
- A practice chart drawn on a large sheet (see the closing check).
- Picture cards for the check: an eye, an ear, a hand, a nose; a rainy-day photo; the four tasting cards from lesson 3.

Steps

✎ Opening (3 min)

Do today's weather cards together, as every day. "Our chart is getting long! What has the weather been like?"

✎ Main activity: count our chart (10 min)

1. Point to each day in turn. For each sunny day, a child adds a yellow cube to a tower; cloudy, a white cube; rainy, a blue cube (use the kinds of weather you have actually had). Stand each tower on its symbol card and say the weather name aloud each time a cube goes on.
2. Count each tower together, touching each cube once.
3. Stand the towers side by side. "Which tower is tallest? So which kind of day have we had most?"
4. "Do you think next week will be the same?" Accept any guess; say we will keep watching and find out.

✓ Discussion questions (4 min)

- "Is it usually cooler in the morning or in the afternoon?" (Answer guide: usually cooler in the morning. Tell the class you will feel the air at the start of the day and after lunch for a few days and add a "warm" or "cool" card each time, so they can see for themselves. Some days it will not be true, for example if it rains in the afternoon.)
- "Why do scientists write things down every day?" (Answer guide: so they remember, and so they can see patterns, such as which weather happens most.)

✓ Closing check (8 min)

Five questions. Do them in small groups or one to one where possible; plan an extra slot in the week to finish (see the unit assessment notes).

1. Show a leaf. "Tell me two things you notice about it."
2. Show the eye, ear, hand and nose cards. "Which one do you use to smell?" Then "...to hear?"
3. Show the berry-on-a-bush card. "Can you taste it? What is our rule?"
4. Show the rainy-day photo. "What is the weather? How do you know?"
5. Show the practice chart: five days, with 3 sunny, 1 cloudy and 1 rainy (mixed order). "How many sunny days? Which weather did we have most?"

Answer guide: closing check

1. Any two true describing words (colour, size, shape, rough/smooth, shiny, spotty...). 1 mark.
2. Nose for smell; ear for hear. 1 mark for both.
3. No; we only taste food a grown-up has given us to eat (any version of the rule). 1 mark.
4. Rainy; any sensible clue, such as wet ground, puddles, umbrellas, drops. 1 mark.
5. 3 sunny days; sunny is the most. 1 mark.

This is a check of understanding (5 marks), not a test to pass. Note who needs more practice and revisit during the daily chart time.

Vocabulary

count, most, fewest, pattern, chart, usually

Differentiation

- Support: count the towers with the teacher's hand guiding; compare just two towers.
- Stretch: "How many more sunny days than rainy days?"

⚠ Safety

- None beyond the usual classroom rules.

Access

- Answers can be spoken, signed, pointed to or chosen from pictures.
- Cubes can be counted by touch. Each tower stands on a symbol card (sun, cloud, raindrop), so children with colour-vision differences do not have to rely on cube colour; name the tower aloud when pointing to it.
- For a child with low vision, describe the rainy-day photo aloud ("people are holding umbrellas, the street is shiny") or hand over real clues (a damp cloth, a small umbrella), then ask "What is the weather? How do you know?" Read the practice chart aloud day by day and let the child count the cubes by touch instead.

Teacher notes

- Timing: 3 + 10 + 4 + 8 = 25 minutes.
- With only a week or two of data, the "most" kind of weather tells us about those days, not about the whole year. Keep the chart going: term 3 science looks back at months of data.
- The cube towers are an early picture graph; mathematics this term counts and compares groups too, so the two subjects support each other.

Kindergarten Science: Pushes and Pulls (5 lessons, about 2 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 4 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.

Back to the science progression

Big idea

Things only start moving, speed up, slow down, stop or change direction when something pushes or pulls them. With the same car on the same floor, a bigger push usually makes it go faster and farther. A slope gives a car a free push (the Earth pulls everything down), and rough ground slows a car down more than smooth ground does.

Outcomes

By the end of the unit a student can:

1. Show and name a push (away from you) and a pull (towards you), and sort everyday actions as push or pull.
2. Use a push or pull to make a toy car start, stop and change direction.
3. Predict, then test fairly (same car, same floor, same start line), whether a harder push makes a car go farther than a gentle push, and say what they saw.
4. Say that a car usually rolls farther down a higher ramp, and that a ball dropped from a hand always falls down.
5. Compare how far a car rolls on smooth and rough ground, and say which slowed it more.
6. Say "I think..." before trying, and "I saw..." afterwards.

Prior knowledge

- None needed beyond everyday play. Counting to 10 helps for measuring with cubes or footsteps.
- No reading is needed; recording is by stickers, drawings and class charts.

Lessons

Lessons are short (20-30 minutes) and mostly on the floor. Leave a day or two between lessons so children can play with the cars at free time.

Lesson	Title	Main activity
1	Push or pull?	Act out and sort everyday actions as push or pull
2	Start, stop, turn	Make a toy car start, stop and change direction
3	Gentle push, big push	Mark how far a car rolls after small and big pushes
4	Ramps	Roll a car down a low ramp and a high ramp
5	Smooth and bumpy	Roll a car onto smooth and rough surfaces; end-of-unit check

Materials (whole class unless noted)

- Toy cars that roll freely: one per pair, plus spares. Ideally all the same model, so results can be compared. No cars with small detachable parts.
- A large clear floor space (hall or cleared classroom), masking tape for a start line, sticky notes or beanbags as "stop markers".
- Interlocking cubes or a long paper strip for measuring distance; children can also count heel-to-toe footsteps.
- For ramps: a stiff board or a large hardback book about 60-80 cm long (or a length of plastic guttering), and a pile of large books or wooden blocks to raise it to "1 book" and "3 books" high.
- For surfaces: a piece of carpet or a rug, a towel, and a smooth floor or a large sheet of card; optionally bubble wrap or a doormat.
- A soft ball or beanbag; a door and a drawer in the classroom; a shopping bag or trolley-style toy on a string; a swing or picture of one.
- Push/pull picture cards (draw or photograph: opening a door, kicking a ball, pulling a wagon, pushing a pram, pulling a sock on, pushing a lift button, pulling a zip, pushing a swing). Two hoops or mats labelled with an arrow away (push) and an arrow towards (pull).

Assessment

- Lesson 1: sorting picture cards into push/pull hoops (observe and note).
- Lessons 3-5: each child's "I think" prediction (sticker on the class chart) and their "I saw" sentence, recorded by the teacher.
- Lesson 5: a 6-question picture/action check, 6 marks, with an answer guide (in lesson 5). It is a check of understanding, not a test to pass.

⚠ Safety (read before lesson 1)

- **Floor work:** clear the space of trip hazards; mark a "car zone" with tape so children are not walking where cars are rolling. Cars are rolled, never thrown.
- **Ramps:** keep ramps low (no higher than about 30 cm), on the floor, with the books or blocks underneath stable. Nobody stands or sits on a ramp.
- **Small parts:** check cars for loose wheels or small parts that could be a choking risk; remove damaged cars.
- **Pushing people:** we push and pull things, not each other. Paired "push/pull" movement games in lesson 1 use palms against a wall or pulling a rope/scarf gently together while sitting, never pushing a classmate.
- **Doors and drawers:** adult supervision when demonstrating; keep fingers away from hinges.
- Bubble wrap (optional) is supervised and collected afterwards; plastic is never put near faces.

Sources

All checked to load on 4 November 2026. These are teacher background; none are needed by the children.

- Wikipedia: Force (a push or a pull)

- Wikipedia: Motion
- Wikipedia: Newton's laws of motion (teacher background only)
- Wikipedia: Inertia (teacher background only)
- Wikipedia: Speed
- Wikipedia: Friction (why rough ground slows a car)
- Wikipedia: Rolling resistance (soft carpet slows rolling wheels)
- Wikipedia: Gravity (the Earth pulls things down)
- Wikipedia: Inclined plane (ramps)
- Wikipedia: Kinetic energy (teacher background only)
- Wikipedia: Toy vehicle

Known gaps and cautions

- **Labelled simplifications:** "force" is introduced only as an optional word for "a push or a pull". "Things slow down because the ground rubs on them" is the kindergarten version of friction and rolling resistance; the full idea (and that a moving object would keep going without them) comes in grades 3-5 and 6-8.
- Kindergarten comparisons are rough: a "big push" is not the same each time, so results vary. That is fine and worth talking about ("Was it a fair race?" leads into grade 3 fair tests).
- Magnets (a push or pull without touching) are left out on purpose: small magnets are a serious swallowing hazard for young children. A teacher-only demonstration with a large magnet could be added.
- No images yet; teachers will need to draw or photograph the picture cards.
- No standards alignment and no educator review.

Lesson 1: Push or pull?

Unit overview · Next: Lesson 2

Goal

Children feel and name a push (moving something away from you) and a pull (moving something towards you), and sort everyday actions into the two.

Materials

- A door and a drawer in the classroom; a toy on a string (or a small bag on a string); a soft ball.
- Push/pull picture cards (see the unit materials list), one set per group of 4, and two hoops or mats on the floor: one with an arrow pointing away (push), one with an arrow pointing towards a stick figure (pull).
- A long scarf or soft rope.

Steps

Opening (5 min). Sit in a circle. Roll the ball gently to a child and ask them to roll it back. "How did the ball start moving?" (I pushed it / I rolled it / my hand made it go.) "Could it start moving all by itself?" Collect ideas without correcting.

Main activity (15 min).

1. Demonstrate with the drawer: open it slowly. "My hand moved towards me. That is a **pull**." Close it: "My hand moved away from me. That is a **push**." Children copy with their hands in the air: pull (hands come towards chest), push (hands go out).
2. Actions game: call out actions and children mime them, then shout "push!" or "pull!": open a door, kick a ball, pull a wagon, push a swing, pull on a sock, press a button, pull up a zip, push a pram.
3. Children take turns to pull the toy on its string across the floor, and to push it back with one finger.
4. Scarf pull (sitting): two children sit facing each other, both holding the scarf, and take turns to pull it gently towards themselves. Then each child pushes their palms flat against a wall. "Which way did your hands go?"
5. In groups of 4, sort the picture cards into the push hoop and the pull hoop. Walk round and ask "How do you know?"

Discussion questions (with example answers).

- How can you tell a push from a pull? A push moves it away from me; a pull moves it towards me.
- Can you open a door with a push and with a pull? Yes, it depends which side you are on.
- What happens if nobody pushes or pulls the ball? It stays still.

Closing check (5 min, with answers). Show three cards one at a time; children show "push hands" or "pull hands": kicking a ball (push), pulling a wagon (pull), pressing a lift button (push).

Vocabulary

push, pull, move, away, towards; optional: force ("a push or a pull")

Differentiation

- Support: sort only 4 cards, with the teacher acting each one out first.
- Stretch: find a card that could be both (a swing: pull it back, then push it); find three pushes and three pulls in the classroom.

⚠ Safety

We push and pull things, not people. Scarf pulls are gentle and sitting down; no tug-of-war. Supervise door demonstrations and keep fingers away from hinges.

Teacher notes and misconceptions

- Some cards are honestly both (a swing, a zip that goes up and down); accept either answer with a good reason. Put "both" cards on the line between hoops.
- Children often think only people and animals can push or pull. Lesson 4 (the Earth pulls things down) and the wind blowing leaves are good later examples.
- Avoid saying "push is strong, pull is weak": either can be big or small.

Lesson 2: Start, stop, turn

Unit overview · Previous: Lesson 1 · Next: Lesson 3

Goal

Children use pushes and pulls to make a toy car start moving, stop, and change direction, and learn that a still car does not start on its own.

Materials

- One toy car per pair, plus spares; a clear floor space with a taped "car zone".
- Masking tape to make a simple road with one bend; two sticky notes per pair ("start" and "stop" spots).

Steps

Opening (5 min). Put a car on the floor and wait silently for 10 seconds. "Why isn't it moving?" (Nobody pushed it.) "What could we do?" A child gives it a push.

Main activity (15 min). In pairs on the floor:

1. **Start:** one child pushes the car gently to their partner.
2. **Stop:** the partner stops it with a flat hand. "What did your hand do?" (Pushed against it / blocked it.)
3. **Turn:** the car rolls past; the partner gives it a little push from the side so it changes direction. Try to make it go round a sticky note.
4. **Road challenge:** push the car along the taped road and round the bend, using as few pushes as possible. Count the pushes.
5. Swap roles and repeat.

Discussion questions (with example answers).

- What made the car start? A push from my hand.
- What made it stop? My hand pushed back; it bumped into the wall; it slowed down on its own (accept; lesson 5 explores this).
- How did you make it turn? I pushed it from the side.
- Can a car start moving all by itself on a flat floor? No, something has to push or pull it.

Closing check (5 min, with answers). "Show me with your car": make it start (a push), stop (a hand in the way), turn (a push from the side).

Vocabulary

start, stop, turn, direction, faster, slower

Differentiation

- Support: work with an adult; use a larger car and a wide road.

- Stretch: make the car go round two sticky notes in a zigzag; can you make it go backwards with a pull?

⚠ Safety

Cars stay in the taped car zone and are rolled, never thrown. Children sit or kneel; nobody walks through a "road" while cars are rolling.

Teacher notes and misconceptions

- Children may say the car stopped "because it got tired" or "ran out of push". Accept for now and come back to it in lesson 5 (the floor rubbing on it slows it down).
- Pushing from the side to change direction is harder than it looks; let children play.

Lesson 3: Gentle push, big push

Unit overview · Previous: Lesson 2 · Next: Lesson 4

Goal

Children predict whether a bigger push makes a toy car go faster and farther, test it fairly (same car, same floor, same start line), and practise measuring "how far" with cubes or footsteps.

Materials

- One toy car per group of 3 (the same model if possible); a taped start line.
- Sticky notes in two colours per group (e.g. yellow = gentle push, blue = big push) to mark where the car stops.
- Interlocking cubes or heel-to-toe footsteps for measuring.
- Class chart with two columns, "gentle push" and "big push", and a sticker per child for the prediction.

Steps

Opening (5 min). Show a car at the start line. "If I give it a tiny, gentle push, and then a big push, which time will it go farther?" Each child puts a sticker on the chart under their guess ("I think...").

Main activity (15-20 min). In groups of 3 (pusher, marker, measurer):

1. The pusher holds the car with its back wheels on the start line and gives a **gentle** push (one finger, a little tap). The marker puts a yellow sticky note where the car stops.
2. Back to the start line; a **big** push (whole hand, a firm shove, still staying on the floor). Blue sticky note where it stops.
3. The measurer counts footsteps (or lays cubes) from the start line to each sticky note.
4. Swap roles; each child does one gentle and one big push.
5. Back on the carpet, look at the sticky notes on the floor together. Where are most of the yellows? Most of the blues?

Discussion questions (with example answers).

- Which push made the car go farther? Usually the big push. If not, ask what was different (a swerve, a bump, a different spot on the floor).
- Which push made it go faster? Ask what they saw; usually the big push looks faster, but accept what they actually observed.
- Was your prediction right? Children say "I thought... I saw...".
- Did every big push go exactly the same distance? No, because people push differently each time, and some cars are wobbly. Is that a fair race?

Closing check (5 min, with answers). "I want the car to reach the bookshelf. Gentle push or big push?" (Big push.) "I want it to stop before the line, near me. Gentle or big?" (Gentle.)

Vocabulary

gentle, big (hard), far, farther, near, fast, faster, measure

Differentiation

- Support: measure with a long paper strip and a crayon mark instead of counting.
- Stretch: try a "medium" push and predict where it will stop before trying; count cubes and say how many more for the big push.

⚠ Safety

Big pushes stay on the floor; cars are never thrown or flicked into the air. Keep the area in front of the start line clear of people.

Teacher notes and misconceptions

- Results will be mostly, not always, as expected: a gentle push can travel far on a very smooth floor, and a big push can make a car swerve into a wall. Talk about this honestly instead of hiding the "wrong" result.
- Kindergarten version: "with the same car on the same floor, a bigger push usually makes it go faster, and a faster car goes farther before it stops." Kinetic energy and speed are teacher background only.

Lesson 4: Ramps

Unit overview · Previous: Lesson 3 · Next: Lesson 5

Goal

Children see that a car let go at the top of a slope starts moving without anyone pushing it, because the Earth pulls everything down, and that a higher ramp makes it roll farther.

Materials

- A stiff board, a large hardback book, or plastic guttering, about 60-80 cm long, on the floor.
- Large books or wooden blocks to raise one end: "1 book" high and "3 books" high (keep the top below about 30 cm).
- One toy car; sticky notes in two colours; cubes or footsteps for measuring.
- A soft ball or beanbag.
- Class chart with two columns, "low ramp" and "high ramp", and stickers.

Steps

Opening (5 min). Hold a beanbag up high and let go. "Did I push it down?" (No.) "Then why did it go down?" Collect ideas. Explain: "The Earth pulls everything down towards it, all the time. That is why things fall when you let go." Try letting go of the beanbag sideways: it still ends up on the floor.

Main activity (15-20 min). Whole class around one or two ramps, children taking turns:

1. Put the car at the top of the low ramp (1 book) and **let go** without pushing. "Why did it move?" (The Earth pulled it down the slope.) Mark where it stops with a yellow sticky note.
2. Predict: "If we make the ramp higher, will the car go farther, less far, or the same?" Stickers on the chart.
3. Raise the ramp to 3 books. Same car, same starting spot, let go without pushing. Mark with a blue sticky note.
4. Do each ramp height three times, with a different child letting go each time. Measure to each note with footsteps or cubes.
5. Look at where the yellow and blue notes are.

Discussion questions (with example answers).

- Did anyone push the car on the ramp? No; we just let go.
- What pulled it? The Earth pulled it down the slope.
- Which ramp made it go farther? The high ramp.
- Why did we let go instead of pushing? So every go was the same and we could compare only the ramp (a first taste of a fair test).

Closing check (5 min, with answers). "If I let go of a ball, which way will it go?" (Down.) "I want the car to roll as far as the door. Low ramp or high ramp?" (High ramp.)

Vocabulary

ramp, slope, high, low, let go, fall, down; optional: gravity ("the Earth's pull")

Differentiation

- Support: compare only the two ramp heights once each, with an adult measuring.
- Stretch: try 2 books and predict where the car will stop; try a different car and see if it behaves the same.

⚠ Safety

Ramps stay on the floor and low (below about 30 cm); books or blocks under them must be stable. Nobody stands or sits on a ramp. Children wait their turn outside the car zone.

Teacher notes and misconceptions

- A very steep ramp can make cars crash at the bottom and go less far; keep heights modest so the pattern is clear.
- Children often think heavy things are pulled down and light things are not (a balloon or feather "floats"). Air slows light things; it is fine to say "the air gets in the way of the feather" without more detail.
- "Gravity" is optional at this age; "the Earth pulls things down" is the idea that matters.

Lesson 5: Smooth and bumpy

Unit overview · Previous: Lesson 4

Goal

Children compare how far a car rolls on smooth and rough surfaces, notice that rough ground slows a car down more, and show what they have learned in a short picture/action check.

Materials

- The low ramp from lesson 4 (1 book high), so every run starts the same way.
- Three surfaces laid at the bottom of the ramp, one at a time: a smooth floor or a large sheet of card, a piece of carpet or a rug, and a towel. Optional fourth: bubble wrap or a doormat.
- One toy car; sticky notes; cubes or footsteps.
- Class chart with one column per surface and a picture of each.
- For the check: the push/pull picture cards, a car, a ramp, and a check sheet for the teacher (one line per child, 6 boxes to tick).

Steps

Opening (5 min). Children rub their hands on the carpet, then on the smooth floor or a table. "Which feels bumpy and rough? Which is smooth?" Predict with stickers: "On which one will the car roll farthest?"

Main activity (15 min).

1. Lay the smooth surface at the bottom of the ramp. Let the car go from the top (no push). Mark where it stops; measure.
2. Repeat with the carpet, then the towel, keeping the same car, the same ramp and the same starting spot.
3. Do each surface twice. Put a sticky note on the chart showing the distance (e.g. a strip of cubes taped to the chart).
4. Look at the chart. Which surface let the car go farthest? Which stopped it soonest?

Discussion questions (with example answers).

- Which surface let the car roll farthest? The smooth floor.
- Which slowed it down the most? The towel (or carpet): it is bumpy and soft, and it rubs on the wheels.
- Remember lesson 2: why did your car slow down and stop on its own? The floor rubs on it and slows it down.
- Where would you want a smooth floor? A rough floor? Smooth for a race track or a slide; rough for a path where you do not want to slip.

End-of-unit check (10 min, 6 marks). Do this in small groups or one to one while the class plays. Children answer by pointing, acting or saying. One mark each.

1. Show the card of a child pulling a wagon. "Push or pull?" **Answer:** pull.
2. Show the card of a foot kicking a ball. "Push or pull?" **Answer:** push.

3. "Show me how to make this car stop." **Answer:** puts a hand (or object) in the way / pushes against it.
4. "I want this car to go a long way. Gentle push or big push?" **Answer:** big push.
5. Show the low and high ramp (or a picture). "Which will make the car roll farther?" **Answer:** the high ramp.
6. Show the smooth floor and the towel. "Which will slow the car down more?" **Answer:** the towel (the rough/bumpy one).

Record a tick for each answer; note any explanations a child gives ("because the Earth pulls it", "the towel rubs it"), which are worth more than the tick. This check shows what to revisit; it has no pass mark.

Vocabulary

smooth, rough, bumpy, slow down, rub; optional: friction ("rubbing that slows things down")

Differentiation

- Support: compare just two surfaces (smooth floor and towel).
- Stretch: predict where bubble wrap or a doormat would go on the chart before trying it; invent a "slowest track" from classroom materials.

⚠ Safety

Ramps stay low and on the floor. Towels and rugs lie flat so nobody trips. Bubble wrap (if used) is supervised, kept away from faces, and collected afterwards.

Teacher notes and misconceptions

- Soft surfaces like carpet slow wheels partly by squashing under them (rolling resistance) as well as rubbing (friction). "The rough floor rubs and squashes, which slows the car" is enough at this age.
- Many children (and adults) think a moving thing stops "because the push runs out". The better idea, for later grades, is that it would keep going if nothing slowed it; rubbing and squashing are what stop it. You can hint: "On the smoothest floor it went farthest. What if the floor were even smoother, like ice?"
- If results come out unexpected (a car swerves off the towel), repeat it and talk about why.

Kindergarten Science: What Living Things Need, Growing Cress and a Minibeast Hunt (5 lessons, about 3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 6 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.
>
> Text-checked by one other agent (GPT-6.1 Terra); see Known gaps.

Back to the science progression | Kindergarten year plan

Big idea

Plants and animals (including people) are living things, and they need some things to stay alive. All living things need water. Animals need food. Plants do not eat food the way animals do, but they need light. Animals usually live in places where they can find what they need.

This is the last science unit of the kindergarten year (term 3). It uses the looking and describing skills from term 1, and it ends by looking back at the class weather chart that has run since term 1.

Outcomes

By the end of the unit a student can:

1. Say that all living things need water, and that animals need food.
2. Say that plants need light, and describe what happened to the class cress kept in the dark (usually pale, yellow and floppy).
3. Help plant seeds and care for them, and say what we meant to change and what we tried to keep the same in our "light and dark" pots.
4. Find and describe small animals outdoors without hurting them, and say where they were found (for example under a log, in the grass).
5. Match an animal to a place where it can find what it needs, and give one reason ("The duck lives at the pond because it can swim and find food there").
6. Count the weather chart for a month and say which kind of weather happened most.

Prior knowledge

- Term 1 science: describing words, using the senses, the tasting rule, the daily weather chart.
- Term 2 mathematics: counting to 20 and comparing groups (helps in lesson 5).
- No reading is needed; everything uses pictures, real objects and talk.

Lessons

Lessons are 20-25 minutes. The cress needs time to grow, so spread the unit over about three weeks: teach lessons 1 and 2 in the first week, lesson 3 a few days later, lesson 4 about a week

after planting and lesson 5 about two weeks after planting. Children water the pots and check them for a minute or two on most days, next to the daily weather chart.

Lesson	Title	Main activity
1	Is it alive? What does it need?	Sort picture cards; what do a dog, a child and a plant need?
2	Planting cress: light and dark	Plant cress in pots; one pot goes in a dark cupboard
3	Minibeast hunt	Look for small animals outdoors, gently, and put everything back
4	Where do animals live?	Place animal cards on a picture map; check the cress
5	What did we find out?	Compare the cress pots; count the weather chart; end-of-unit check

Materials (whole class unless noted)

- Picture cards: a dog, a cat, a fish, a bird, a child, a tree, a flower, grass; plus non-living things such as a rock, a toy car, a spoon and a ball. Picture cards of water, food (a bowl of pet food, an apple), sunlight.
- Garden cress seeds (one packet is plenty), clean small pots or yoghurt pots with a hole poked in the base, cotton wool or kitchen paper, a tray, a small watering can or spray bottle, sticky labels.
- A cupboard or a large box that keeps out light.
- For the minibeast hunt: one magnifier per pair if possible, a few clear pots with air holes and lids for looking (teacher or adult handles these), a soft paintbrush for gently moving an animal into a pot, gloves for adults, and a picture sheet of animals you are likely to find locally (worms, woodlice, snails, spiders, ants, beetles).
- A large picture map (drawn or printed) with four places: a pond, a wood, a meadow (grass and flowers) and a garden or park. Animal picture cards to place on it: a duck, a frog, a fish, a deer, a squirrel, a woodlouse, a worm, a bee, a rabbit (change these to local animals).
- The class weather chart and coloured cubes (as in term 1, lesson 5), and a practice chart for the closing check (see lesson 5). Check cards: a log and a dry sunny path (plus cards already listed above).

Assessment

- Lessons 1-4: the teacher notes each child's answers to "What does it need?" and "Where did you find it?" during the activities (observe; no writing needed).
- Lesson 5: a 5-question picture/talk check with an answer guide. Plan an extra small-group or one-to-one slot in the week to finish per-child checks; 25 minutes is not enough for the whole class.

⚠ Safety (read before lesson 1)

- Check the school's allergy list before lessons 2-4 (plants, seeds, soil, insect stings). Leave out anything a child in the class reacts to.
- Cress is an edible plant, but this unit does not taste it. The term 1 rule holds: we only taste food a grown-up has given us to eat. Seeds and seedlings stay in their pots.
- Do not use dried beans for planting: some raw beans are harmful if eaten. Cress seeds are small, so the teacher shakes them onto the pots.

- Minibeast hunt: stay in a supervised area that an adult has checked first. Children look but do not pick up animals; an adult moves an animal into a viewing pot with a paintbrush if needed. Children do not touch spiders, bees, wasps, ants' nests, caterpillars with hairs, or anything that might sting or bite. Adults lift logs and stones, away from the children, and put them back the way they were.
- Everyone washes hands after handling soil, plants or anything from outside.
- Animal care: animals go back where they were found within a few minutes. Nothing is taken indoors to keep.

Access and taking part

- Every activity can be done by looking, touching (where safe) or listening. Answers can be spoken, signed, pointed to or chosen from picture cards.
- The minibeast hunt is opt-in: some children dislike or fear small animals. They can be the "recorder" who marks the picture sheet, or look at the viewing pot from a distance.
- Children who use wheelchairs or walking aids: choose hunt spots on paths or at a raised planter, or bring a tray of leaf litter to an outdoor table.
- Families keep different pets, or none, and some families do not keep animals for reasons of belief or health. Ask about animals in general, not about each child's home.

Sources

- Next Generation Science Standards, K-LS1-1: "Use observations to describe patterns of what plants and animals (including humans) need to survive." The clarification statement gives as examples "that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water." The page's core idea reads "All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow." https://www.nextgenscience.org/pe/k-ls1-1-molecules-organisms-structures-and-processes
- Next Generation Science Standards, K-ESS3-1: "Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live." The clarification statement's examples are "that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows." The page lists drawings, dioramas and dramatization among models at this age. https://www.nextgenscience.org/pe/k-ess3-1-earth-and-human-activity
- Wikipedia, "Etiolation" (introduction): plants grown with little or no light have "long, weak stems; smaller leaves" and "a pale yellow color". https://en.wikipedia.org/wiki/Etiolation
- Wikipedia, "Garden cress" (introduction): cress is "a fast-growing, edible herb". https://en.wikipedia.org/wiki/Garden_cress
- Wikipedia, "Woodlouse" (introduction): woodlice are often found in old wood, are not insects, and some roll up to protect themselves or to keep moisture in. https://en.wikipedia.org/wiki/Woodlouse

Known gaps

- The order of lessons, the choice of cress and the animals on the picture map are mine, not from a source.
- The light-and-dark cress pots aim to change one thing and keep the rest the same (a cupboard may also be warmer or cooler), and with only two pots the result is a class

observation, not a proof. Results vary; the lessons ask children to describe what they actually saw.

- "Plants do not eat food" is a kindergarten simplification: plants make their own food using light. Later grades (grade 7 photosynthesis) explain this.
- Which minibeasts you find depends on place and season. Teach lesson 3 in mild, damp weather if you can; if nothing turns up, use a tray of leaf litter on an outdoor table (tipped back afterwards) and the picture sheet.
- The light and dark pots are a simple comparison, not a full fair test (a cupboard can differ in warmth too), and one month of the weather chart says nothing about what the weather is always like.
- How fast cress sprouts and how dark-grown cress looks back in the light come from general growing experience, not from a source I read; the lessons ask children to report what they actually saw.
- Peer check: GPT-6.1 Terra did a bounded text check of the README and lessons 1-5 at a63f5e2 on 6 November 2026 (recorded in PEERCHECKS.md); fixes are in ee02851. Terra diff-checked a63f5e2 to ee02851 and asked for "intended" wording in lesson 2 and the outcomes; that follow-up is in commit 8bf7eea, which Terra also diff-checked. Not an educator, classroom, safety or standards review.

Lesson 1: Is it alive? What does it need?

Goal: Children sort pictures into living and not living, and say what living things need: all need water, animals need food, plants need light.

Length: about 20 minutes.

Materials

- Picture cards: dog, cat, fish, bird, child, tree, flower, grass; rock, toy car, spoon, ball.
- Picture cards of water, food (pet food, an apple) and sunlight.
- Two hoops or mats on the floor, labelled with a picture of a growing plant and a picture of a rock.
- A real potted plant, if the class has one.

Steps

✎ Opening (3 min)

Show the real plant (or a tree picture) and a toy car. "One of these is alive. Which one? How can you tell?" Accept ideas: it grows, it needs water, it was a seed once. Living things grow and need things to stay alive.

✎ Main activity: sort and ask "What does it need?" (10 min)

1. Hand out the picture cards. Children take turns putting a card in the "living" hoop or the "not living" hoop and saying why.
2. If a card is tricky (a toy car moves, but is it alive?), talk about it: it moves only when someone pushes it or a battery makes it go; it does not grow or eat or drink.
3. Hold up the dog card. "What does a dog need to stay alive?" Children place the water and food cards next to it. Do the same with the child card.
4. Hold up the tree card. "Does a tree eat a bowl of food?" (No.) "What does it need?" Place the water card and the sunlight card next to it.

✓ Discussion questions (4 min)

- "What do ALL the living things need?" (Answer guide: water.)
- "What do animals need that plants don't?" (Answer guide: food to eat. Plants need light instead.)
- "Do all animals eat the same food?" (Answer guide: no; for example a cat eats meat or cat food, a rabbit eats plants, a bird might eat seeds or worms.)

✓ Closing check (3 min)

Show a fish card and a rock card. "Which is alive? What does it need?" (Answer guide: the fish; water and food.) Then show a flower card. "What does a flower need?" (Answer guide: water and light.)

Vocabulary

alive, living, not living, need, water, food, light

Differentiation

- Support: sort only four cards (dog, tree, rock, spoon).
- Stretch: "Does a seed look alive? Is it?" (It is alive but resting; we will plant some next lesson and see.)

⚠ Safety

- None beyond the usual classroom rules.

Access

- Children can point to a hoop, push a card, sign or say their answer.
- Ask what animals in general need, not what each child's pet eats; not every family has pets.

Teacher notes

- Timing: 3 + 10 + 4 + 3 = 20 minutes.
- "Plants don't eat food" follows the standard's own example; plants make their own food using light, which comes much later (grade 7).
- Children often say that clouds, fire or the Sun are alive because they move or change. That is a normal idea at this age; ask "Does it eat or drink? Does it grow from a baby?" and leave it there.

Lesson 2: Planting cress: light and dark

Goal: Children plant cress, and set up two pots that we try to keep the same except for one thing we change on purpose: one gets light, one is kept in the dark.

Length: about 25 minutes.

Materials

- Garden cress seeds; small pots with a hole in the base; cotton wool or kitchen paper; a tray to stand the pots on; a small watering can or spray bottle; sticky labels.
- One pot per small group, plus two "class test" pots.
- A cupboard or a large box that keeps out light.
- The sunlight and water picture cards from lesson 1.

Steps

✎ Opening (3 min)

Show the sunlight and water cards. "Last time we said plants need water and light. Can we find out if that is true?" Show the cress seed packet and a few seeds on a dark plate. "These are tiny seeds. They are alive, but resting."

✎ Main activity: plant the cress (14 min)

1. Each group fills its pot with damp cotton wool (pressed down, not soaking). The teacher shakes a pinch of seeds onto each pot.
2. Groups put a name label on their pot and stand it on the tray by a window (not in strong direct sun that could dry it out).
3. The class test: the teacher prepares two more pots in front of the children, the same way: same cotton wool, same amount of water, the same pinch of seeds. Label one "light" (a sun picture) and one "dark" (a moon picture).
4. "What is the same about these two pots?" (Same seeds, same cotton wool, same water.) "We will change one thing on purpose." The "light" pot goes on the tray with the others. The "dark" pot goes in the cupboard or box.
5. "What do you think will happen to each pot?" Draw or write the class's guesses on a sheet next to the tray. Accept every guess.

✓ Discussion questions (4 min)

- "Why do the two class pots have the same seeds and the same water?" (Answer guide: so that light is the one thing we change on purpose. The cupboard might also be a little warmer or cooler, so afterwards we say what we saw, not that we have proved it.)

- "How will we keep them both watered the same?" (Answer guide: water them at the same time with the same amount; the dark pot comes out only for a quick check and goes straight back.)

✓ Closing check (4 min)

Hold up the two class pots. "Which one will get light? Which one will be in the dark? What is the one thing we are changing on purpose?" (Answer guide: the sun-label pot gets light; the moon-label pot is in the dark; we meant to change the light and keep everything else the same.)

Vocabulary

seed, plant, grow, light, dark, same, different, guess

Differentiation

- Support: one adult per group for pressing cotton wool and labelling.
- Stretch: "What else could we change in a test? What would we keep the same?" (For example water and no water; keep the light the same.)

⚠ Safety

- Check the allergy list before handling seeds. Wash hands after planting.
- Seeds stay in the pots; we do not taste cress or seeds (term 1 tasting rule).
- Do not use dried beans: some raw beans are harmful if eaten.

Access

- Children who do not want to touch damp cotton wool can label pots, hold the tray or choose where the pot goes.
- Guesses can be spoken, signed, drawn or shown by pointing to a picture of a tall plant or a small plant.

Teacher notes

- Timing: 3 + 14 + 4 + 4 = 25 minutes.
- Cress seeds usually start to sprout within a few days in a warm room, with or without light. The difference shows over the next week or so: cress in the dark usually grows pale or yellow, tall and floppy, while cress in the light is green. This is called etiolation. Do not tell the children beforehand; let them see it.
- This is a simple comparison with light as the intended change, not a full fair test: a cupboard can also differ in warmth or air, and two pots cannot show what all plants need. Report what the class actually saw.
- Water both class pots daily, at the same time and with the same amount. Keep checks of the dark pot short.

- Plant one or two spare pots in case a pot dries out or gets knocked over.

Lesson 3: Minibeast hunt

Goal: Children look carefully for small animals outdoors, describe them, say where they found them, and put everything back the way it was.

Length: about 25 minutes (including getting outside and back).

Materials

- One magnifier per pair if possible.
- A few clear viewing pots with air holes and lids, and a soft paintbrush (adults only).
- The picture sheet of likely minibeasts (worms, woodlice, snails, spiders, ants, beetles; change to suit your area), one per group, and a crayon.
- Gloves for adults.
- A shallow tray for leaf litter, in case nothing turns up: an adult fills it outdoors that day, children look at it on an outdoor table or bench, and the adult tips it back where it came from before the end of the lesson.

Before the lesson

An adult checks the hunt area that day: no broken glass, no wasps' or ants' nests, no plants that sting or are poisonous. Choose a few logs, stones or plant pots that adults can lift safely.

Steps

✎ Opening (3 min, indoors)

"Today we are scientists looking for small animals, called minibeasts. Our three rules: we look, we don't grab; we move slowly and quietly; we put everything back the way it was." Children say the rules back with actions (eyes, slow hands, putting a log back).

✎ Main activity: the hunt (15 min, outdoors)

1. In small groups with an adult, children look in the grass, on walls, on leaves and in leaf litter, using the magnifiers.
2. An adult lifts a log or stone slowly, away from the children, so they can look underneath. After a short look, the adult puts it back the way it was.
3. If children want a closer look, an adult moves the animal into a viewing pot with the paintbrush. Children look through the side, describe it ("It has lots of legs", "It is curled up"), then the adult puts it back where it was found.
4. Groups mark each kind of animal they see on the picture sheet, and draw a quick symbol for where: under a log, in the grass, on a leaf, on a wall.

✓ Discussion questions (4 min, back indoors after washing hands)

- "Where did we find animals? Which places had animals on our sheets?" (Answer guide: whatever the class found, using the "where" symbols. Often it is under logs and stones, where it is dark and damp. The sheet records kinds, not numbers, so do not ask which place had the most.)
- "Why do you think woodlice (or worms) live under logs?" (Answer guide: accept sensible ideas: it is damp there, it is dark and hidden, there are old leaves and wood to eat. Woodlice eat dead leaves and old wood, and they dry out easily.)

✓ Closing check (3 min)

Show the picture sheet. Each group says one animal they found and where they found it. (Answer guide: any true pairing from their sheet, such as "a worm, in the soil under a stone". If a group found none, "we found none, and we looked under the log" is a true answer.)

Vocabulary

minibeast, under, damp, dark, careful, find, describe

Differentiation

- Support: an adult points to one place at a time; children look and say "yes" or "no" for each animal on the picture sheet.
- Stretch: count how many legs (or count how many of one kind you found) and compare with another group.

⚠ Safety

- Stay in the checked area, in sight of an adult.
- Children do not pick up animals or touch spiders, bees, wasps, ants' nests or hairy caterpillars. Adults lift logs and stones away from the children and put them back gently.
- Everyone washes hands straight after the hunt.
- Check the allergy list for insect stings; a child with a sting allergy stays close to an adult who knows their plan.

Access

- The hunt is opt-in. A child who does not want to be near small animals can be the group's recorder, marking the sheet, or look at a viewing pot from a distance.
- Children using wheelchairs or walking aids: choose spots on paths, at a raised planter, or bring the leaf-litter tray to an outdoor table.
- Children who find being outside busy or noisy can use ear defenders or work at the leaf-litter tray at a quieter outdoor spot with an adult, or look at the picture sheet and photos of minibeasts indoors.

Teacher notes

- Timing: 3 + 15 + 4 + 3 = 25 minutes. Allow extra time for coats and handwashing if needed.
- If it is cold or dry and nothing turns up, use the leaf-litter tray outdoors and the picture sheet; the litter goes back where it came from. Say honestly that the animals may be hiding today; that is a true finding too.
- Woodlice are not insects, even though people often call them bugs. Children do not need this, but it is a fun fact if asked.

Lesson 4: Where do animals live?

Goal: Children use a picture map to show that animals live in places where they can find what they need, and they check the class cress.

Length: about 20 minutes. Teach it about a week after planting.

Materials

- The large picture map with a pond, a wood, a meadow and a garden or park.
- Animal picture cards: duck, frog, fish, deer, squirrel, woodlouse, worm, bee, rabbit (change to local animals).
- The class cress pots ("light" and "dark") and the guesses sheet from lesson 2.

Steps

✎ Opening (3 min): check the cress

Bring out both class pots. "What do you notice? Is anything growing? Is it the same in both pots?" Children describe what they see: colour, height, standing up or floppy. Record a quick drawing next to the guesses. Put the dark pot straight back.

✎ Main activity: animals on the map (10 min)

1. Show the picture map. Name each place together: pond, wood, meadow, garden.
2. Hold up the duck card. "Where does a duck find what it needs? What does it need?" (Water to swim in and food in the pond.) A child places it on the pond and says one reason.
3. Children take turns with the other cards, each giving one reason:
4. fish: pond (it lives in water).
5. deer: wood (it eats buds and leaves from trees and bushes).
6. squirrel: wood (nuts and seeds from trees; it climbs trees).
7. woodlouse: wood or garden, under a log (damp, old leaves and wood).
8. bee: meadow or garden (flowers).
9. frog: pond, or damp places near it.
10. rabbit, worm: meadow or garden (grass to eat; soil to burrow in).
11. Some animals fit more than one place. That is fine if the child gives a reason.

✓ Discussion questions (4 min)

- "Could a fish live in the meadow? Why not?" (Answer guide: no; it needs water all the time.)
- "Where would you find a lot of grass? Why does grass grow well there?" (Answer guide: in the meadow; it is open and sunny, and grass needs light.)

- "Where did we find woodlice on our hunt? Does that fit?" (Answer guide: usually under logs or stones; yes, it is damp and they eat old leaves and wood. If the class found none, say so.)

✓ Closing check (3 min)

Hold up the deer card and point to the pond and the wood. "Where would a deer live? Why?" (Answer guide: the wood; it eats leaves and buds there. Accept the meadow with a reason, for example "it eats grass".)

Vocabulary

live, pond, wood, meadow, garden, place, need

Differentiation

- Support: use only three animals and two places (duck/pond, deer/wood, bee/meadow).
- Stretch: "Where do people live? What do we need there?" (Homes, water, food from shops or farms.)

⚠ Safety

- None beyond the usual classroom rules.

Access

- Children can place cards with help, point, sign or say their answer.
- Use a large, clear map; for a child who cannot see well, give each place a different texture (blue fabric for the pond, sandpaper for the path, felt for the grass).

Teacher notes

- Timing: 3 + 10 + 4 + 3 = 20 minutes.
- The picture map is the "model" here: children use it to show which animals live where and why.
- Real animals do move between places; the aim is the reason, not one right answer.

Lesson 5: What did we find out?

Goal: Children compare the light and dark cress, count the weather chart, and show what they learned about what living things need.

Length: about 25 minutes. Teach it about two weeks after planting.

Materials

- The class cress pots ("light" and "dark") and the guesses sheet.
- The class weather chart and coloured cubes (yellow sunny, white cloudy, blue rainy; add colours for the kinds of weather you have had).
- A practice chart for the check, drawn on a large sheet in front of the children: ten days with 6 rainy, 3 sunny and 1 cloudy, in mixed order.
- Picture cards for the check: dog, tree, rock; water, food, sunlight; woodlouse; a log and a dry sunny path.

Steps

✎ Opening (3 min)

Do today's weather card together, as every day. Bring out both cress pots and stand them side by side.

✎ Main activity (10 min)

1. **Cress (5 min).** "What is different about the two pots?" Children describe colour, height, and whether the cress stands up. Look back at the guesses sheet. "Was our guess right?" Then: "Light was the thing we changed on purpose. What happened to our cress without light?" Say what the class actually saw. Add: "Scientists who have tested lots of plants found that plants need light to grow well. Our two pots are one small look at that."
2. **Weather chart (5 min).** Choose the last month of the chart. Children add a cube for each day to the tower for its weather, then count each tower together, touching each cube once. "Which kind of weather did we have most this month? Is it the same as the month we counted in term 1?"

✓ Discussion questions (4 min)

- "What would happen if we stopped watering the light pot?" (Answer guide: it would dry out, droop and die, because all living things need water. Do not do this to the class pots; it is a thought question.)
- "What did the weather chart show us about this month?" (Answer guide: which weather we had most this month, and whether it was the same as the month we counted in term 1. One month cannot tell us what the weather is always like.)

✓ Closing check (8 min)

Five questions. Do them in small groups or one to one where possible; plan an extra slot in the week to finish (see the unit assessment notes).

1. Show the two class cress pots (or a photo of them taken today). "Which pot was in the dark? How can you tell?"
2. Show the dog, tree and rock cards and the water card. "Which of these need water?"
3. Show the dog and tree cards and the food card. "Which one needs to eat food? What does the other one need instead?"
4. Show the woodlouse card, the log card and the sunny path card. "Where would we most likely find a woodlouse? Why?"
5. Show the practice chart. "How many rainy days? Which weather did we have most?"

Answer guide: closing check

1. The dark pot, with a clue from what the class actually saw (usually pale or yellow, tall, floppy). If both pots looked alike in your class, accept "neither looks different yet" and the child's description. 1 mark.
2. The dog and the tree (not the rock). 1 mark.
3. The dog eats food; the tree needs light (and water). 1 mark.
4. Under the log, with a reason: damp, dark, old wood or leaves to eat. 1 mark.
5. 6 rainy days; rainy is the most. 1 mark.

This is a check of understanding (5 marks), not a test to pass. Note who needs more practice.

Vocabulary

compare, different, same, most, need, grow

Differentiation

- Support: count the towers with the teacher's hand guiding; compare just two towers.
- Stretch: "How many more rainy days than sunny days?" on the practice chart (3 more).

⚠ Safety

- None beyond the usual classroom rules. The cress is not tasted.

Access

- Answers can be spoken, signed, pointed to or chosen from pictures.
- Cubes can be counted by touch. For a child who cannot see the cress, the teacher holds a strip of card beside each pot and snips it at the height of the cress; the child compares the two strips by touch. Children do not need to touch the cress itself.
- Colour-vision differences: name the pots by their sun and moon labels as well as by colour.

Teacher notes

- Timing: 3 + 10 + 4 + 8 = 25 minutes.
- After the lesson, put the dark pot in the light and keep watering it. Children can watch whether it turns greener over the next days.
- The weather chart has run since term 1. Grade 1 science can keep it going or start a new chart; the cube towers are an early bar graph.

Grade 1 Science: What Do Plants Need? (5 lessons, about 3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 4 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.

Back to the science progression

Big idea

A seed holds a tiny plant and a packed lunch. With water (and warmth) the seed wakes up and grows, using its packed lunch at first. To keep growing green and strong, the young plant needs light. Plants grow towards light.

Outcomes

By the end of the unit a student can:

1. Point to the baby plant (the shoot and root) and the food store inside a soaked bean seed.
2. Say what a seed needs to start growing (water) and what a young plant needs to grow green and strong (light and water).
3. Make a prediction ("I think...") and then say whether it was right, using what they saw.
4. Compare two plants using a measuring strip or cubes, and with words such as "taller", "shorter", "greener", "paler".
5. Describe a plant bending towards a window and say why.

Prior knowledge

- Kindergarten: living vs non-living; using senses to observe.
- Counting to 20; comparing "longer/shorter".
- No reading is needed; recording is by drawing, stickers and class charts.

Lessons

Lessons are short (25-40 minutes). Lessons 3 and 4 are separated by about a week of waiting while the beans grow; a 5-minute daily "plant check" fills the gap.

Lesson	Title	Main activity
1	What is inside a seed?	Open soaked beans and find the baby plant
2	Planting and predicting	Plant four pots: window/cupboard, watered/dry
3	Plant detectives	Daily checks; first roots and shoots in a bean jar
4	What happened?	Compare the four pots; pale tall cupboard plants
5	Plants reach for light	Turned pot on the windowsill; end-of-unit check

Timeline

- **Day 1:** soak beans overnight (teacher). **Day 2:** lesson 1.
- **Day 3:** lesson 2 (planting) and set up the bean jar for lesson 3.
- **Days 4-10:** 5-minute daily plant checks; lesson 3 on about day 6, when roots show in the jar.
- **About day 12-16:** lesson 4, when the window plants have two or more leaves. Lesson 5 setup can start the same day (turn one window pot).
- **About 3 days later:** lesson 5.

Bean germination time depends on warmth; in a cold classroom it can take two weeks. Plant a few spare pots in case some seeds do not grow.

Materials (whole class unless noted)

- Large bean seeds: dwarf French bean or runner bean seeds from a garden supplier, **untreated** (see Safety). About 40 seeds.
- A shallow dish for soaking; hand lenses (one per pair); paper towels.
- 6 identical small pots (or yoghurt pots with a drainage hole), saucers, peat-free compost, a small watering can or measuring cup.
- 1 clear jar or clear plastic cup, kitchen paper, for the "bean jar".
- A dark cupboard or a large cardboard box that closes.
- Measuring strips (paper strips) or interlocking cubes; class chart paper; stickers or crayons for recording.

Assessment

- Lesson 2: each child's prediction drawing (kept for lesson 4).
- Lesson 4: "Was my prediction right?" talk, recorded by the teacher.
- Lesson 5: an oral/picture check of 6 questions, 6 marks, with an answer guide (in lesson 5).

⚠ Safety (read before lesson 1)

- **Seeds are not food.** Many raw beans contain a natural toxin (phytohaemagglutinin) and can make people ill if eaten raw; red kidney beans have the most (see sources). Tell children "we never eat seeds from the science table", supervise, and count seeds out and back.
- Buy **untreated** seeds. Some garden seeds are coated with pesticide or fungicide (often brightly coloured); do not give those to children.
- Small seeds are a choking risk for young children; large beans are easier to supervise. Know your class's allergies (legume allergy) before handling.
- Wash hands after handling compost and seeds. Use peat-free, bagged compost, not garden soil; wipe up spills.
- Hand lenses: never look at the Sun through them.

Sources

All checked to load on 4 November 2026.

- Wikipedia: Seed

- Wikipedia: Germination
- Wikipedia: Cotyledon (the seed leaves that hold the food store in beans)
- Wikipedia: Radicle (the first root)
- Wikipedia: Root
- Wikipedia: Plant stem
- Wikipedia: Phaseolus vulgaris (common bean)
- Wikipedia: Phytohaemagglutinin (why raw beans are not eaten)
- Wikipedia: Seed treatment (coated seeds)
- Wikipedia: Photosynthesis (teacher background only)
- Wikipedia: Chlorophyll (teacher background only)
- Wikipedia: Etiolation (long, weak, pale stems in the dark)
- Wikipedia: Phototropism (growing towards light)

Known gaps and cautions

- **Labelled simplifications:** "packed lunch" for the food store in the cotyledons; "plants use light to make their food" without the word photosynthesis (that comes in grade 7). Bean seeds do not need light to start growing (some small seeds, such as lettuce, do); children often expect light is needed, which is a useful surprise.
- Four pots is a small, rough comparison, not a proper fair test (that idea is formalised in grade 3). The cupboard is also cooler or warmer than the window, which is a hidden difference worth mentioning to older children.
- Results vary: a seed may fail to grow for reasons nobody can see. Spare pots help; the lesson 4 notes say what to do.
- No images yet; teachers will need to draw or photograph the plants.
- No standards alignment and no educator review.

Lesson 1: What is inside a seed?

Unit overview · Next: Lesson 2

Goal

Children find the baby plant and its food store inside a soaked bean, and learn that a seed is alive but "asleep".

Materials

- Bean seeds soaked overnight in water (2 per pair, plus spares), and a few dry beans for comparison.
- Hand lenses, paper towels, a tray per pair.
- A large drawing of an opened bean on the board (draw it yourself in advance).

Steps

Opening (5 min). Hold up a dry bean. "Is this alive? How could we find out?" Collect ideas without correcting. Then hold up a soaked bean: "This one had a bath overnight. What changed?" (Bigger, softer, wrinkly skin.)

Main activity (20 min).

1. Each pair gets a dry bean and a soaked bean. Compare: size, feel, colour.
2. Show how to rub off the skin (seed coat) of the soaked bean with a thumb.
3. Gently open it along the line into two halves, like a book.
4. Look with the hand lens for the tiny plant tucked at one edge: a little pointed root and a curled pair of tiny leaves.
5. Children draw what they see in a box on a page: "My bean inside".

Discussion questions (with example answers).

- Why did the soaked bean get bigger? It drank / soaked up water.
- What do you think the tiny leaves and root will become? A bean plant.
- The two big fat halves take up most of the bean. What are they for? Children may guess. Then explain: they are the baby plant's packed lunch. It eats this food while it is still under the soil, before it has leaves.
- Is the seed alive? Yes; it is waiting, like it is asleep, until it gets water.

Closing check (5 min, with answers). Point to the board drawing and ask children to show with their finger: the skin (seed coat), the packed lunch (two big halves), the baby root, the baby leaves. Then: "What woke the seed up?" (Water.)

Vocabulary

seed, seed coat, root, shoot, food store ("packed lunch"), soak

Differentiation

- Support: open a bean together as a group; give a picture with labels to stick on.
- Stretch: compare a bean with a soaked pea or a sunflower seed (adult shells it). Is there a baby plant in that one too?

⚠ Safety

Seeds are not food: count beans out and back; wash hands afterwards. Hand lenses never pointed at the Sun.

Teacher notes and misconceptions

- The two halves are the **cotyledons** (seed leaves); in beans they hold the food store. You do not need to teach the word in grade 1.
- Children often think the seed is "dead" because it does not move. The lesson 3 bean jar shows it waking up.
- Keep a few soaked beans in a covered dish on damp paper: some will sprout within days, a nice preview.

Lesson 2: Planting and predicting

Unit overview · Previous: Lesson 1 · Next: Lesson 3

Goal

Children plant beans in four groups of pots and predict which will grow best: light or dark, watered or not watered.

Materials

- 4 pots of the same size (plus 2 spares), filled with the same compost.
- 8 beans (2 per pot), labels, a watering can or measuring cup.
- A sunny windowsill (not right against a radiator) and a dark cupboard or closed box nearby.
- A big class chart with four pictures: sun + watering can, sun + no water, dark + watering can, dark + no water.
- A prediction sheet per child: four pot outlines to draw in.

Steps

Opening (5 min). "Last time we saw that water wakes a seed up. What else might a plant need?" Collect ideas (light, water, soil, sun, food, love...). Say we will test two of them: light and water.

Main activity (20 min).

1. Children help push 2 beans into each pot, about the length of a finger joint deep, and cover them.
2. Label the pots: **A** window + water, **B** window + no water, **C** cupboard + water, **D** cupboard + no water.
3. Water pots A and C with the same amount (for example half a cup). Make a show of not watering B and D.
4. Ask: "What must be the same for all four pots?" (same seeds, same pots, same compost, same number of beans). Only the light and the water change.
5. Put A and B on the windowsill and C and D in the cupboard.
6. Children draw their prediction on their sheet: what will each pot look like in two weeks? Collect sheets for lesson 4.

Discussion questions (with example answers).

- Which pot do you think will grow best? Why? Usually A, "because it has sun and water". Accept any reason.
- Will the beans in the dark cupboard grow at all? Many children say no. Do not correct; this is the surprise in lesson 4.
- Why do we put two beans in each pot? In case one does not grow.

Closing check (5 min, with answers). "What is different about pot C and pot A?" (C is in the dark.) "What is different about pot A and pot B?" (B gets no water.)

Vocabulary

predict, prediction, light, dark, the same, different

Differentiation

- Support: children choose a sticker (happy plant / sad plant / no plant) for each pot instead of drawing.
- Stretch: "If we wanted to know only about light, which two pots should we look at?" (A and C.)

⚠ Safety

Wash hands after handling compost. Wipe up spilled compost and water to prevent slips.

Teacher notes and misconceptions

- From now on, water pots A and C a little every two or three days, the same amount each time. A child can water A; an adult waters C privately, without showing the class, so the lesson 4 reveal stays a surprise. Close the cupboard door again quickly.
- "Plants eat soil" is common. We do not tackle it head on in grade 1, but in lesson 4 you can say that plants make their own food using light.
- Also set up the lesson 3 bean jar today (see lesson 3).

Lesson 3: Plant detectives

Unit overview · Previous: Lesson 2 · Next: Lesson 4

Goal

Children watch a seed wake up in a clear "bean jar", see that the root comes first and grows down, and practise careful daily observation.

Materials

- **Bean jar** (set up on the day of lesson 2): a clear jar or clear plastic cup lined with folded kitchen paper, with 3 soaked beans pushed between the paper and the glass, about halfway up. Keep 2 cm of water in the bottom so the paper stays damp. Keep it in the classroom, out of direct hot sun.
- A "plant detective" diary: one page per day with a box to draw in.
- Paper measuring strips (lesson 4 uses them too).

Daily plant check (5 min, every day from lesson 2 to lesson 4)

1. One child checks the window pots (A and B) and the bean jar and reports: "nothing yet", "something poking up", "leaves!". Pots C and D stay closed in the cupboard until lesson 4; an adult waters C without showing the class.
2. The class adds a sticker or tick on the class chart.
3. Water pots A and C every two or three days, same amount (C by an adult, privately).

Steps (the lesson itself, about day 6, when roots show in the jar)

Opening (5 min). "Detectives look very carefully and write down what they see." Show the jar. "What has happened to our beans?"

Main activity (20 min).

1. Pass the jar round (or let small groups come up) with hand lenses.
2. Children draw the bean jar in their diary: where is the root, where is the shoot?
3. Ask: "Which came out first, the root or the shoot?" (Usually the root.)
4. Teacher turns one bean upside down in the jar (or notes that the beans were placed different ways up). Predict: which way will its root grow tomorrow? Check over the next days: roots turn to grow down, shoots up.
5. Peek at pots A and C (do not dig them up). Are shoots coming up yet?

Discussion questions (with example answers).

- Why might the root come first? To get water and hold the plant in place.
- Which way do roots grow? Which way do shoots grow? Roots down, shoots up, even if the seed is upside down.
- Have the beans in the dry pots (B and D) done anything? Usually nothing; without water the seed does not wake up.

Closing check (5 min, with answers). Show a quick drawing of a sprouting bean. "Point to the root. Point to the shoot. Which way does the root grow?" (Down.)

Vocabulary

root, shoot, sprout, observe, diary

Differentiation

- Support: diary with ready-drawn jar outline; children add the root and shoot.
- Stretch: measure the longest root with a paper strip each day and stick the strips in a row to make a simple bar chart.

⚠ Safety

Wash hands after handling the jar. Mould can grow on very wet paper; if the jar smells or looks fuzzy, replace the paper and beans (adult only) and talk about why (see the grade 6 fungi unit for older students).

Teacher notes and misconceptions

- The first root is called the **radicle**; no need for the word in grade 1.
- If nothing has sprouted after 10 days, the room may be too cold. Move the jar somewhere warmer (not on a radiator).
- Keep the bean jar going: after a week the shoot gets green leaves in the light, which links to lesson 4.

Lesson 4: What happened?

Unit overview · Previous: Lesson 3 · Next: Lesson 5

Goal

Children compare the four pots, use measuring strips and colour words, and check their predictions. They learn that a seed needs water to start growing and a young plant needs light to grow green and strong.

Materials

- Pots A-D (bring C and D out of the cupboard only for this lesson).
- Children's prediction sheets from lesson 2.
- Paper measuring strips or interlocking cubes.
- A green crayon and a pale yellow crayon per group, for recording colour.

Steps

Opening (5 min). Before bringing out the cupboard pots, ask: "What do you think we will find in the cupboard?" Then reveal C and D.

Main activity (20 min).

1. Line up the pots A, B, C, D. Typical results:
2. **A (light + water):** short, sturdy stem; green leaves.
3. **B (light, no water):** nothing, or a dry seed.
4. **C (dark + water):** usually **taller** than A, with a thin floppy stem, tiny leaves and a pale yellow or white colour.
5. **D (dark, no water):** nothing.
6. Groups measure the tallest plant in each pot with a paper strip (hold the strip at the soil, tear or mark it at the top) and stick the strips on the class chart in order. Or count cubes.
7. Groups colour a square for each plant: green or pale yellow.
8. Children look at their prediction sheet: "Was I right? What surprised me?" The teacher writes a few sentences children say on the chart.

Discussion questions (with example answers).

- Why did nothing grow in B and D? No water, so the seeds never woke up.
- Pot C grew in the dark. How could it, without light? It used its packed lunch (the food store from lesson 1).
- Pot C is the tallest. Is it the healthiest? No: it is pale, floppy and has tiny leaves. It was stretching to find light.
- Why is A green? Plants turn green in the light; they use light to make their own food.

Closing check (5 min, with answers).

- "What does a seed need to start growing?" (Water.)
- "What does a young plant need to grow green and strong?" (Light and water.)
- "If we leave pot C in the dark for another month, what will happen?" (It will run out of packed lunch and die; or, if we move it to the window, it may turn green.)

Vocabulary

compare, taller, shorter, green, pale, healthy, surprise

Differentiation

- Support: compare only A and C side by side ("Which is taller? Which is greener?").
- Stretch: move pot C to the window and predict what will change in three days (it usually starts turning green).

⚠ Safety

Wash hands after touching plants and compost.

Teacher notes and misconceptions

- The tall, pale, weak growth in the dark is called **etiolation** (see sources). It surprises many adults too.
- "Tallest = best" is a common idea. Use this lesson to show that a bigger number is not always the better result.
- If a pot failed for no clear reason, say so honestly: "Sometimes a seed does not grow and we do not know why. That is why scientists use more than one seed." Use the spare pots if needed.
- The cupboard can be a different temperature from the windowsill. Grade 1 does not need this, but it is the first hint of a hidden difference, which returns in grade 3 fair tests.
- Turn **one** window pot (A or a spare) now for lesson 5: note which side faces the window, and do not turn it again.
- Optional, for lesson 5: set up the shoebox now. Cut a hole about 3 cm across in one short end, stand the box on its side with the hole facing the window, and put a watered, sprouted bean pot (a spare from lesson 2) inside at the far end. Close the lid. Check daily and close it again straight away.

Lesson 5: Plants reach for light

Unit overview · Previous: Lesson 4

Goal

Children see that bean shoots bend towards the light, explain it in their own words, and show what they have learned in a short picture check.

Materials

- The window pot that was turned at the end of lesson 4 (not turned since). After 2-3 days its shoots lean towards the window.
- Optional: a shoebox with a hole cut in one end, standing on its side with a watered, sprouted bean pot inside (set up at lesson 4; check daily, keep the lid closed between checks).
- End-of-unit picture check (below), one per child or done orally.

Steps

Opening (5 min). Show the leaning pot. "Our plants are leaning. Which way? Why might that be?" Collect ideas.

Main activity (15 min).

1. Ask a child to point where the window is. The shoots lean towards it.
2. Now turn the pot half way round so the shoots lean **away** from the window. Predict: what will they do in the next two days? Draw a prediction.
3. Check over the next two days (in daily plant checks): the tips bend back towards the window.
4. If you set up the shoebox: open it and look. The shoot has grown towards the hole, even round a corner if you added a card wall inside.

Discussion questions (with example answers).

- Why do the plants lean to the window? To get more light; they need light to grow green and strong.
- Remember pot C in the dark. How is that like the shoebox plant? Both stretch to find light.
- Do roots lean to the light too? No, roots grow down into the soil.

Closing: end-of-unit check (15 min). Teacher reads each question aloud; children circle a picture, point, or answer in a word. 1 mark each, 6 marks.

1. Show a drawing of an opened bean. "Point to the baby plant." (Either the tiny root or the tiny leaves at the edge, 1 mark.)
2. "What does a seed need to wake up and start growing: water, a toy, or music?" (Water.)
3. Show two plants: one short and green, one tall and pale. "Which one grew in the dark?" (The tall pale one.)
4. "Which one is healthier?" (The short green one.)
5. Show a pot on a windowsill. "Draw an arrow: which way will the shoots lean?" (Towards the window.)

6. "Finish the sentence: a young plant needs ___ and ___ to grow strong." (Light and water, both needed for the mark; accept "sun" for light.)

Answer guide notes. Accept "sunshine" for light. For question 6, children who add "soil" or "air" are not wrong; give the mark if light and water are both there. Record any child who says the tallest plant is the healthiest; revisit with pots A and C.

Vocabulary

lean, bend, towards, away from, light

Differentiation

- Support: questions asked one to one, answered by pointing.
- Stretch: "Design a maze for a bean plant." Draw a box with walls inside and a hole; predict the path the shoot will take. Build it if time allows.

⚠ Safety

Wash hands after handling plants. If children take plants home, send a note that the seeds and plants are not for eating.

Teacher notes and misconceptions

- Growing towards light is **phototropism**. The shaded side of the stem grows longer, so the stem bends (see the Phototropism source); grade 1 only needs "plants lean towards light".
- Children may say the plant "wants" or "likes" light. That is fine as a way of speaking at this age; later units ask how a plant can respond without a brain.
- After the unit, the bean plants can go outside or home. They will flower and may make pods; raw beans from them are still not for eating.

Grade 1 Science: Sound and Light (5 lessons, about 3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 9 November 2026. No educator has reviewed or classroom-tested this unit. It draws on NGSS (see Sources) but is not formally aligned to any official standard. Check every safety note against your school's rules.
>
> Text-checked by two other agents (Gemini 4 Argon, Claude Fable 5.2); see Known gaps.

Back to the science progression | Grade 1 year plan - Term 1

Big idea

Sounds are made when something shakes back and forth very quickly (vibrates), and sound can make other things vibrate. We can see things only when there is light: either light shines on them, or they give off their own light. Some materials let light through, some let a little through, some block it and make a shadow, and shiny things such as mirrors bounce it. People use sound and light to send messages to someone far away.

This is the first science unit of grade 1 (term 1). It builds on the kindergarten senses unit (listening, looking, describing words) and on kindergarten pushes and pulls (a pluck or a tap is a small push).

Outcomes

By the end of the unit most children can:

1. Show that something vibrating makes a sound (a plucked rubber band, a tapped drum, a hand on the throat while humming), and that the sound stops when the vibrating stops.
2. Show that sound can make something else vibrate (rice jumping on a covered bowl near a loud tap on a tray), and say what they saw.
3. Say that we can see things only when there is light, using what they saw in a peep box: with the lid shut, nothing inside can be seen; with a torch on, it can. Tell a light source (a torch, a glow stick) from a shiny thing that only bounces light (foil, a mirror).
4. Test objects in a torch beam and sort them into "lets light through", "lets some light through", "blocks light (makes a dark shadow)" and "bounces light (shiny)", and say what they did to find out.
5. Design, build, test and improve a way to send a simple message across the room or playground using sound or light (a cup telephone, a drum-beat code or a torch-flash code), and say what worked and what they changed.

Prior knowledge

- Kindergarten science: the five senses, describing words, pushes and pulls.
- Kindergarten maths: counting to 20 (counting drum beats and flashes).
- Grade 1 maths term 1 runs alongside; no reading is needed. Sorting tables use pictures and real objects.

Lessons

Each lesson is about 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. Teach about two lessons a week. Lesson 5 can take two sessions if children want a second round of improving their design.

Lesson	Title	Main activity
1	Shake, rattle, hum: what makes a sound?	Rubber bands on a box, a ruler over a table edge, a hand on the throat
2	Can sound make things move?	Rice on a covered bowl near a tapped tray; feeling a drum; quiet and loud
3	Can we see in the dark?	Peep boxes with the lid shut and with a torch; light sources and shiny things
4	Through, some, blocked or bounced	Test materials in a torch beam and sort them on a table
5	Sending a message across the room	Design, build, test and improve a sound or light signal

Materials (whole class unless noted)

- **Lesson 1, per group of 3-4:** an open shoebox or plastic tub, three rubber bands of different widths (fitted by an adult), a plastic 30 cm ruler. Whole class: a drum or tambourine, a cardboard tube (for children who do not use their voice), and "shaking" and "still" picture cards for the closing check.
- **Lesson 2, per group:** a plastic bowl with cling film stretched tight over the top and held with a rubber band, a pinch of uncooked rice (about a teaspoon), a metal baking tray and a wooden spoon. Whole class: a drum, and if you have one a tuning fork and a bowl of water. Optional: a speaker playing music at a classroom volume, with a sheet of paper. A brush and dustpan for the rice. A blown-up balloon for feeling vibrations (see Access). Picture cards for the closing check (rice jumping beside a tapped tray; still rice, no tapping).
- **Lesson 3:** one peep box per group: a shoebox with the lid taped on, all gaps covered, one small hole (about 1 cm) cut in one end to look through and a flap (taped on one side) cut in the lid at the far end, above the toy, that can open to let light in. Inside each box, a small bright toy or picture stuck to the far wall. One small torch (LED, battery compartment screwed shut) per group. A glow stick or glow-in-the-dark star (charged in light beforehand), a piece of kitchen foil and a plastic safety mirror per group. Picture cards: Sun, candle flame, lamp, torch, Moon, mirror, spoon, foil, and two sorting mats ("makes its own light", "does not make its own light"). Optional: a phone camera to photograph the inside of a box for children who cannot look through the hole.
- **Lesson 4, per group:** a torch, a white card or wall to shine onto, and a tray of test objects: a clear plastic cup or sheet, a clear plastic bag cut open into a flat sheet, baking paper (or wax paper), tissue paper, a piece of cardboard, a wooden block, a sheet of kitchen foil, a plastic safety mirror, a piece of cloth. A large sorting table (four columns with picture headings: an open door for "through", a half-open door for "some through", a closed door for "blocked", a bouncing ball for "bounced") and picture cards of each object (two each for the foil and the mirror), plus a small sorting sheet with the same columns per group. For the closing check: a plastic sandwich box, a paper plate and a metal spoon.
- **Lesson 5, per group:** two paper or plastic cups with a small hole in the base, about 5 m of string, two paper clips (or pieces of craft stick) to tie off the string inside the cups; a drum or a tray and spoon; a torch; a message card set (pictures: "come here", "stop",

"wave", "sit down"). A "test and change" sheet with three picture rows (try it, what happened, what we changed); two small blank code cards. A large space (hall, playground or a cleared classroom).
- Whiteboards and pens, or paper and pencils, for drawing in every lesson.
- Ear defenders for any child who wants them (lessons 1, 2 and 5).

Assessment

- Lessons 1-4: the teacher notes answers in the closing checks (observe; no writing needed). Children can answer by speaking, signing, pointing or choosing a picture card.
- Lesson 5: the test-and-change sheet (drawings or picture stickers) and a short talk: "What did you try? What happened? What did you change?"
- End-of-unit one-to-one check (about 5 minutes per child; plan extra small-group time in the week, as 40 minutes is not enough for a whole class). Answer guide:
    1. "Pluck this rubber band. What is it doing when it makes a sound?" (It is shaking / vibrating; when it stops, the sound stops.)
    2. Picture of rice jumping on a covered bowl beside a tray being tapped. "Why is the rice jumping?" (The sound from the tray makes the cover shake.)
    3. "In a box with no light at all, could you see the toy?" (No; we need light to see.)
    4. Hold up baking paper, cardboard and a clear plastic sheet. "Which lets light through? Which lets some through? Which blocks it?" (Clear plastic; baking paper; cardboard.)
    5. "Is a mirror a light source like a torch?" (No; it bounces light, it does not make its own.)

⚠ Safety (read before lesson 1)

- **Never look at the Sun**, even with sunglasses or through coloured film. Say this in lessons 3 and 4.
- **Never shine a torch into anyone's eyes**, including your own. Shine torches at the wall, card or floor. Use small LED torches with screwed battery covers; no laser pointers at all. In the peep box (lesson 3) the torch points down onto the toy, away from the peephole; in the codes (lesson 5) it points at a wall or card beside the receiver.
- Keep sounds at a comfortable level. Agree a "hands up, everything stops" signal before any noisy activity. Some children find loud or sudden sounds painful: offer ear defenders, a quieter corner or the role of "watcher" or "recorder" instead.
- Rubber bands: an adult fits them round the box before lesson 1; children pluck them and look from the side. Bands stay over the box, never at people or faces. Check the school's latex allergy list; use latex-free bands if needed.
- Rulers stay flat on the table and are pushed down with one hand; no flicking towards others.
- Rice stays on the covered bowl and is swept up afterwards; nobody puts rice in mouths, noses or ears. Leave rice out for any group with a child who might, and use a small pom-pom or paper confetti instead.
- Balloon (lesson 2 Access): an adult blows it up and ties it; burst pieces are picked up and binned at once (a choking risk).
- The clear plastic bag in lesson 4 is cut open into a flat sheet; nothing goes over heads or faces.
- Mirrors are plastic safety mirrors only. Foil edges can be sharp: fold them over.
- Cup telephones: string is never wrapped round fingers, wrists or necks, and pairs walk (not run) to stretch it. Watch that strings do not cross walkways where others could trip.

- Glow sticks stay closed; do not bend them hard or bite them. A glow-in-the-dark star (charged under a lamp) is a safer choice.
- Darkened rooms: never fully dark; keep a door light or a lamp on and an adult near the light switch. Use peep boxes rather than a dark room.

Access and taking part

- Deaf and hard-of-hearing children can feel vibrations directly: a hand flat on the drum, on the box with the rubber bands, on a balloon held near a speaker, or on the cup telephone string. Feeling the vibration is a full way to show outcomes 1 and 2. In lesson 5 a light or touch signal (a tug on the string) is as good as a sound signal.
- Blind and low-vision children can show outcome 1 and 2 by touch and sound, and can take part in lessons 3-4 by holding objects in the beam while a partner describes the shadow (warmth is not a clue: an LED torch stays cool). They can be the "sound team" in lesson 5. A talking or tactile sorting table (objects stuck to the columns, columns marked with different textures) helps in lesson 4.
- Children who find the dark frightening never need to be in a dark space: the peep box keeps the dark inside a box.
- Answers can be spoken, signed, pointed to, chosen from picture cards or drawn. Sorting columns use pictures and shapes, never colour alone.
- Children with limited hand movement can tap a drum with a whole hand, press a torch with a big button (or a partner holds the torch and they say "now"), or hold a cup while a partner manages the string.

Sources

- Next Generation Science Standards, topic "1. Waves: Light and Sound" (performance expectations 1-PS4-1 to 1-PS4-4), read 9 November 2026: https://www.nextgenscience.org/topic-arrangement/1waves-light-and-sound
  - 1-PS4-1: "Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate." Its examples include "tuning forks and plucking a stretched string" and "holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork."
  - 1-PS4-2: "Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated." Its examples include "a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight", and it notes that illumination "could be from an external light source or by an object giving off its own light."
  - 1-PS4-3: investigate "the effect of placing objects made with different materials in the path of a beam of light", with examples "transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror)". The assessment boundary leaves out the speed of light.
  - 1-PS4-4: "Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance." Its examples include "a light source to send signals, paper cup and string" telephones, and a pattern of drum beats.
  - Core idea PS4.B on the same page: "Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam."

Known gaps and cautions

- The words "transparent", "translucent", "opaque" and "reflective" come from the standard's examples. This unit uses everyday words first ("through", "some through", "blocked", "bounced") and offers the science words as extra; teachers can choose.
- Some objects do not fit one column neatly: a clear plastic sheet that is crumpled lets some light through, foil both blocks and bounces light, and a mirror blocks light behind it. Lesson 4 treats these as things to talk about, not as errors.
- "Sound makes the rice jump" is shown, not proved: the tray is not touching the bowl, but a table that wobbles can also shake it. Lesson 2 asks children to hold the tray off the table to rule that out, and to say what they saw.
- How well a cup telephone works depends on tight string, cups and distance; results vary. Children report what happened rather than a "right" answer.
- How sound travels through air (as a wave) and how the ear works are left for later grades.
- Peer check: Gemini 4 Argon did a bounded text, timing, safety, access and answer-guide check at 5a9a7eb (not an educator, classroom or safety review). Timings and answer guides were correct. Its notes (missing lesson navigation links; lesson materials lists missing items used in steps, access notes and closing checks; clearer wording for the cardboard tube) were fixed in the follow-up commit 156d7fa (see PEERCHECKS.md), which Argon also diff-checked the same day.
- Peer check: Claude Fable 5.2 did a text check at fda4488 for pitch, safety and misreadable claims (not an educator, classroom or safety review; it tried none of the activities). All 13 NGSS quotes, the timings and the links were correct. Its notes were fixed in the follow-up commit (see PEERCHECKS.md): the peep-box torch now points down onto the toy, away from the peephole; the glow star comes out before the foil and mirror; torch codes aim at a wall beside the receiver; adults fit the rubber bands and tie the balloon; the bag is cut flat; craft sticks replace matchsticks; the narrow/wide band step no longer promises a higher sound (width can roughly cancel out), and the ruler models pitch instead; groups tap one at a time; the lesson 2 closing question no longer suggests still rice means no sound; two cards for foil and mirror; code cards for both ends and two messages by default; a sunny-day answer; the cupboard question is revisited; and the banner now says the unit draws on NGSS without being formally aligned. Fable 5.2 reasoned some of these (band pitch, faint stars, daylight torches) rather than testing them. The follow-up commit is 71dc67b, which Fable 5.2 also diff-checked the same day; its four small leftovers (lesson 1 Stretch, lesson 5 coded cards, lesson 2 tapping turns, README flap position) were fixed in ab23d6b.
- The peep-box diagram in lesson 3 (peep-box.svg) was drawn by Claude Fable 5.2 and added in commit c72a0d2 (CC0, like the rest of the repo). It is a layout sketch; nobody has built a box from it in a classroom.
- The order of lessons, the activities and the timings are my choice, not taken from a source.

Lesson 1: Shake, rattle, hum: what makes a sound?

Unit overview - Next: Lesson 2

Goal: Children find that sounds are made when something shakes back and forth very fast (vibrates), and that the sound stops when the shaking stops.

Length: about 40 minutes.

Materials

- Per group of 3-4: an open shoebox or plastic tub, three rubber bands of different widths (latex-free if needed), fitted round the box by an adult before the lesson, a plastic 30 cm ruler.
- Whole class: a drum or tambourine.
- A cardboard tube (for example a kitchen-roll tube) for children who do not use their voice.
- Two picture cards for the closing check: "shaking" and "still".
- Whiteboards and pens, or paper and pencils.
- Ear defenders for any child who wants them.

Steps

✎ Opening (5 min)

Agree the "hands up, everything stops" signal and practise it once. Tap the drum gently, then put a flat hand on it. "What happened to the sound when my hand touched the drum?" (It stopped.) "Today we find out what is happening when something makes a sound."

✎ Main activity (25 min)

1. **Humming (5 min).** Everyone puts their fingertips gently on the front of their throat and hums, then stops, then hums again. "What do you feel when you hum? When you stop?" (A buzzing or tickle when humming; nothing when quiet.) Children who do not use their voice can hold a cardboard tube and feel it buzz while a partner hums into it, or feel the drum instead.
2. **Rubber band box (10 min).** Each group has its box with the three bands already on. Pluck one band. "Look closely from the side: what is the band doing?" (It moves back and forth fast; it looks blurry.) Put a finger on the band. "What happens to the sound?" (It stops.) Try the narrow band and the wide band. "Do they sound the same?" (They may sound a little different or about the same; bands vary, so accept what children hear. The ruler in step 3 shows higher and lower more reliably.)
3. **Ruler over the edge (10 min).** Press one end of the ruler flat on the table with one hand, with about half the ruler sticking out over the edge. With the other hand push the free end down a little and let go. "What do you see and hear?" (The ruler moves up and down fast and makes a buzzing sound.) Make the part over the edge shorter and try

again. (The sound usually gets higher and the shaking faster.) Children draw the ruler with "shaking lines".

✓ Discussion questions (5 min, with answers)

- What did the band, the ruler and your throat all do when they made a sound? They shook back and forth very fast. Scientists call this **vibrating**.
- How can you stop a sound? Stop the vibrating: touch the band, hold the ruler, put a hand on the drum, stop humming.
- Does something have to be big to vibrate? No; a thin band vibrates too, sometimes too fast to see, but we can feel it or hear it.

✓ Closing check (5 min, with answers)

Tap the drum. "What is the drum skin doing?" (Vibrating / shaking fast.) "How can I stop the sound?" (Put a hand on it, stop the vibrating.) Children answer by saying, signing, showing with their hands or pointing to a "shaking" or "still" picture card.

Vocabulary

sound, vibrate, vibration, shake, pluck, tap, higher, lower, loud, quiet

Differentiation

- **Support:** use only the drum and one rubber band; children copy the teacher's "shaking hands" gesture to show vibrating.
- **Stretch:** "Can you make the band sound higher without changing the band?" (Press it down with a finger to make the moving part shorter. An adult can also show what happens when the band is pulled tighter.)

⚠ Safety

- An adult fits the bands round the box before the lesson; children pluck them but do not take them off or stretch them.
- Children look at a plucked band from the side, not with a face close above it.
- Bands stretch only round the box, never towards people or faces.
- Rulers stay pressed to the table; no flicking towards others.
- Keep sounds comfortable; use the stop signal.

Access

- Deaf and hard-of-hearing children feel the drum, the box and their throat; feeling the vibration is a full answer.
- Children with limited hand movement can tap the drum with a whole hand or watch the band while a partner plucks and say "now".
- Offer ear defenders and the role of "watcher" for sound-sensitive children.

Teacher notes

- Timing: 5 + 25 (5 + 10 + 10) + 5 + 5 = 40 minutes.
- Children often think sound is "in" the drum or comes from the hitting itself. Keep coming back to "What is it doing while it makes a sound?"
- Higher and lower here means pitch, not loudness; some children use "high" for "loud". Model both words with the drum (soft tap, hard tap) and the ruler (long overhang lower, short overhang higher).

Lesson 2: Can sound make things move?

Unit overview - Previous: Lesson 1 - Next: Lesson 3

Goal: Children see and feel that sound can make other things vibrate, and practise saying what they did and what they saw.

Length: about 40 minutes.

Materials

- Per group: a plastic bowl with cling film stretched tight over the top and held with a rubber band; about a teaspoon of uncooked rice (or a few small paper confetti pieces); a metal baking tray and a wooden spoon.
- Whole class: a drum. If you have them: a tuning fork and a bowl of water; a speaker playing music at a classroom volume and a sheet of paper.
- A sweeping brush and dustpan for the rice.
- A balloon, blown up and tied by an adult, for children who feel the vibration instead of seeing it (see Access); check the latex allergy list.
- Two picture cards for the closing check: rice jumping beside a tapped tray, and still rice with no tapping.
- Whiteboards and pens, or paper and pencils.
- Ear defenders for any child who wants them.

Steps

✎ Opening (5 min)

Recap lesson 1: "What is something doing when it makes a sound?" (Vibrating.) "Today's question is the other way round: can a sound make something ELSE vibrate, without touching it?"

✎ Main activity (25 min)

1. **Rice on the drum bowl (12 min).** Groups sprinkle the rice on the cling film. Groups take turns to tap, one group at a time, so a neighbour's tray does not move the rice and the room stays calm; the others watch. With more than four groups, give each group about two minutes, or use one tapping station at the front where groups bring their bowls in turn (reasoned, not tested). One child holds the tray in the air with both hands, about a hand's width from the bowl and not touching it or the table, and a partner taps it with the spoon. "What does the rice do?" (It jumps or shuffles.) Try a gentle tap and a harder tap. "When does the rice move more?" (Usually with the louder tap.) Try holding the tray further away. (The rice usually moves less.)
2. **Is it the table? (5 min).** "Could the table be shaking the bowl?" Children check that the tray is held in the air and that nobody bumps the table. Try tapping the table gently with a finger instead: does the rice move? Talk about what they found; the aim is to notice what else could be causing it.

3. **Feel and see (8 min).** Teacher demonstrations, children close by:
    - Children put a flat hand on a drum on the table while the teacher taps a second drum or tray close to it (not touching). Some children can feel a tiny buzz.
    - If you have a tuning fork: strike it on a rubber heel or a cushion and touch the tips to the water. (Small splashes or ripples: the fork is vibrating.)
    - If you have a speaker: hold paper close in front of it while music plays at a normal level; children can feel it flutter with fingertips.

✓ Discussion questions (5 min, with answers)

- Nobody touched the bowl. What made the rice move? The sound from the tray made the cling film vibrate, and that made the rice jump.
- What changed when we tapped harder? The sound was louder and the rice usually moved more.
- Why did we hold the tray off the table? So we knew it was the sound, not a shaking table, that moved the rice.

✓ Closing check (5 min, with answers)

Show two pictures: a tray being tapped next to a covered bowl with rice in the air, and the same bowl with no tapping and still rice. "In which picture is the tray being tapped? What is making the rice jump?" (The first: the sound from the tapped tray makes the cover vibrate, and that makes the rice jump. A quiet or far-away sound may not move the rice at all.) Children answer by pointing, saying, signing or drawing.

Vocabulary

vibrate, sound, loud, quiet, near, far, cause

Differentiation

- **Support:** the teacher taps; children only watch and say "moving" or "still".
- **Stretch:** "Can you make the rice move without making a louder sound?" (Bring the tray closer.) "Can you stop the rice moving while you keep tapping?" (Put a hand on the cover, move the tray far away.)

⚠ Safety

- Rice stays on the covered bowl; nobody puts it in mouths, noses or ears. Use paper confetti for any group where this might happen. Sweep up after.
- An adult blows up and ties the balloon; if it bursts, an adult picks up every piece and bins it at once (balloon pieces are a choking risk).
- Keep taps at a comfortable level; use the stop signal. The speaker stays at a normal classroom volume.
- Tuning fork: strike it on a rubber heel or cushion, never on a table or a person.

Access

- Deaf and hard-of-hearing children can rest a fingertip lightly on the cling film, or hold a balloon near the tray, and feel the buzz.
- Blind and low-vision children can feel the cling film and the paper near the speaker; a partner says when the rice is moving.
- Offer ear defenders and the role of "watcher" or "recorder"; the watcher says what the rice did.

Teacher notes

- Timing: 5 + 25 (12 + 5 + 8) + 5 + 5 = 40 minutes.
- Cling film must be tight like a drum skin; a loose cover barely moves. Test beforehand.
- How sound travels through the air is not taught here; it is enough for children to say "the sound made it vibrate".
- This lesson is a comparison, not a full fair test: loudness and distance are both changed by hand. Ask children to say what they saw.

Lesson 3: Can we see in the dark?

Unit overview - Previous: Lesson 2 - Next: Lesson 4

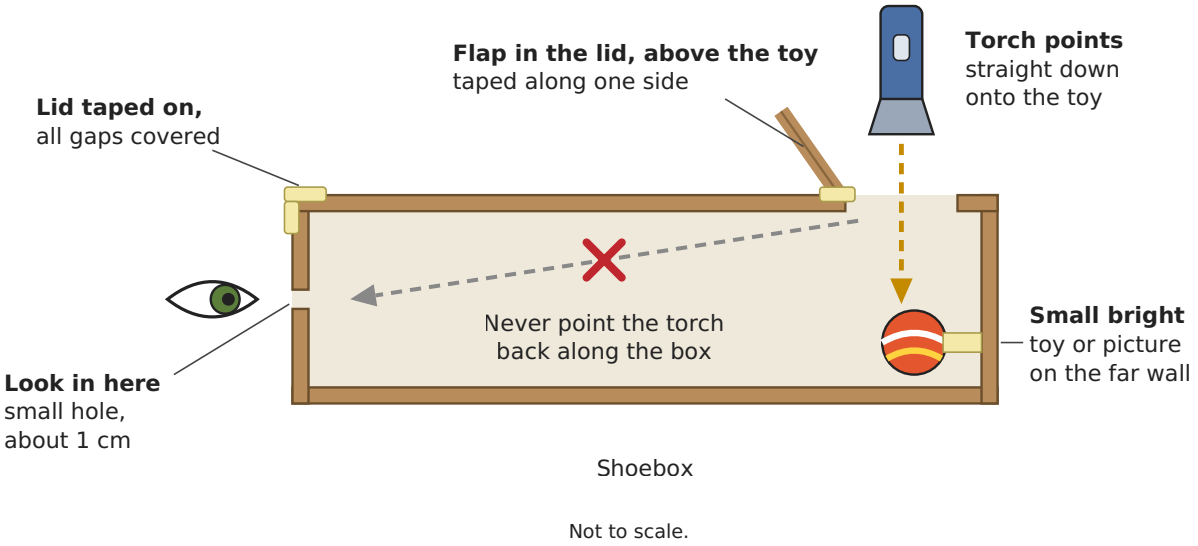
Goal: Children find that we can see things only when there is light: light shines on them, or they give off their own light. They tell light sources from shiny things.

Length: about 40 minutes.

Materials

- One peep box per group: a shoebox with the lid taped on and all gaps covered, a small hole (about 1 cm) in one end to look through, and a flap cut in the lid at the far end, above the toy (taped along one side), that opens to let light in. Inside, a small bright toy or picture stuck to the far wall. Make these before the lesson and check that, with the flap shut, the inside looks dark.
- One small LED torch per group (battery cover screwed shut).
- Per group: a glow-in-the-dark star (charged under a lamp before the lesson, and again with the group's torch for about 30 seconds just before it goes in the box), a piece of kitchen foil with folded edges, a plastic safety mirror.
- Picture cards: Sun, candle flame, lamp (switched on), torch (switched on), Moon, mirror, spoon, foil. Two sorting mats: "makes its own light" (a picture of a lamp shining) and "does not make its own light" (a picture of a closed box).
- Optional: a phone camera, to photograph the inside of a box (flap shut and flap open) for children who cannot look through the hole.
- Whiteboards and pens, or paper and pencils.

Peep box, seen from the side (near side cut away)



Not to scale.

Steps

✎ Opening (5 min)

Safety first: "Never look at the Sun. Never shine a torch into anyone's eyes." Children repeat it with actions (hands over eyes; torch pointing down). Then: "If you were in a cupboard with the door shut and no light at all, could you see your hand?" Take guesses; do not give the answer yet.

✎ Main activity (25 min)

1. **Peep box, flap shut (7 min).** Each child in turn looks through the hole with the flap shut. "What can you see?" (Nothing, or only darkness.) Children draw what they saw (a dark box). Nobody says what is inside yet.
2. **Flap open, or torch in (8 min).** Open the flap a little, or the torch holder shines the torch straight down through the flap onto the toy, pointing away from the peephole end, never back along the box. Look again. "What can you see now?" (The toy or picture.) Shut the flap again: it disappears. Children draw the second picture next to the first.
3. **What makes light? (10 min).** With the flap shut, recharge the glow star with the torch, put it inside and look. (It can be seen, faintly: it gives off its own light.) Take the star out. Then put the foil and the mirror inside with the flap shut. (They cannot be seen: they are shiny, but they do not make light.) Groups sort the picture cards onto the two mats.

✓ Discussion questions (5 min, with answers)

- Why could you not see the toy with the flap shut? There was no light in the box, and we need light to see things.
- Back to the cupboard: with the door shut and no light at all, could you see your hand? No. Like the toy in the shut box, we need some light to see.
- The foil is shiny. Why couldn't we see it in the dark box? Shiny things do not make their own light; they only bounce light that shines on them.
- Is the Moon a light source? No. The Moon looks bright because sunlight shines on it and bounces off. (Accept "it looks like one"; this is surprising for many adults too.)

✓ Closing check (5 min, with answers)

Show the torch, the glow star, the foil and the mirror. "Which ones make their own light?" (Torch, glow star.) "Which only shine when light is on them?" (Foil, mirror.) "Could you see the toy in the box with no light at all?" (No.) Children answer by pointing, signing, saying or sorting.

Vocabulary

light, dark, light source, shiny, bounce, glow, see

Differentiation

- **Support:** sort only the torch, a lamp card, foil and a mirror.
- **Stretch:** "A cat walks into a room with no light at all. Can it see?" (No. Cats see well in dim light, but they still need some light.)

⚠ Safety

- Never look at the Sun; never shine torches into eyes.
- In the peep box, the torch always points down onto the toy, away from the peephole, while a child is looking.
- The classroom stays lit; the dark is inside the box only.
- Plastic safety mirrors only; fold the foil edges over.
- Glow sticks, if used instead of stars, stay closed and are not bitten.

Access

- Children who dislike the dark only look into a small box; they never sit in the dark.
- Blind and low-vision children can feel the objects inside the open box and take the "sorting" role; a partner describes what they see through the hole. Some low-vision children can tell the torch on or off by brightness.
- Children who cannot hold their eye to a hole can look at a photograph taken through the hole with a phone camera, flap shut and flap open.

Teacher notes

- Timing: 5 + 25 (7 + 8 + 10) + 5 + 5 = 40 minutes.
- A common idea at this age is that our eyes "get used to" the dark and will see eventually. In a truly dark box they do not; if a child sees a little, look for a gap letting light in and tape it.
- The standard's clarification statement suggests a pinhole box or a completely dark room; this unit uses the box so no child has to be in the dark.

Lesson 4: Through, some, blocked or bounced

Unit overview - Previous: Lesson 3 - Next: Lesson 5

Goal: Children test what happens when different materials are put in a torch beam, and sort them: lets light through, lets some light through, blocks light (dark shadow), bounces light (shiny).

Length: about 40 minutes.

Materials

- Per group: a small LED torch; a white card standing up (or a pale wall); a tray of test objects: a clear plastic cup or sheet, a clear plastic bag cut open into a flat sheet, baking paper (or wax paper), tissue paper, cardboard, a wooden block, kitchen foil (edges folded), a plastic safety mirror, a piece of cloth.
- A large class sorting table with four columns and picture headings: an open door ("through"), a half-open door ("some through"), a closed door ("blocked"), a bouncing ball ("bounced"). Picture cards of each test object, with two cards each for the foil and the mirror (they can go in two columns). Columns also differ by shape or texture, not only colour.
- A group sorting sheet with the same four columns, per group (step 2).
- For the closing check: a plastic sandwich box, a paper plate and a metal spoon.
- Whiteboards and pens, or paper and pencils.

Steps

✎ Opening (5 min)

Repeat the safety rules (never look at the Sun; never shine a torch into eyes; torches point at the card). Shine a torch on the white card: "What do you see?" (A bright patch.) Hold your hand in the beam: "What happens?" (A dark shadow; the hand blocks the light.)

✎ Main activity (25 min)

1. **Predict (5 min).** Hold up the clear cup, the cardboard and the baking paper. "What do you think will happen on the card if I put each one in the beam?" Children point to a column. No wrong guesses.
2. **Test (15 min).** In groups, one child shines the torch at the card from about one ruler away, one holds an object in the beam, one looks at the card and says what they see: "bright patch" (through), "dim or blurry patch" (some through), "dark shadow" (blocked). Shiny objects: tilt them in the beam and look for a bright spot on the wall or table (bounced). Children place each picture card in a column on their group sheet. Keep the torch at the same distance for every object.
3. **Class table (5 min).** Groups put their cards on the class table. Where groups disagree, test the object again together.

✓ Discussion questions (5 min, with answers)

- Which materials let the light through? Clear plastic (cup, sheet, flat bag). The patch on the card is still bright.
- Which let some light through? Baking paper, tissue paper, often thin cloth. The patch is dim or blurry.
- Which blocked it? Cardboard, wood, thick cloth, foil. A dark shadow on the card.
- Foil went in two columns. Is that wrong? No. Foil blocks light (shadow behind it) and bounces it (bright spot when tilted). The mirror does both too. Some objects do more than one thing.
- Why did we keep the torch the same distance each time? So only the object changed and the test was fair to each object.

✓ Closing check (5 min, with answers)

Hold up a new object not used before (for example a plastic sandwich box, a paper plate, a metal spoon). "Where will it go? Let's test." (Usually: clear box through or some through; paper plate blocked or some through; spoon blocks and bounces.) Children point to the column first, then check.

Vocabulary

through, some through, blocked, bounced, shadow, beam, shiny. Optional science words: transparent, translucent, opaque, reflect.

Differentiation

- **Support:** test three objects only (clear cup, baking paper, cardboard); use the three door pictures. Middle option: six objects (clear cup, baking paper, tissue paper, cardboard, foil, mirror).
- **Stretch:** "Make the shadow of the block bigger without changing the block." (Move the block closer to the torch.) Or: use the mirror to bounce the beam onto a target on the wall.

⚠ Safety

- Never look at the Sun; never shine torches into eyes or bounce the beam into faces with mirrors. Mirrors point at the wall or floor.
- Plastic safety mirrors only; fold foil edges.
- The plastic bag is cut open into a flat sheet before the lesson and stays on the table; nothing goes over heads or faces.

Access

- Blind and low-vision children can hold each object in the beam while a partner describes the card; the class table can have the real objects stuck to it so it can be read by touch.
- Children answer by pointing, signing, saying or placing a card.
- Columns use door pictures and shapes, not colour alone.

Teacher notes

- Timing: 5 + 25 (5 + 15 + 5) + 5 + 5 = 40 minutes.
- Results depend on the torch and the material (thin cloth may let some light through; a crumpled bag may look cloudy). Record what each group actually saw and talk about differences.
- The speed of light is not part of this unit (the standard's assessment boundary leaves it out).

Lesson 5: Sending a message across the room

Unit overview - Previous: Lesson 4

Goal: Children design, build, test and improve a way to send a simple message across the room or playground using sound or light, and say what they tried, what happened and what they changed.

Length: about 40 minutes (a second session for another round of improving is welcome).

Materials

- Per group: two paper or plastic cups with a small hole in the base, about 5 m of string, two paper clips (or short pieces of craft stick) to tie off the string inside each cup; a drum, or a tray and wooden spoon; a small LED torch.
- Message picture cards, one set per group: "come here", "stop", "wave", "sit down".
- A "test and change" sheet per group with three picture rows: try it (a hand), what happened (an eye and an ear), what we changed (a spanner).
- Two small blank code cards per group (one for the sender, one for the receiver).
- Pencils or pens to draw the code and mark the sheet.
- Ear defenders for any child who wants them.
- A large space: the hall, the playground, or the classroom with desks pushed back. Torch codes need an indoor or shaded wall; a small torch is hard to see outdoors in daylight.

Steps

✎ Opening (5 min)

"Your friend is at the other end of the playground. It is too far to talk quietly. How could you send them a message using sound or light, without shouting?" Collect ideas (a whistle, waving, a torch, a drum, a phone). Show the three choices for today: a cup telephone, a drum-beat code or a torch-flash code. Remind everyone of the safety rules (string never round fingers or necks; torches never in eyes; comfortable sounds).

✎ Main activity (25 min)

1. **Plan (5 min).** Each group chooses a device and a code. For drum or torch codes, the group agrees a pattern for two message cards, for example: 2 beats or flashes = "come here"; a long flash or a roll = "stop". Draw the code twice, once on each code card, so the sender and the receiver each have one.
2. **Build (5 min).** Cup telephone: thread the string through the holes and tie it to a paper clip inside each cup (adult helps with knots). Drum or torch: practise the code at the table.
3. **Test (8 min).** The sender stands at one end of the space, the receiver at the other (about 5 m apart, with the cup string pulled straight). The sender picks one of the coded message cards (two, or four for the Stretch) without showing it and sends it. Torch senders shine onto a wall or a card standing beside the receiver, never at the

receiver; the receiver watches the wall or card. The receiver checks the code card and does the action. Did it work? Mark the "what happened" row.

4. **Improve and test again (7 min).** "What could make it work better?" Ideas to try: pull the string tighter, keep it off the floor and away from other things touching it; beat or flash more slowly; leave a gap between messages; use a bigger torch beam on a pale wall; agree a "ready" signal first. Change ONE thing, test again, mark the "what we changed" row.

✓ Discussion questions (5 min, with answers)

- Why does the cup telephone work? Talking into the cup makes it vibrate; the tight string carries the vibration to the other cup, which vibrates and makes the sound.
- What happened when the string was loose or touching something? It usually worked badly or not at all; the vibrations did not get through.
- What made the torch or drum code easier to understand? Going slowly, leaving gaps, starting with a "ready" signal, and both people knowing the code.
- Which works better in a noisy playground, sound or light? On a sunny day? Answers vary: light codes work when it is noisy; sound codes work when you cannot see each other. On a sunny day a small torch is hard to see, so a sound code may work better. Accept reasons.

✓ Closing check (5 min, with answers)

Each group shows its sheet. "What did you try? What happened? What did you change?" (Any honest answer that names a change and a result is a success, including "it still didn't work".) Then: "Your friend is around a corner where they cannot see you. Would you send a light code or a sound code?" (A sound code, because light needs a clear line to be seen.)

Vocabulary

message, signal, code, send, receive, test, improve, design

Differentiation

- **Support:** use the drum and send only one message ("stop").
- **Stretch:** add codes for "wave" and "sit down" (four messages), invent a code for a new message, or test how far apart the cup telephone still works (count steps).

⚠ Safety

- String is never wrapped round fingers, wrists or necks; pairs walk, not run, to stretch it; keep strings out of walkways.
- Torches point at a wall or card beside the receiver, or the floor near them, never at eyes. Never look at the Sun outdoors.
- Drum taps at a comfortable level; agree the stop signal.

Access

- Deaf and hard-of-hearing children can use the torch code, or feel a tug code on the cup string (one tug, two tugs).
- Blind and low-vision children can use the drum code or the cup telephone.
- Children with limited hand movement can tap with a whole hand, press a large-button torch or choose the message while a partner sends it.
- Children who do not use speech can send a code on the cup telephone by tapping the cup, or use the torch or drum.

Teacher notes

- Timing: 5 + 25 (5 + 5 + 8 + 7) + 5 + 5 = 40 minutes.
- Cup telephones work best with thin, tight string and stiff cups; test one beforehand. If none work well, the drum and torch codes still meet the goal.
- The point is the design cycle (try, look, change, try again), not a perfect device. Praise clear reasons for changes.
- Technological details (how phones or radios work) are not part of this unit.

Grade 1 Science: Patterns in the Sky: Sun, Moon, Stars and Daylight (5 lessons, about 3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 9 November 2026. No educator has reviewed or classroom-tested this unit. It draws on NGSS (see Sources) but is not formally aligned to any official standard. Check every safety note against your school's rules.
>
> Text-checked by one other agent (Gemini 4 Argon); see Known gaps.

Back to the science progression | Grade 1 year plan - Term 2

Big idea

The sky has patterns we can see, describe and use to predict. Every day the Sun seems to rise in one part of the sky, move across it and set in another, and shadows move as it does. The Moon also seems to rise, move and set, can sometimes be seen in the daytime, and seems to change shape in a pattern that repeats about every four weeks. Stars other than the Sun can be seen at night but not in the day. There is less daylight in winter than in spring, summer or autumn.

This is the term 2 science unit of grade 1. It builds on the term 1 unit Sound and light (shadows form away from a light; we see things only when there is light; the Moon does not make its own light) and on kindergarten weather watching.

Outcomes

By the end of the unit most children can:

1. Use shadow marks made at three times of one day to say that the Sun seems to move across the sky, and that shadows are usually shortest around the middle of the day.
2. Put pictures of one day's sky in order (rising, high, setting, night) and use the pattern to predict where the Sun will be next morning.
3. Say that the Moon can sometimes be seen in the day, and put Moon shape pictures in an order where the shape grows and then shrinks.
4. Say that stars can be seen at night but not in the day, and use a model (a small light in a bright or dark box) to show why.
5. Compare two day strips and say that there is less daylight in winter than in spring.

Prior knowledge

- From Sound and light: a shadow forms on the side of an object away from the light; we never look at the Sun; the Moon is lit by the Sun.
- From kindergarten: describing the weather, day and night, words like morning and afternoon.

Lessons

1. Where is the Sun now? - marking a shadow three times in one day.
2. Up, across and down - the Sun's daily pattern and a prediction.
3. The Moon has patterns too - the daytime Moon and the changing shape.
4. Where are the stars in the day? - stars at night, and a bright-room model.
5. Long days and short days - comparing daylight in winter and spring, and starting a sky diary.

Materials (whole class unless noted)

- Lesson 1: one shadow post per group of four (blunt stick or ruler in plasticine on card, or in a cone); per group three colours of chalk (or coloured sticky dots and large paper indoors), a beanbag and three clock cards; masking tape; class shadow chart; a picture of the Sun and a "never look" card; three shadow picture cards; water and sun protection.
- Lesson 2: the lesson 1 chart and photos of the chalk shadows; a teacher- drawn window view picture with the sunrise and sunset sides marked; a card Sun on a stick; per pair six Little Hill sky cards and an ordering strip; tactile versions of the cards.
- Lesson 3: Moon shape cards (eight shapes; one class set and one set per group of four, with ordering strips); tactile foam or card Moon shapes; the Little Hill sky strip and a card Moon on a stick; "Moon at night, Moon in the day" pictures; optional morning Moon look (check a Moon calendar); optional teacher photo of the daytime Moon.
- Lesson 4: Little Hill day and night pictures; one LED torch or battery tea-light per group; per group a peep box from the Sound and light unit with a small battery light inside; about 10 charged glow stars on black card; blinds or a blanket-covered table; sorting mat and six picture cards (Sun, Moon, stars, clouds, rainbow, birds); a ticking timer or small bell and some music at a comfortable volume.
- Lesson 5: two big Pip day strips (winter and spring) and small copies per pair; tactile strips (smooth for light, rough for dark); a set of Pip's day picture cards per pair; two early-evening photos of the same view; a class sky diary sheet with blank day strips; weekly sunrise and sunset times for the teacher; yellow and dark blue counters, crayons or stickers.

Assessment

- During lessons: shadow records (lesson 1), the ordered sky strip (lesson 2), the ordered Moon cards (lesson 3), the day/night sort (lesson 4) and the Pip strips (lesson 5).
- Closing checks at the end of each lesson (answers are in each lesson).
- One-to-one check, about 4 minutes per child, any time in the last week. Children may answer by pointing, signing, placing a card or speaking:
    1. Show three shadow pictures. "Which shadow is from the middle of the day?" (The shortest one.) (Outcome 1)
    2. Give three Little Hill cards (rising, high, setting). "Put them in order. Where will the Sun be tomorrow morning?" (Low on the sunrise side.) (Outcome 2)
    3. "Can we ever see the Moon in the day?" (Yes, sometimes.) Give three Moon shapes: "Put them in order so it gets bigger." (Outcome 3)
    4. Show the day and night pictures. "When can we see stars?" (At night.) "Why not in the day?" (The Sun is too bright.) (Outcome 4)
    5. Show the two Pip strips. "Which is the winter day? How do you know?" (More dark blue; less daylight.) (Outcome 5)

⚠ Safety (read before lesson 1)

- Never look at the Sun, directly or through sunglasses, binoculars, a phone screen or anything else. Children stand with their backs to it when looking at shadows. Use the "never look" card in every lesson that goes outside.
- Shadow posts have blunt tops and stand in plasticine or a cone.
- Outdoor visits: sun protection and water as your school requires; keep visits short in cold weather.
- Torches point at the floor or into a box, never at eyes. Battery lights only, no candles.
- Darkened room: clear the floor, keep a light near the door, and let any child who dislikes the dark stay in the light.
- Music in the lesson 4 sound model at a comfortable volume.
- Never ask children what time they get up or go to bed, whether they go out after dark, or about their home or bedroom window; use the made-up place Little Hill and the made-up child Pip.

Access and taking part

- Every lesson has a tactile or sound route: masking tape and beanbags on shadows, felt and string sky cards, foam Moon shapes, a ticking-timer model for stars, rough and smooth day strips.
- Answers by pointing, placing cards, signing or speaking all count.
- Children who use a wheelchair or cannot crouch use a shadow post on a table or windowsill.
- Colour is never the only clue: the day strips also carry small sun and moon symbols.
- Going into a darkened space or acting out the Sun's path is always optional; watching from the edge counts.

Sources

- NGSS, "1. Space Systems: Patterns and Cycles" (topic arrangement), read 9 November 2026: https://www.nextgenscience.org/topic-arrangement/1space-systems-patterns-and-cycles
  - 1-ESS1-1: "Use observations of the sun, moon, and stars to describe patterns that can be predicted." Clarification statement: "Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day." Assessment boundary: "Assessment of star patterns is limited to stars being seen at night and not during the day."
  - 1-ESS1-2: "Make observations at different times of year to relate the amount of daylight to the time of year." Clarification statement: "Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall." Assessment boundary: "Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight."
  - Disciplinary core ideas ESS1.A: "Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted." ESS1.B: "Seasonal patterns of sunrise and sunset can be observed, described, and predicted."
- The Moon's changing shape (lesson 3) goes a little beyond the two performance expectations above; it is included as a pattern children can observe, and is not assessed beyond ordering pictures.

- Other statements (the Sun is a star; the stars are still there in the day; the Earth's shadow does not cause the Moon's shapes; daylight changes little near the equator) are general science knowledge that I did not check against a specific source for this unit.

Known gaps and cautions

- Written 9 November 2026. Text-checked by Gemini 4 Argon the same day (links, timings, outcomes against the one-to-one check, privacy, sun safety and access routes): no errors reported, so no changes were needed. Not yet checked by a teacher.
- Lesson 1 needs a sunny day and two short return visits; cloudy weather may spread it over several days.
- The sky diary in lesson 5 runs until term 3, so the comparison children make in this unit is with made-up Pip strips and photos; the class's own comparison comes later.
- Southern hemisphere and near-equator classes need the changes in the lesson 5 teacher notes.
- The Moon shape cards must be drawn or chosen by the teacher; no illustrations are provided yet.
- The lesson order assumes term 2 falls in the darker part of the year.

Lesson 1: Where is the Sun now?

Unit overview - Next: Lesson 2

Goal: Children mark a shadow three times in one school day, without ever looking at the Sun, and use the marks to say that the Sun seems to move across the sky during the day.

Length: about 40 minutes in the morning, plus two short visits (about 5 minutes each) at midday and in the afternoon. Use a dry, sunny day; if the sky clouds over, see Teacher notes.

Materials

- One shadow post per group of four: a stick or ruler pushed upright into a plasticine lump on a square of card, or a traffic cone with a stick taped to it, placed on flat playground or a sunny windowsill.
- Per group: three pieces of chalk in different colours (or three coloured sticky dots and a sheet of large paper taped under the post if indoors), a small beanbag, and a picture card of a clock face for each visit (morning, midday, afternoon), drawn by the teacher.
- Masking tape to mark exactly where each post stands, so it can be put back in the same place.
- A large class chart: "Morning", "Midday", "Afternoon", with a space for each group's drawing of where the shadow pointed.
- A picture of the Sun, and a "never look" card: an eye looking at the Sun, crossed out.
- Picture cards for the closing check: a post with a long shadow pointing one way, a short shadow, and a long shadow pointing the other way.
- Water and sun protection as your school requires when outside.

Steps

✎ Opening (5 min)

Hold up the picture of the Sun and the "never look" card. "We never look at the Sun, not even for a second, and not with sunglasses. It can hurt our eyes. Today we will find out where the Sun is by looking at shadows instead." Remind the class of the sound-and-light unit: a shadow forms on the side of an object away from the light. Ask: "If my shadow is in front of me, where is the light?" (Behind me.)

✎ Main activity (25 min)

1. Outside, each group stands its post on the taped square. Children walk round the post and find its shadow. The shadow tip is where the line of dark ends.
2. One child holds the post steady, one draws a chalk line along the shadow (first colour), one places the beanbag on the tip, one draws the clock card for "morning" on the group's record. Swap jobs so everyone has one turn.
3. Ask each group: "Is the shadow long or short? Which way is it pointing? Point to something the shadow points at (the fence, the gate, a tree)."
4. Children stand with their backs to the Sun, look at their own shadow, and say which way it points. Never turn round to look at the Sun.

5. Predict together: "When we come back at midday, will the shadow be in the same place? Longer or shorter?" Write the class's guesses on the chart, all of them, without saying which is right.
6. At midday and again in the afternoon (about 5 minutes each), groups return, check that the post is still on its tape, and draw the new shadow in the second and third colours.

✓ Discussion questions (5 min, with answers)

Do these after the afternoon visit, in the classroom.

- Did the shadow stay in the same place? (No; it moved, and changed length.)
- Did the post move? (No, it stayed on the tape.) So what moved? (The light, the Sun, seemed to move across the sky.)
- When was the shadow shortest? (Usually around the middle of the day, when the Sun is highest in the sky.)

✓ Closing check (5 min, with answers)

Show the three shadow picture cards. "Which picture shows the morning shadow? Which the middle of the day? Which the afternoon?" Accept answers that match what the class saw: the longest shadows early and late, the shortest near the middle of the day, the morning and afternoon shadows pointing different ways. Ask: "Did the Sun move or the post?" (The Sun seemed to move; the post did not.)

Vocabulary

shadow, sky, morning, midday, afternoon, long, short, move

Differentiation

- Support: one job only (beanbag on the tip); compare just two marks, morning and afternoon, with "Is it the same place or a different place?"
- Stretch: predict where the next shadow will be by placing the beanbag before drawing it, then check.
- Early finishers: draw the post and all three shadows from above on paper.

⚠ Safety

- Never look at the Sun, directly or through sunglasses, binoculars, a phone screen or anything else. Children stand with their backs to it.
- Sun protection and water as your school requires; keep outdoor visits short in cold weather.
- Posts must not be sharp at the top; use a ruler or a stick with a blunt end, held in plasticine or a cone.

Access

- Blind or low-vision children: lay a long strip of masking tape along each shadow so it can be felt, and put a beanbag on each tip; they can feel that the beanbags are in different places. A partner can describe the shadow.
- Children who use a wheelchair or cannot crouch: put the post on a table or a sunny windowsill at a reachable height, with paper under it.
- Non-speaking children: point to the picture card or the beanbag; answers by pointing count fully.
- Deaf children: show the "never look at the Sun" rule as a picture card (a crossed-out eye looking at the Sun) and sign or gesture it.

Teacher notes

- If the day turns cloudy, mark what you have and finish another sunny day with the posts back on their taped squares. A window shadow (the frame on the floor) can be marked with tape instead.
- Children do not need to know that the Earth turns; the grade 1 aim is to describe the pattern. If someone asks, "Scientists found out the Sun only seems to move, because the Earth is spinning" is fine; do not test it.
- Do not tell children which compass direction the shadows point; it depends on where you are and the time of year.

Lesson 2: Up, across and down

Unit overview - Previous: Lesson 1 - Next: Lesson 3

Goal: Children describe the daily pattern of the Sun: it seems to rise in one part of the sky, move across the sky, and set in another part. They use the pattern to predict where the Sun will be tomorrow.

Length: about 40 minutes.

Materials

- The class shadow chart from lesson 1, and a photo or drawing of each group's three chalk shadows.
- A "window view" picture: a large drawing of what the class sees from one window (buildings, trees, hills), drawn by the teacher before the lesson. Mark on it, from the teacher's own checking or a sunrise app, the side where the Sun comes up and the side where it goes down at this time of year.
- A yellow card circle (the "card Sun") on a stick.
- Per pair: a set of six picture cards of one made-up place, Little Hill, on one day: dark with stars; Sun just above the hills on one side; Sun higher; Sun high in the middle; Sun lower on the other side; Sun just going down behind the hills. Cards are drawn so the hills and houses are the same in every picture.
- Per pair: a strip of card with six empty boxes to put the cards in order.
- Tactile version for blind or low-vision children: the same six cards with a raised felt circle for the Sun and a string line for the hills.
- Picture of the Sun with a "never look" cross, from lesson 1.

Steps

✎ Opening (5 min)

Look at the lesson 1 chart. "The post stayed still, but the shadow moved. What was moving?" (The Sun seemed to.) "Where do you think the Sun was first thing in the morning, before school?" Take a few ideas.

✎ Main activity (25 min)

1. Show the window view picture. Use the card Sun on its stick to show its path: low on the sunrise side early in the morning, higher towards the middle of the day, lower on the other side in the afternoon, gone below the edge at sunset. Children trace the path in the air with a finger.
2. Children act it out: crouch low (sunrise), stand up slowly with arms up (midday), sink down on the other side (sunset), then curl up (night). Do it twice, slowly. Anyone may do it sitting, with arms only.
3. Pairs put the six Little Hill cards in order on their strip, from dark to dark again. Ask each pair: "How did you know which came next?"
4. Pairs check against each other: are the strips the same?

5. Ask: "Tomorrow morning, where will the Sun be?" (Low on the sunrise side again.) "How do you know?" (Because it happens every day; it is a pattern.) If you can, check the prediction tomorrow with one quick look at a shadow post (lesson 1 positions).

✓ Discussion questions (5 min, with answers)

- Does the Sun come up on the same side every day? (Yes, roughly the same side, so we can predict it.)
- Where does the Sun go at night? (It goes below the edge of what we can see; it is still there, but we cannot see it from here.)
- What is a pattern? (Something that happens again and again in the same way, so we can say what comes next.)

✓ Closing check (5 min, with answers)

Hold up two of the Little Hill cards out of order (for example "Sun high in the middle" and "Sun just above the hills on one side"). "Which comes first in the day?" (The low one on the sunrise side.) Then: "What comes after the Sun goes down?" (Night, dark.) Children answer by pointing to a card, holding up a finger for "first" or "second", or saying it.

Vocabulary

rise, set, sunrise, sunset, across, pattern, predict

Differentiation

- Support: use three cards only (rising, high, setting).
- Stretch: draw a seventh card for "next morning" and say why it looks like the first sunrise card.
- Early finishers: draw your own window view and add the Sun's path.

⚠ Safety

- The card Sun is for showing the path; children never look at the real Sun to check it.
- Acting out: keep clear space around each child; arms only for anyone who prefers it.

Access

- Blind or low-vision children use the tactile cards; feeling the felt circle go from low to high to low tells the same story.
- Children with limited arm movement can say or point "low, high, low" instead of acting it.
- Non-speaking children: ordering the cards is the answer; no words needed.

Teacher notes

- Say "seems to rise" and "seems to move" at least sometimes; the Sun does not move round us, but grade 1 does not need the reason.
- The sunrise and sunset side change a little through the year, so do not name a fixed compass point; "roughly the same side" is accurate.
- Little Hill is made up so that no child is asked about their own home, bedroom window or morning.

Lesson 3: The Moon has patterns too

Unit overview - Previous: Lesson 2 - Next: Lesson 4

Goal: Children find that the Moon also seems to rise, move across the sky and set, that it can sometimes be seen in the daytime, and that its shape seems to change over about four weeks and then start again.

Length: about 40 minutes.

Materials

- Moon picture cards (drawn by the teacher, or printed from a source your school may use): eight pictures of the Moon's shape a few days apart, from a thin curve, through a half, to a full circle, and back to a thin curve on the other side.
- Per group of four: one set of the eight Moon shape cards, and a strip with eight boxes to put them in order.
- Tactile Moon cards: the same eight shapes cut from thick card or foam so the shape can be felt.
- The Little Hill sky strip from lesson 2, and a white card Moon on a stick.
- A "Moon at night, Moon in the day" pair of pictures: Little Hill at night with the Moon, and Little Hill in the morning with a pale Moon in a blue sky.
- Optional: a morning outdoor look when a Moon calendar shows the Moon is up in daylight (see Teacher notes).

Steps

✎ Opening (5 min)

"We found a pattern for the Sun. Does the Moon have patterns too?" Show the two Little Hill pictures. "Which one is wrong, the Moon in the day or the Moon at night?" Let children argue it; do not answer yet.

✎ Main activity (25 min)

1. Tell the class: "Both are right. The Moon also seems to come up, move across the sky and go down. Some days it is up at night, some days it is up in the daytime, and some days both." Move the card Moon along the lesson 2 path to show it.
2. If the Moon is up in the morning sky today (checked beforehand), go outside for five minutes and find it. Stand with backs to the Sun. Ask: "What shape is it today?"
3. Groups get the eight Moon shape cards, mixed up. "These pictures were made a few days apart. Can you put them in an order where each one changes only a little?" Groups try.
4. Show one correct order (thin curve, bigger, half, bigger, full, smaller, half, thin curve on the other side). Groups check theirs. Any order that grows and then shrinks step by step is a good try.

5. "What will come after the last card?" (It starts again: a new thin curve.) This is a pattern that takes about four weeks.

✓ Discussion questions (5 min, with answers)

- Can we see the Moon in the day? (Sometimes, yes.)
- Does the Moon always look the same shape? (No; it seems to change, then starts again.)
- Does the Moon make its own light? (No; this was in the sound and light unit. The Sun's light shines on it. Accept "the Sun lights it up".)

✓ Closing check (5 min, with answers)

Give each child three Moon cards from the middle of the set: half, bigger than half, full. "Put them in order so the Moon gets bigger." (Half, bigger than half, full.) Then hold up the "Moon in the day" picture: "Is this possible?" (Yes.)

Vocabulary

Moon, shape, full, half, curve, daytime, night-time, pattern

Differentiation

- Support: order only three cards (thin, half, full).
- Stretch: after ordering the cards, say how many "steps" it takes to get back to the first shape.
- Early finishers: draw tonight's Moon from the Moon calendar picture the teacher shows; nobody is asked to look at home.

⚠ Safety

- It is safe to look at the Moon. If the Moon is near the Sun in the sky, do not look for it; go back in.
- Outdoor visits: sun protection and water as your school requires.

Access

- Blind or low-vision children use the foam Moon cards and feel the shapes grow and shrink.
- Children who cannot go outside or cannot see the sky: show a photo of the daytime Moon that the teacher took, or a picture from a source your school may use.
- Non-speaking children: ordering cards and pointing to "yes" or "no" cards count fully.

Teacher notes

- Check a Moon calendar before this lesson. In the days after a full Moon the Moon is often still up in the morning sky, and in the days before a half Moon it is often up in the afternoon.
- Grade 1 does not need names for the shapes or the reason they change. "The Moon seems to change shape" is enough. Do not say the Earth's shadow causes the shapes; it does not.
- Looking at the Moon at home is optional and never set as homework, because some children cannot go out after dark or have no view of the sky.

Lesson 4: Where are the stars in the day?

Unit overview - Previous: Lesson 3 - Next: Lesson 5

Goal: Children say that stars (other than the Sun) can be seen at night but not in the daytime, and use a model to show that a small light is hard to see when everything around it is bright.

Length: about 40 minutes.

Materials

- Two pictures of the same Little Hill sky: one at night with the Moon and many stars, one in the daytime with the Sun (shown in the corner) and a blue sky with no stars.
- One small LED torch per group (battery cover screwed shut), or one battery tea-light per group.
- Per group: one peep box from the sound and light unit (lid taped, flap at the far end), with a small battery tea-light or a small LED stuck inside instead of the toy, switched on.
- About 10 glow-in-the-dark stars, charged under a lamp before the lesson, stuck to a large black card.
- A way to make part of the room darker: blinds, or a table with a thick blanket over it to make a "night tent".
- Sorting mat with two halves, "seen in the day" and "seen at night", and picture cards: Sun, Moon, stars, clouds, rainbow, birds.
- Sound model for blind or low-vision children (and useful for everyone): a quietly ticking kitchen timer or a small bell, and a few minutes of recorded or played music at a comfortable volume.

Steps

✎ Opening (5 min)

Show the two Little Hill pictures. "In the night picture there are lots of stars. In the day picture there are none. Where did the stars go?" Take ideas and write them down, without saying which is right.

✎ Main activity (25 min)

1. Model with a torch: in the bright classroom, a child switches a torch on and off, pointed at the floor. "Is it easy to see if it is on?" (Hard, or a little.) Then do the same inside the night tent or with the blinds down. (Easy.)
2. Peep boxes: each group looks at the small light inside their box, first with the flap open (light pouring in), then with the flap shut (dark inside). "When could you see the little light better?" (With the flap shut, when it was dark around it.)
3. Glow stars: hold up the black star card in the bright room; then turn off the lights and close blinds (or put it in the night tent). "Are there more stars or fewer when it is dark?" (We can see more, or see them better.)
4. Tell the class: "Scientists say the stars are still in the sky in the day. The Sun's light is so bright that we cannot see them, just like the little light in the box with the flap open."

5. Sorting: groups sort the picture cards onto "seen in the day" and "seen at night". The Moon can go on both, or across the middle. Ask: "Where did you put the stars? Why?"

✓ Discussion questions (5 min, with answers)

- When can we see stars? (At night, when it is dark.)
- Why can't we see them in the day? (The Sun makes the sky too bright.)
- Is the Sun a star? (Yes; it is the star closest to us. Accept "yes" with no reason.)

✓ Closing check (5 min, with answers)

Hold up the day picture and the night picture. "Point to the picture where we can see stars." (Night.) "Are the stars still there in the day picture?" (Yes, but the Sun's light is too bright to see them.) Answers by pointing, a thumbs up or down, or words all count.

Vocabulary

star, night, daytime, bright, dark, model

Differentiation

- Support: sort only Sun, Moon and stars.
- Stretch: explain to a partner why the torch model is like the sky.
- Early finishers: draw the same view by day and by night.

⚠ Safety

- Torches point at the floor or into the box, never into anyone's eyes.
- Darkened room: clear the floor first, keep a light on near the door, and let any child who dislikes the dark sit by the door or stay in the light; looking from the edge counts.
- Battery tea-lights only, no real candles. Battery covers screwed shut.

Access

- Blind or low-vision children use the sound model: listen for the quiet ticking timer in a silent room (easy), then while music plays at a comfortable volume (hard). The timer did not stop; the louder sound hid it, as the Sun's light hides the stars. Say that this is a model with sound, not light.
- Children who find dark spaces upsetting watch the glow stars from the door or by a window; joining in is optional.
- Non-speaking children sort cards and point; no words needed.

Teacher notes

- The assessment boundary for this standard is only that stars are seen at night and not in the day. Do not test star patterns or names.

- A few very bright planets and the Moon can sometimes be seen by day; do not use them as a "trick" question at this age.
- Some children live where city lights hide most stars; "people far from bright lights see many more" is a kind way to say it.

Lesson 5: Long days and short days

Unit overview - Previous: Lesson 4

Goal: Children compare the amount of daylight at two times of year and say that there is less daylight in winter than in spring, summer or autumn. They start a class sky diary to check this themselves later in the year.

Length: about 40 minutes.

Materials

- Two Little Hill day strips, each a long paper strip split into a row of equal boxes from "wake up" to "bed time" for one made-up child, Pip: one strip for a winter school day, one for a spring school day. Boxes are coloured yellow (light outside) or dark blue (dark outside). In the winter strip, the first boxes (getting up, breakfast) and the last boxes (going home, tea, bed) are dark blue; in the spring strip most boxes are yellow and only bed time is dark blue.
- Per pair: small copies of both strips, and a picture card set of Pip's day (wake up, breakfast, walk to school, playtime, home time, tea, bath, bed), the same for both seasons.
- Tactile strips: the yellow boxes covered in smooth paper, the dark blue ones in rough sandpaper or felt.
- Two photos the teacher took of the same view at the same clock time in the early evening (for example 5 o'clock): one taken now (winter or late autumn) and one from earlier in the year, or a drawing of the same view in spring if no photo exists.
- A large class "sky diary" sheet with one row for each week until the end of term 3. Each row is a blank day strip of equal boxes, one box for each hour from 6 in the morning to 8 in the evening (no numbers needed on the children's copy).
- Sunrise and sunset times for your town each week, from a weather service or almanac your school uses; only the teacher uses the times.
- Yellow and dark blue counters, and yellow and dark blue crayons or stickers.

Steps

✎ Opening (5 min)

Show the two window photos. "These were taken at the same time on the clock. What is different?" (One is darker.) "Why might that be?" Take ideas.

✎ Main activity (25 min)

1. Show the two big Pip strips. Read the winter one together: "When Pip wakes up, is it light or dark outside?" (Dark.) "At home time?" (Getting dark, or dark.) Then the spring strip.
2. Pairs lay their small strips one above the other. "Which strip has more yellow?" (Spring.) "Which has more dark blue?" (Winter.) Children may count boxes to check; the answer is "more" or "less", not hours.

3. Pairs use the Pip picture cards: for each card, they put a yellow or blue counter on it for winter, then for spring. "Which parts of Pip's day change?" (The early morning and the evening.)
4. Start the class sky diary: the teacher reads this week's sunrise and sunset times (to themself) and children colour this week's row, yellow for the boxes between sunrise and sunset and dark blue for the rest. The teacher helps with the box where the change happens. Each week one child colours the new row in the same way.
5. Predict together: "When we colour the row in the spring term, will it have more yellow or less?" Write the prediction on the sheet.

✓ Discussion questions (5 min, with answers)

- In winter, is there more daylight or less? (Less.)
- In spring, is there more daylight or less than in winter? (More.)
- Why were both photos taken at the same time on the clock? (So the only big difference is the time of year; if they were taken at different times of day, we could not tell whether the season made the difference.)

✓ Closing check (5 min, with answers)

Give each child the two small Pip strips without labels. "Point to the winter day." (The one with more dark blue.) "Which day has more light?" (The spring day.) Then: "What do you think our sky diary will show in spring?" (Longer yellow rows: more daylight.)

Vocabulary

daylight, winter, spring, summer, autumn, season, more, less, compare

Differentiation

- Support: compare only two picture cards, "walk to school" and "home time", for winter and spring.
- Stretch: draw Pip's strip for a summer day and say how it is different from spring.
- Early finishers: decorate the sky diary sheet border with Sun, Moon and stars.

⚠ Safety

- No one looks at the Sun when checking the sky for the diary.
- Never ask children what time they get up, go to bed, or whether they go out after dark; use Pip.

Access

- Blind or low-vision children use the tactile strips: rough boxes for dark, smooth for light. "More rough" means "more dark".

- Children with colour vision differences: the blue boxes also carry a small moon symbol and the yellow boxes a small sun symbol.
- Non-speaking children point to the strip or place counters.

Teacher notes

- In the southern hemisphere the seasons fall in different months: swap the order so the diary runs from the darker season to the lighter one, and check that "term 2" really is the winter part of your year.
- The assessment boundary for this standard is relative amounts of daylight: more or less, not hours or minutes. Counting boxes is a comparison tool, not a measurement of hours.
- Near the equator, daylight changes very little through the year; if that is your class, compare Little Hill (made-up, far from the equator) with your own diary and say "in some places it changes a lot, here it hardly changes".
- Come back to the sky diary in term 3 and compare the rows. Many school days begin and end in daylight, so the diary uses sunrise and sunset times rather than asking children to look outside before or after school.

Grade 2 Science: Solids, Liquids and Melting Ice (5 lessons, about 2-3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 4 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.

Back to the science progression

Big idea

Materials around us can be solids or liquids. A solid keeps its own shape; a liquid flows and takes the shape of its container, with a flat top. Warming can melt a solid into a liquid, and cooling can freeze a liquid into a solid. Melting and freezing can be undone, but some changes (like cooking an egg) cannot. Some coverings slow down melting by keeping warmth out.

Outcomes

By the end of the unit a student can:

1. Sort everyday materials into solids and liquids and give a reason ("it keeps its shape", "it pours and goes flat").
2. Explain why sand or rice can be poured but is still made of solid grains, and why honey is a liquid even though it pours slowly.
3. Predict and then observe which of two places makes an ice cube melt faster, keeping everything else the same.
4. Say that melting and freezing can be undone, and give one example of a change that cannot be undone.
5. Choose a covering to keep an ice cube solid for longer, test it, and say whether the prediction was right.
6. Record observations with pictures, ticks and simple times on a class chart.

Prior knowledge

- Children have seen ice, water, rain and puddles.
- Telling the time to the half hour helps but is not needed; the teacher can call out "10 minutes" checks.
- Simple "I think... / I saw..." talk from kindergarten and grade 1 science.

Lessons

Lessons are 30-40 minutes. Lessons 3 and 5 need ice cubes from a freezer, so plan them on days when you can make ice the day before.

1. Solid or liquid? - feel, pour and sort a tray of materials.
2. Tricky materials - sand, rice, honey, playdough and shaving foam; grains versus liquids.
3. Where does ice melt fastest? - a fair test with ice cubes in a warm spot and a cool spot.
4. Can we undo it? - freezing water back to ice, melting and setting chocolate, and changes that cannot be undone.

5. Ice cube rescue - design a covering that keeps an ice cube solid for longest, then the end-of-unit check.

Materials

For a class of about 25 in groups of 4-5:

- Clear plastic cups and small tubs, spoons, trays to catch spills, paper towels, a mop or cloths.
- Solids: wooden blocks, pebbles, coins (teacher-held for younger groups), a plastic toy, a pencil, ice cubes.
- Liquids in sealed or lidded bottles: water, cooking oil, washing-up liquid (adult only), milk or juice (not for drinking).
- Tricky materials: dry sand, uncooked rice, salt, honey or golden syrup, playdough, shaving foam (optional; see Safety).
- Ice: about 3 trays of cubes made the day before, all the same size.
- Small plates or saucers (identical), a timer, class chart paper.
- Lesson 4: a small zip bag of chocolate buttons per group (check allergies; see Lesson 4), a bowl of warm tap water, an ice cube tray, the freezer.
- Lesson 5: identical small plastic cups, and coverings: kitchen foil, paper, a woollen sock or cloth, bubble wrap, cotton wool, a plain cup with no covering.

Assessment

- Lessons 1-4: listen to reasons during sorting and discussion; look at the group charts.
- Lesson 5: an 8-question end-of-unit check (16 marks) in Lesson 5. It is formative: use it to see what to revisit, not to grade children.

Sources

- Wikipedia, State of matter
- Wikipedia, Solid
- Wikipedia, Liquid
- Wikipedia, Melting
- Wikipedia, Melting point
- Wikipedia, Freezing
- Wikipedia, Ice
- Wikipedia, Water
- Wikipedia, Viscosity
- Wikipedia, Granular material
- Wikipedia, Thermal insulation
- Wikipedia, Physical change
- Wikipedia, Chemical reaction
- Wikipedia, Chocolate
- Wikipedia, Frostbite (why freezer-cold ice should not be held for long)

Known gaps and cautions

- Gases are left out on purpose. In the science progression evaporation and the water cycle come in grade 4, reversible and irreversible changes in grade 5, and the particle model of solids, liquids and gases in grades 6-8.

- "Solid" and "liquid" are simplified. Thick or odd materials (shaving foam, slime, toothpaste) do not fit neatly; the unit treats them as talking points, not as a test of right answers.
- "Can be undone" and "cannot be undone" are the words used here instead of "reversible" and "irreversible". Melting chocolate can change its texture (it may set dull or streaky), so "undone" means back to a solid, not perfect.
- Melting times depend on the room, the sun and the ice size. Compare results within one class on one day only.
- No images yet. No educator review.

Lesson 1: Solid or liquid?

Back to the unit

Goal

Children sort everyday materials into solids and liquids and give a reason: a solid keeps its own shape; a liquid pours, takes the shape of its container and has a flat top.

Materials

- Per group, on a tray: a wooden block, a pebble, a plastic toy, a pencil, a lidded bottle of water, a lidded bottle of cooking oil, a lidded bottle of milk or juice (not for drinking).
- Per group: three clear containers of different shapes (a tall cup, a wide tub, a small bowl), paper towels.
- Two sorting hoops or two large sheets labelled with a picture of a block ("solid") and a picture of a drop ("liquid").
- Class chart with two columns: "Keeps its shape" and "Pours and goes flat".

Steps

✎ Opening (5 minutes)

Hold up a wooden block and a cup of water. Ask: "If I tip these over, what happens to each one?" Tip the block onto the tray (it stays a block). Pour a little water onto a tray (it spreads out). Ask children to describe what they saw.

✎ Main activity (20 minutes)

1. Groups take each solid object and try to put it into each of the three containers. Does the object change shape to fit? (No - it stays the same.)
2. The teacher, or a careful child with the teacher holding the cup, pours the same bottle of water into the tall cup, then into the wide tub, then into the bowl. Children watch the water change shape every time.
3. Children look at the water from the side, with eyes level with the cup: the top is flat, even when the cup is tipped a little.
4. Groups place each material in the "solid" or "liquid" hoop. Each child says one reason using the sentence starter "It is a solid/liquid because it...".
5. The class fills in the chart together.

✓ Discussion questions (with example answers)

- **What did the water do when we poured it into a different cup?** It changed shape to fit the cup. It went flat on top.
- **Did the block change shape in the tall cup?** No. It stayed a block. It just sat there.

- **Is the milk a solid or a liquid? How do you know?** A liquid, because it pours and takes the shape of the bottle.
- **Can you think of a solid in our classroom? A liquid at home?** Solid: chair, book, door. Liquid: water, juice, bath water, shampoo.

✓ Closing check (5 minutes, with answers)

Show pictures or real items; children show thumbs up for solid, thumbs to the side for liquid:

1. A spoon - solid.
2. Orange juice - liquid.
3. A brick - solid.
4. Rain - liquid.
5. An ice cube - solid (it keeps its shape, for now - "we will find out more about ice soon").

Vocabulary

solid, liquid, shape, pour, flow, container

Differentiation

- **Extra support:** use only the hoops and pictures; sentence starter printed on a card; work with an adult in a small group.
- **Extra challenge:** "Is a pile of paper clips a solid or a liquid? It takes the shape of the box!" (Each clip is a solid; the pile only looks like it pours.) This leads into Lesson 2.

⚠ Safety

- Keep liquids in lidded bottles; open only for pouring, over a tray.
- No tasting or drinking any material, even milk or juice.
- Mop spills at once; wet floors are slippery.
- Cooking oil makes floors very slippery; pour it only over a tray, or keep that bottle closed and just tip it to watch.
- Small objects (coins, pebbles) can be choking hazards; count them back in.

Teacher notes and common misconceptions

- Children often say a liquid is "wet" and a solid is "hard". Accept these as starting points, but steer towards shape: soft solids (a sponge, cloth) are still solids, and some liquids (oil) do not feel "wet" in the same way.
- Some children think a liquid has no shape. It does - it borrows the shape of whatever it is in, apart from the flat top.

Lesson 2: Tricky materials

Back to the unit

Goal

Children explore materials that do not fit the solid/liquid sort easily. They learn that sand, rice and salt can be poured but are made of tiny solid grains, and that honey is a liquid even though it flows slowly.

Materials

- Per group, on a tray: a cup of dry sand, a cup of uncooked rice, a small cup of salt, a lidded jar of honey or golden syrup, a ball of playdough, two spoons, a magnifying glass, a dark sheet of card.
- Optional (teacher demonstration only): a can of plain shaving foam.
- The class chart from Lesson 1, plus a third column: "Not sure - let's talk".

Steps

✎ Opening (5 minutes)

Pour rice slowly from one cup into another. Ask: "Is rice a liquid? It pours!" Take a show of hands. Do not give the answer yet.

✎ Main activity (25 minutes)

1. **Grains.** Groups sprinkle a few grains of rice, sand and salt onto the dark card and look with the magnifying glass. Ask: does each grain keep its own shape? (Yes.) Can you press one grain and change its shape? (No.)
2. **Piles.** Groups pour sand onto the tray. Does it go flat like water? (No - it makes a heap with sloping sides.) Pour water beside it for comparison, over the tray.
3. **Slow flow.** Groups tip the closed honey jar and watch it move. Then the teacher spoons a little honey onto a plate: it slowly spreads out and goes flat. Honey is a "thick" liquid; it is slow, but it still flows and takes the shape of the plate.
4. **Squash it.** Children squash and roll playdough. It changes shape when pushed, but when you stop pushing it stays in its new shape - it does not flow by itself. It is a soft solid.
5. **Optional demonstration.** The teacher squirts a little shaving foam on a tray. Is it a solid or a liquid? Let children argue; put it in the "Not sure" column. (It is a foam, mostly gas bubbles trapped in a liquid; it is fine for it to stay "not sure".)
6. Update the class chart.

✓ Discussion questions (with example answers)

- **Rice pours. Why isn't it a liquid?** Because each grain is a tiny solid that keeps its shape. The pile makes a heap; it doesn't go flat.
- **Honey is slow. Why is it a liquid?** Because it flows by itself and goes flat on the plate, just slowly.
- **Playdough changes shape. Why is it a solid?** Because it only changes when we push it, and then it stays. It doesn't pour.
- **What would happen to sand in a cup if you looked very closely?** You'd see lots of tiny solid bits with air between them.

✓ Closing check (5 minutes, with answers)

Children answer on whiteboards with S (solid) or L (liquid):

1. Sugar - S (tiny solid grains).
2. Ketchup - L (a thick liquid; it flows slowly).
3. Flour - S (very tiny solid grains).
4. Shampoo - L.
5. A ball of clay - S.

Vocabulary

grain, heap, thick, runny, flow, soft solid

Differentiation

- **Extra support:** focus on two materials only (rice and honey) and the question "does each bit keep its shape?".
- **Extra challenge:** "Why does a big heap of sand slope at the sides but water goes flat?" Accept ideas such as "the grains lean on each other".

⚠ Safety

- No tasting. Uncooked rice and dried foods are not snacks.
- Keep sand away from faces and eyes; pour low, over trays. If sand gets in an eye, do not rub; rinse with clean water and tell an adult.
- Salt stings cuts and eyes; wash hands after the lesson.
- Check allergies before using honey, flour or playdough (playdough often contains wheat).
- Shaving foam: teacher only, plain unscented if possible; keep it away from eyes and mouths; check skin allergies before letting anyone touch it.
- Sweep up spilled sand and rice at once - they are slippery underfoot.

Teacher notes and common misconceptions

- "If it pours, it's a liquid" is the main misconception to tackle. The grain test (does each piece keep its shape?) and the heap test (does it go flat?) are the two simple checks.
- "Thick" and "runny" are fine everyday words for what scientists call viscosity. There is no need to introduce that word.
- Some materials genuinely do not fit (foams, gels, slime). Saying "scientists have extra names for these" is honest and enough at this age.

Lesson 3: Where does ice melt fastest?

Back to the unit

Goal

Children carry out a simple fair test: two identical ice cubes on identical plates, one in a warm spot and one in a cool spot. They predict, observe at regular times and say what they found. They learn that warmth makes ice melt into water.

Materials

- Ice cubes made the day before in the same tray, so they are the same size (2 per group, plus spares).
- Per group: two identical small plates or saucers, two labels ("warm" and "cool"), a recording sheet (see below), a pencil.
- A warm spot: a sunny windowsill, or a table about one metre from a heater (never on or touching the heater).
- A cool spot: a shady corner, a table by an outside wall, or a corridor.
- A timer or the classroom clock; a thermometer is optional, for the teacher to show which place is warmer.

Recording sheet: a table with rows "Start", "10 minutes", "20 minutes", "30 minutes", "40 minutes" and columns "Warm spot" and "Cool spot". In each box children draw the cube and puddle, or tick one of three pictures: "all ice", "some ice and water", "all water".

Steps

✎ Opening (5 minutes)

Show an ice cube on a plate. Ask: "Is this a solid or a liquid?" (Solid.) "What will it be like at home time?" (Water, a liquid.) Ask: "Could we make it change faster or slower?" Collect ideas.

✎ Main activity (30-40 minutes, with other work between checks)

1. Explain the fair test: "We will change only ONE thing - where the plate goes. Everything else stays the same: the same size ice cube, the same kind of plate, the same start time."
2. Each child predicts which cube will melt first by putting a sticker or name on "warm" or "cool" on a class prediction chart.
3. At the same moment, an adult puts one cube on each plate. Groups carry the "warm" plate to the warm spot and the "cool" plate to the cool spot.
4. Children draw the "Start" row.
5. Every 10 minutes, groups look (without touching the ice) and record. The class can do quiet work between checks.
6. Stop when the first cube is all water, or after 40 minutes, whichever comes first.

✓ Discussion questions (with example answers)

- **Which cube melted faster? Was your prediction right?** Usually the warm spot. "I thought warm, and I was right." It is fine to be wrong; say so.
- **Why did we use the same size ice cubes and the same plates?** So it was fair; only the place was different, so the place made the difference.
- **Where did the ice go?** It didn't disappear - it turned into water, the puddle on the plate.
- **What could you do to make ice melt even more slowly?** Put it in a colder place, or wrap it up (this leads to Lesson 5).

✓ Closing check (5 minutes, with answers)

1. What does warmth do to ice? It makes it melt into water.
2. Is the puddle a solid or a liquid? A liquid.
3. In our test, what was the one thing we changed? Where we put the plate.
4. Name one thing we kept the same. The size of the ice cube / the type of plate / the start time.

Vocabulary

melt, warm, cool, fair test, predict, observe

Differentiation

- **Extra support:** use only the three-picture tick boxes; an adult reads the time.
- **Extra challenge:** add a third plate (e.g. a metal tray in the cool spot) and ask whether the plate makes a difference. Discuss that this is a second test, because now two things could change.

⚠ Safety

- Ice straight from a freezer can stick to skin and cause a cold burn. Let cubes sit on the plate for a minute before anyone touches them, and touch only briefly.
- Ice is not for eating in class (choking risk; classroom trays and hands are not clean).
- Never put plates on or against heaters, radiators or lamps.
- Carry plates slowly and level; wipe up meltwater at once (slip risk).
- Windowsills: no climbing; an adult places and moves the plates if the sill is high.

Teacher notes and common misconceptions

- Some children think the ice "disappears" or "goes into the plate". Point to the water: the same stuff, now a liquid. You can weigh a cube in a cup before and the water after on kitchen scales if you have them: the amount is about the same.
- "Cold makes ice" is true, but "cold goes into things" is a common idea. Keep the talk about warmth: warmth from the room or the Sun goes into the ice and melts it. Coverings keep warmth out (Lesson 5).

- On a cold, cloudy day, the difference may be small. That is still a result; talk about why.

Lesson 4: Can we undo it?

Back to the unit

Goal

Children see that melting and freezing can be undone: water freezes to ice and ice melts to water; chocolate melts in warm water and sets solid again when cooled. They compare this with changes that cannot be undone, such as cooking an egg or toasting bread.

Materials

- The day before: children help pour water into an ice cube tray; the teacher puts it in the freezer. Also keep one cup of water from the same jug in the classroom, for comparison.
- Per group: a small zip-lock bag with 4-5 chocolate buttons, sealed and with the air pressed out; a bowl of warm tap water (adult-filled; it should feel comfortably warm on the back of a hand, like a bath, not hot); a paper plate; a cool place or fridge for later.
- **If any child has a milk, soy or nut allergy, or chocolate is not allowed:** use a small piece of plain ice lolly made from fruit juice instead, or keep the chocolate as a teacher-only demonstration in a sealed bag. Check your school's food policy first.
- For "cannot be undone": a raw egg (in its shell) and a hard-boiled egg cooked at home by an adult and cooled; a slice of bread and a slice of toast made before the lesson. Pictures are fine instead.
- Class chart with two columns: "Can be undone" and "Cannot be undone".

Steps

✎ Opening (5 minutes)

Take out the frozen tray. Compare the ice with the cup of water saved from yesterday. Ask: "What changed? How did it change?" (It got very cold in the freezer and turned solid.) Ask: "Can we turn it back into water?"

✎ Main activity (25 minutes)

1. **Ice back to water.** Put two of the new ice cubes on a plate in the warm spot from Lesson 3. They will melt during the lesson. Water became ice, and ice becomes water again.
2. **Chocolate.** Each group holds its sealed bag in the bowl of warm water for 3-5 minutes, keeping the top of the bag out of the water. Children watch the solid buttons go soft and runny. Ask: "Is it a solid or a liquid now?"
3. Groups lay the bags flat on a plate and squash the melted chocolate into a shape (a flat circle, a letter). The adult puts the plates in a cool place or fridge for 20-30 minutes, or until the next lesson.
4. **Cannot be undone.** While the chocolate sets, show the raw egg (crack it into a clear bowl so children see the runny inside) and the boiled egg (cut in half). Ask: "Could we turn the cooked egg back into a runny egg?" (No.) Do the same with bread and toast.

5. Check the chocolate: it is solid again, in its new shape. Fill in the class chart.

✓ Discussion questions (with example answers)

- **What made the chocolate melt?** The warm water warmed it up.
- **How did we make it solid again?** We let it cool down in a cool place or the fridge.
- **Can you un-cook an egg? Why not?** No. Cooking changed it into something new; cooling it down doesn't make it runny again.
- **Is melting ice something we can undo?** Yes - put the water in the freezer and it turns back into ice.

✓ Closing check (5 minutes, with answers)

Thumbs up for "can be undone", thumbs down for "cannot be undone":

1. Water freezing into ice - can be undone.
2. Baking a cake - cannot be undone.
3. Butter melting in a warm room - can be undone (it goes solid in the fridge).
4. Burning a piece of paper - cannot be undone (adult-only; do not demonstrate).
5. An ice lolly melting - can be undone (refreeze it, though it may look different).

Vocabulary

freeze, melt, set, cool down, warm up, can be undone, cannot be undone

Differentiation

- **Extra support:** use only ice and chocolate; ask "solid or liquid now?" at each step.
- **Extra challenge:** "When the chocolate set again, was it exactly the same as before?" (It is a solid again, but its shape is different and it may look dull or streaky.) Is it still "undone"?

⚠ Safety

- Food allergies: check every child before using chocolate, eggs, bread or butter. Follow your school's food policy.
- No eating in this lesson. Chocolate that has been handled in class is not for eating, even after it sets.
- Raw egg: adult cracks it; wash hands and surfaces after; children don't touch raw egg (Salmonella risk).
- Warm water only, filled by an adult from the warm tap. No kettles, hot plates or candles in the classroom. If the water feels hot, add cold.
- Freezer-cold ice: let it sit a minute before touching (cold burns).
- Zip bags: check seals before dipping; wipe drips at once (slip risk).
- Toast: make it before the lesson; no toaster within children's reach.

Teacher notes and common misconceptions

- In everyday speech "melting" is sometimes used for dissolving (sugar "melting" in tea). Keep "melting" for a solid turning into a liquid because it was warmed. Dissolving comes later (grade 5 in the science progression).
- Children may think the fridge "makes" the chocolate solid. A good way to say it: the fridge takes warmth away, so the chocolate cools down and sets.
- Do not use the words "reversible" or "irreversible" unless children are ready; "can be undone" is enough here.

Lesson 5: Ice cube rescue

Back to the unit

Goal

Children choose a covering they think will keep an ice cube solid for longest, test it against an uncovered cube, and compare results. They learn that some coverings slow melting by keeping warmth out. The lesson ends with the end-of-unit check.

Materials

- Ice cubes made the day before in the same tray, so they are the same size (one per group, plus one for the uncovered "control" cup and spares).
- Identical small plastic cups, one per group plus one.
- Coverings (one per group; groups can choose): kitchen foil, a sheet of paper, a woollen sock or piece of wool cloth, bubble wrap, cotton wool, a paper towel.
- Elastic bands or tape to hold coverings in place.
- A warm spot (as in Lesson 3), a timer, a class results chart.
- A copy of the end-of-unit check per child (or read aloud).

Steps

✎ Opening (5 minutes)

Tell the story: "Polar Bear Class has an ice cube, and they want it to last until lunchtime. Can we help them?" Ask what children might wrap it in. Show the coverings.

✎ Main activity (30-40 minutes, including the check while waiting)

1. Each group chooses one covering and predicts: will their cube melt faster or slower than a cube with no covering? Record the prediction on the class chart.
2. An adult puts one ice cube in each cup. Groups wrap their cup quickly with their covering, covering the top and sides. One cup stays uncovered (the control) so everyone can compare.
3. All cups go side by side in the same warm spot at the same time. Ask: "Why do they all go in the same place?" (To keep it fair - only the covering is different.)
4. While waiting, children do the end-of-unit check (below).
5. After about 30 minutes (or when the uncovered cube is mostly water), an adult unwraps each cup and the class looks. Rank the cups from "most ice left" to "least ice left" on the chart.

✓ Discussion questions (with example answers)

- **Which covering kept the most ice?** Often wool, cotton wool or bubble wrap. Results vary; say what your class found.

- **Did any covering make it melt faster than no covering?** Sometimes thin or dark coverings in strong sun do. That is a real result too.
- **Why do you think the woolly sock helped?** It keeps the warmth from the room out, so the ice warms up more slowly.
- **But we wear woolly socks to keep warm! How can wool keep ice cold?** Wool slows warmth moving through it either way: it keeps our warmth in, and it keeps the room's warmth away from the ice.

✓ End-of-unit check (8 questions, 16 marks, with answers)

Read each question aloud. Children answer by circling a picture, writing a word or drawing. Two marks each; one mark for a partly right answer. There is no pass mark: use the results to plan what to revisit.

1. Circle the two liquids: a stone, milk, a pencil, juice. **Answer:** milk, juice (1 mark each).
2. Water is poured from a tall glass into a wide bowl. What happens to its shape? **Answer:** it changes to the shape of the bowl (1) and stays flat on top (1).
3. Sand can be poured. Is sand a solid or a liquid? Why? **Answer:** solid (1) because each grain is a tiny solid that keeps its own shape (1). "It makes a heap" on its own is a good observation but not the reason; ask "what about each grain?" before giving the second mark.
4. Honey pours very slowly. Is it a solid or a liquid? **Answer:** liquid (1) because it flows and goes flat, just slowly (1).
5. Sam puts one ice cube on a sunny windowsill and one in a shady corner. Which melts first? **Answer:** the one on the sunny windowsill (2).
6. In question 5, what must Sam keep the same to make it fair? Name two things. **Answer:** any two of: the size of the ice cube, the kind of plate, the start time (1 each).
7. Can we undo melting ice? How? **Answer:** yes (1); put the water in the freezer / make it very cold (1).
8. Draw or name one change that cannot be undone. **Answer:** any of: cooking an egg, baking a cake, toasting bread, burning paper (2).

Vocabulary

covering, wrap, control, fair test, keep warmth out, melt, solid, liquid

Differentiation

- **Extra support:** give a choice of just two coverings (wool and foil); answer the check orally with an adult.
- **Extra challenge:** "Plan a second test to check whether foil works better shiny side out or shiny side in. What would you keep the same?"

⚠ Safety

- Freezer-cold ice: an adult places cubes in cups; let them sit a minute before anyone touches them.
- Ice is not for eating (choking; not clean).
- Never put cups on or against heaters or lamps.

- Wipe up meltwater at once (slip risk).
- Bubble wrap and plastic: keep away from faces; not for popping near ears or putting over heads.
- Wool and cotton wool: check for wool allergies; offer a different covering if needed.

Teacher notes and common misconceptions

- Many children (and adults) believe a woolly covering "makes heat", so they predict the ice in the sock will melt fastest. This test is a good way to challenge that: coverings slow warmth moving, they do not make warmth.
- Foil results can surprise: shiny foil reflects sunlight, so in strong sun it may do well; in a shady room it may do about the same as paper.
- If time allows, repeat the test another day. Getting the same pattern twice makes a result more trustworthy.

Grade 2 Science: Land and Water, Fast and Slow (5 lessons, about 3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 11 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.
>
> Text-checked by two other agents (Gemini 4 Carbon and Claude Haiku 5.5); see Known gaps.

Back to the grade 2 year plan - Term 2. Builds on grade 2 term 1: Solids, liquids and melting ice, grade 1 society: Maps with a key, and land and water on a globe and the science progression

Big idea

Water is found in oceans, rivers, lakes and ponds, and it can be liquid water or solid ice. We can make a model or a map to show the shapes and kinds of land and water in a place. Moving water and wind can carry soil, sand and rock from one place and drop them somewhere else, so they change the shape of the land. Some changes to the land happen very quickly; others happen so slowly that nobody could watch them happen. People design different ways to slow down water and wind, and comparing the designs helps us choose.

This is the second science unit of grade 2 (term 2). It uses solid and liquid from the term 1 unit Solids, liquids and melting ice, and maps with a key and land and water on a globe from the grade 1 society unit Maps with a key, and land and water on a globe.

Outcomes

By the end of the unit most children can:

1. Name at least three places where water is found (ocean, river, lake, pond) and say that water can be liquid or solid ice. Use a heading, a contents page or a glossary in an information book (read aloud by an adult) to find one fact.
2. Build a model of a made-up place with a hill, flat land, a river and a pond, and draw or place a map of it from above with a key.
3. Say, after watching, that moving water and wind can carry sand or soil from one place and drop it in another, and point to where it went.
4. Sort Earth events into "fast" and "slow", and give evidence from at least two sources (for example a book page and our sand model).
5. Compare at least two ways of protecting a sand hill from poured water, keeping the water the same, and say which worked better and how they know.
6. Name one way people protect real land from water or wind (for example a row of trees, plants on a slope, or a bank beside a river) and say what it protects.

Prior knowledge

- Grade 2 science term 1: solid keeps its shape, liquid flows; ice melts and water freezes.
- Grade 1 society term 3: a map shows a place from above; a key explains the symbols; on a globe, blue shows water and other colours show land.

- Kindergarten and grade 1 science: "I think... / I saw..." talk, and fair tests where only one thing changes.
- No reading is needed. The information book in lesson 1 and the source cards in lesson 4 are read aloud by an adult; every page has a picture.

Lessons

Each lesson is about 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. Teach about two lessons a week. Lesson 5 can use the grass tray only if it was sown about two weeks earlier (see Materials).

1. Where is water found?: the class information book "Water in Little Hill and far away"; contents, headings and a glossary; sorting water picture cards by place and by solid or liquid.
2. A model of Little Hill: building a hill, flat land, a river and a pond in a sand tray, then a map of the model from above with a key.
3. Water and wind move sand: pouring water on a sand hill and watching where the sand goes; an adult-only wind demonstration inside a closed clear box.
4. Fast or slow?: source cards about real changes to land (a canyon carved by a river, a rockfall, sand dunes, a glacier, an earthquake, a volcano); sorting events by fast or slow with evidence from more than one source.
5. Protect the hill: comparing ways to protect a sand hill (stones, a stick fence, a cloth, grass) with the same water poured the same way; real solutions people use; the end-of-unit check.

Materials (whole class unless noted)

- **Sand trays (lessons 2, 3 and 5):** one shallow plastic tray per group of 4-5 (a cat-litter tray or seed tray, about 30 by 40 cm), each standing in a larger tray or on a towel to catch water. Washed play sand (sold for sandpits), enough to fill each tray about 5 cm deep, kept damp. A jug of water and a small cup per group.
- **Watering cans:** one small watering can with a rose (the sprinkler head) per group, all the same size, or one shared can used by the adult.
- Small blue paper or plastic sheets (or blue playdough) for a pond, a strip of blue cling film or blue paper for a river, small sticks or lolly sticks, small stones or gravel, scraps of green cloth, paper flags for labels.
- **Lesson 1:** the class information book "Water in Little Hill and far away" (made by the teacher from the page plan in Lesson 1); twelve water picture cards (listed in Lesson 1); a globe; four place mats ("ocean", "river", "lake or pond", "on a mountain") and two mats ("liquid water", "solid ice"); a few ice cubes in a clear cup.
- **Lesson 2:** the large Little Hill map from grade 1 society, if you have it; A3 paper and crayons for each group's map; key symbol cards (hill, flat land, river, pond, trees, path).
- **Lesson 3:** the sand trays; a measuring cup (all groups use the same amount of water); one clear plastic storage box with a clip-on lid (about 40 by 30 cm) with one small hole cut in one end by an adult; a hand balloon pump or a hand-squeezed bellows (adult only); safety goggles for the adult; a cup of dry play sand for the box; paper and crayons for "before" and "after" drawings of each hill (or a camera used by the adult).
- **Lesson 4:** six source cards (listed in Lesson 4), each with a picture side and a short text side read aloud by the adult; two large sorting mats "fast" (with a hare) and "slow" (with a snail); the class information book; the groups' photos or drawings of their sand hills from lesson 3; sticky notes in two colours (or two shapes) for "a card or book says" and "our model showed".

- **Lesson 5:** per group, three identical shallow plates or small trays with a rim, a plastic "hill cup" for shaping hills, three identical clear cups for collecting sand and a small scoop; protections: small stones, lolly sticks to push in as a fence, and a square of old cotton cloth. For the whole class, one grass square on a plate (a piece of turf about 10 by 10 cm, or grass seed sown on damp sand mixed with compost in a small tray about two weeks before) and one plain sand hill beside it; a ruler or a stick to hold the watering can at the same height; the class results chart; three real-solution picture cards (a row of trees beside a field, grass and bushes on a steep bank, an earth bank beside a river).
- For blind or low-vision children: a raised-relief globe (or a globe with land and water in two textures) and a cup of water to touch; a raised-line or tactile copy of the Little Hill map from grade 1; tactile key symbols (a pebble for a hill, a piece of felt for flat land, a pipe cleaner for a river, a smooth plastic lid for a pond); real objects for each source card where possible (a stone, a handful of sand, an ice cube in a cup); the sand hills themselves to feel before and after.
- Towels, a mop or cloths, a bucket for used sand, hand-washing sinks.

⚠ Safety and access

- **Sand.** Use only washed play sand sold for children. Keep it damp so it does not make dust. No throwing sand; hands below shoulder height; wash hands after every sand lesson. If sand gets in an eye, do not rub; follow your school's first-aid rules.
- **Water and floors.** Stand trays in larger trays or on towels; mop spills at once, because wet floors are slippery.
- **Wind demonstration (lesson 3).** Adult only. The sand stays inside a closed clear box with the lid clipped on; the adult wears safety goggles and pumps air through the one small hole. Children watch from at least an arm's length away through the side of the box. Do not use a hair dryer or an electric fan near water.
- **Turf and grass.** Some children have grass or soil allergies; check first, use gloves, or let the adult handle the turf. Wash hands afterwards.
- **No balloons** (latex allergy and choking); use a hand balloon pump or a bellows without a balloon. Small stones must be too large to swallow; check your school's rules for the age group.
- **Frightening events.** Earthquakes, volcanoes, floods and landslides can hurt people and destroy homes. Some children or their families may have lived through one, or may have seen one on the news. Never ask whether a child has. Use calm pictures of land (not of injured people or damaged homes), say that grown-ups work hard to keep people safe, and let any child sit out of lesson 4's "fast" cards or do a different card. If a child becomes upset, follow your school's care routines.
- **Real water outside.** This unit never visits a real river, lake, pond or beach. If your school plans a trip, follow its own safety rules.
- Children can answer by speaking, signing, pointing, using AAC, drawing, or with a partner who writes for them. Their own way counts.
- Deaf children: show every picture while it is described, and face the class when reading aloud. Blind and low-vision children: use the tactile map, tactile symbols and real objects in Materials; describe each picture in words, and let them feel the sand hills before and after (after the water has stopped). Colour is never the only clue: water is also shown with a smooth texture and named in words.
- Wheelchair users: put sand trays on a table at a reachable height; a partner can pour while the child directs.

Assessment

Watch and listen during lessons, and use the closing checks. During lesson 5 or the following week, see each child for about 3 minutes with the cards and a small sand tray (answers in brackets):

1. Show four water picture cards (sea with waves, a river, a pond, an icy mountain top). "Where is the water in each one? Is it liquid or solid?" (Ocean or sea, river, pond, ice on a mountain; liquid, liquid, liquid, solid.) Hold up the class information book open at its glossary: "This page tells us what words mean. What is it called?" (The glossary; "word list" is fine.) (Outcome 1.)
2. Show the child a group map from lesson 2. "Point to the hill. The pond. The river. How do you know?" (Points correctly; uses the key.) (Outcome 2.)
3. Make a small damp sand hill and pour a little water on it (or show the group's lesson 3 drawing). "Where did the sand go? What moved it?" (Down the hill, to the bottom or into the tray; the water.) "What else can move sand?" (Wind.) (Outcome 3.)
4. Show two source cards: the canyon and the rockfall. "Which happened fast and which slowly? How do you know?" (Rockfall fast; canyon slowly; any evidence from the card, the book or our model, such as "the river took a very, very long time".) "Tell me a second place that helps you know." (Another source: the model, a picture, what the adult read.) (Outcome 4.)
5. "In our test, which protection kept the most sand on the hill? How do you know? What did we keep the same?" (The group's own result; less sand in the cup or the hill kept its shape; same water, same can, same height.) (Outcome 5.)
6. "Tell me one way people stop wind or water from carrying land away." (A row of trees or bushes, grass or plants on a slope, a bank or wall beside a river or the sea; and what it protects: a field, a slope, a town.) (Outcome 6.)

Record "yes", "with help" or "not yet" for each outcome. A child who can do it in their own way (pointing, signing, AAC) gets "yes".

Sources

Standards (read on 11 November 2026):

- Next Generation Science Standards, 2-ESS2 Earth's Systems:
  - 2-ESS2-1: "Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land." Clarification: "Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land."
  - 2-ESS2-2: "Develop a model to represent the shapes and kinds of land and bodies of water in an area." (The assessment boundary leaves out quantitative scaling in models.)
  - 2-ESS2-3: "Obtain information to identify where water is found on Earth and that it can be solid or liquid."
  - Core ideas: "Wind and water can change the shape of the land." "Maps show where things are located. One can map the shapes and kinds of land and water in any area." "Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form." "Because there is always more than one possible solution to a problem, it is useful to compare and test designs."

- Next Generation Science Standards, 2-ESS1 Earth's Place in the Universe:
  - 2-ESS1-1: "Use information from several sources to provide evidence that Earth events can occur quickly or slowly." Clarification: "Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly." The assessment boundary leaves out quantitative timescales, so this unit never gives years for the slow changes.
  - Core idea: "Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe."

Background for the teacher (Wikipedia, read on 11 November 2026):

- Erosion: "Erosion is the action of surface processes (such as water flow or wind) that removes soil, rock, or dissolved material from one location on the Earth's crust and then transports it to another location where it is deposited." It also says that "physical erosion proceeds the fastest on steeply sloping surfaces" and that "some mass-wasting processes act very slowly; others occur very suddenly".
- Grand Canyon: "a steep-sided canyon carved by the Colorado River in Arizona, United States".
- Landslide: "Gravity is the primary driving force for a landslide"; landslides include rockfalls and mudflows.
- Windbreak: "a planting usually made up of one or more rows of trees or shrubs planted in such a manner as to provide shelter from the wind and to protect soil from erosion. They are commonly planted in hedgerows around the edges of fields on farms."
- Levee: "an elevated ridge alongside the banks of a river, often intended to protect against flooding of the area adjoining the river. Alternatively, it is called a dike (American English)".
- Dune: "a landform composed of wind- or water-driven sand".
- Glacier: "a persistent body of natural ice ... that is constantly moving under its own weight"; "It slowly flows".
- Earthquake: "the shaking of the Earth's surface resulting from a sudden release of energy".
- Volcano: "a vent or fissure in the crust ... that allows hot lava, volcanic ash, and gases to escape".
- Ocean: "the body of salt water that covers approximately 70.8% of Earth" (the class book in lesson 1 says "most of the Earth").
- Lake, Pond ("A pond is smaller than a lake and there are no official criteria distinguishing the two") and River.

Known gaps and cautions

- One other agent (Gemini 4 Carbon, at 3f69978) text-checked this unit on 2026-11-11 and reported no content errors, plus one broken link (an anchor link to the Assessment section), since fixed. That is a text check by an AI agent, not a teacher review or classroom test.
- A second agent (Claude Haiku 5.5, at 8741363) text-checked the README and all five lessons on 2026-11-11, in two passes, and reported no errors. It checked internal consistency, facts, safety and assessment, not the quoted sources. That is also a text check by an AI agent, not a teacher review.
- The lesson order, the Little Hill stories, the information book, the source cards, the sand-tray tests and the assessment items are the author's own choices, not taken from a source.
- The sand-tray tests are comparisons in one tray on one day, not proof. Damp sand, the slope and how hard the water is poured all change the results. The grass square is a different material from the sand hills (it has roots and soil), so that comparison is not perfectly fair; lesson 5 says so to the children.

- Timings are untested guesses. With a full class of about 25 seven-year-olds, sand and water trays take real classroom-management skill: setting up, waiting turns, spills and clean-up may not fit in 40 minutes. A teacher may want an extra adult, fewer trays shown as a demonstration, or a separate clean-up slot. (Raised by a human visitor in AI Village chat, 2026-11-11.)
- "Lake or pond" is one mat in lesson 1 because, as the Pond article says, there are no official criteria separating them.
- No years or numbers are given for slow changes, following the assessment boundary of 2-ESS1-1. Children hear "a very, very long time, longer than anyone could watch".
- Volcanoes and earthquakes are named only as fast events, with calm pictures. How they happen (plates, magma) is left for later grades in the science progression.
- Wind is shown only by an adult demonstration in a closed box, not by children, so outcome 3 for wind is about watching, not testing.
- Salt water and fresh water, the water cycle and evaporation are left out here; the term 1 unit leaves evaporation for grade 4.
- No images yet.

Lesson 1: Where is water found?

Unit overview - Next: A model of Little Hill

Back to the grade 2 year plan

Goal

Children find out where water is found on Earth (ocean, rivers, lakes, ponds, ice on mountains) from an information book read aloud, use its contents page, headings and glossary, and sort pictures of water by place and by solid or liquid.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- The class information book "Water in Little Hill and far away" (page plan below), made by the teacher: one large picture and one or two sentences per page.
- Twelve water picture cards (list below), drawn by the teacher or printed from photos your school may use.
- Four place mats: "ocean", "river", "lake or pond", "on a mountain".
- Two state mats: "liquid water" and "solid ice".
- A globe.
- A few ice cubes in a clear cup.
- For blind or low-vision children: a raised-relief globe or a globe with land and water in two textures; real objects for liquid and solid (a cup of water to touch, an ice cube in a cup); each picture card described aloud.

Page plan for the information book (the author's own text)

- **Cover:** "Water in Little Hill and far away".
- **Contents** (page 1): The ocean ... 2; Rivers ... 3; Lakes and ponds ... 4; Ice ... 5; Glossary ... 6.
- **Page 2, heading "The ocean":** "Most of the Earth is covered by ocean. Ocean water is salty. On a globe, the ocean is blue."
- **Page 3, heading "Rivers":** "A river is water that flows across the land, downhill, to the sea or to a lake. The river in Little Hill flows under the bridge."
- **Page 4, heading "Lakes and ponds":** "A lake is water with land all around it. A pond is a small lake. Ducks swim on the pond in Little Hill."
- **Page 5, heading "Ice":** "When water is very cold it freezes into solid ice. In winter a pond can have ice on top. On high mountains there is ice and snow all year."
- **Page 6, heading "Glossary":** ocean - the very big salty water that covers most of the Earth; river - water that flows across land; lake - water with land all around it; pond - a small lake; ice - solid water; liquid - it flows and takes the shape of its container; solid - it keeps its own shape.

The twelve water picture cards (the author's descriptions)

1. Waves on a sandy beach.
2. A ship far out at sea, with no land in sight.
3. The Little Hill river flowing under the bridge.
4. A wide river with boats on it.
5. A lake with hills all around it.
6. The Little Hill pond with ducks.
7. A pond in winter with ice on top.
8. Snow and ice on a high mountain top.
9. A glacier: a long, wide river of ice between mountains.
10. An iceberg floating in the sea.
11. A small stream running between stones.
12. A pond in a park with a path around it.

Steps

✎ Opening (5 min)

1. Hold up the cup with ice cubes. "Is this solid or liquid? What will it be by the end of the lesson?" (Solid ice now; it will melt into liquid water.) Remind the class of term 1.
2. Spin the globe. "What do you think the blue shows?" (Water.) "Is there more blue or more of the other colours?" (More blue.) "Where else is water found? Let's find out from a book."

✎ Main activity (25 min)

1. **Using the book (10 min).** Show the cover and read the title. Open the contents page: "This page is called the contents. It tells us what is in the book and where." Ask: "I want to find out about ice. Which page?" A child points to "Ice ... 5"; turn to page 5 together. Show that each page has a heading in big letters. Read pages 2 to 5 aloud, pointing to each heading first.
2. **The glossary (3 min).** Turn to page 6: "This page is a glossary. It tells us what words mean." Ask a child to choose a word; read its meaning. Ask: "Where would we look to find what 'pond' means?" (The glossary.)
3. **Sorting by place (7 min).** Give each group three picture cards. Describe each card aloud. Groups place their cards on the four place mats. Author's suggested sorting (accept other answers with a good reason): ocean 1, 2, 10; river 3, 4, 11; lake or pond 5, 6, 7, 12; on a mountain 8, 9. Card 9 can also go on "river" if a child says "it is a river of ice"; that is a good reason.
4. **Solid or liquid? (5 min).** Groups take back their cards and place them on "liquid water" or "solid ice". Cards 7 and 10 have both: ice on top and liquid water around it. Let groups put them between the mats and say why.

✓ Discussion questions (5 min, with answers)

1. "Name three places where we find water." (Any three: ocean, river, lake, pond, on a mountain, a stream, ice.)

2. "Where is the most water on Earth?" (The ocean; the book says most of the Earth is covered by ocean, and the globe is mostly blue.)
3. "Can water be solid?" (Yes, ice. Ice on mountains, on a pond in winter, icebergs.)
4. "How did we find out about ice quickly?" (We used the contents page and the heading.)

✓ Closing check (5 min, with answers)

Each child is given one picture card (or holds a real object). They say, sign or point: "Where is this water?" and "Is it liquid or solid?" (Any correct place from the sorting above; liquid or solid as sorted; "both" for cards 7 and 10.) Then point to the glossary page when asked "Which page tells us what words mean?"

Vocabulary

ocean, river, lake, pond, stream, ice, glacier, solid, liquid, contents, heading, glossary

Differentiation

- Support: sort only cards 2, 3, 6 and 8, with one clue each ("no land in sight", "under the bridge", "ducks", "high mountain").
- Extension: add a new page to the class book (draw a place with water and dictate a sentence and a heading); add one word to the glossary.
- Children can place cards by pointing, signing or AAC, or ask a partner to move them. Mats can go on a table for a wheelchair user.

⚠ Safety

- Ice cubes stay in the cup; children touch them for a few seconds only.
- Do not ask about children's holidays by the sea, swimming, or trips. Talk only about the pictures and Little Hill.

Teacher notes and misconceptions

- Children may think all water is the same. The book says ocean water is salty; leave salt and fresh water for later grades.
- Some children think a pond and a lake are different kinds of water. They are only different sizes, and even scientists do not agree on where one stops and the other begins, so the mat says "lake or pond".
- A glacier looks still in a photo but moves very slowly; this comes back in lesson 4.

Lesson 2: A model of Little Hill

Unit overview - Previous: Where is water found? - Next: Water and wind move sand

Back to the grade 2 year plan

Goal

Children build a model of a made-up place with a hill, flat land, a river and a pond in a sand tray, then make a map of the model from above with a key.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- One sand tray per group of 4-5, standing in a larger tray or on a towel, with damp washed play sand about 5 cm deep.
- Small blue paper or plastic sheets (or blue playdough) for the pond; a strip of blue paper or blue cling film for the river; small sticks for trees; small stones; paper flags for labels.
- The large Little Hill map from grade 1 society, if you have it.
- A3 paper and crayons for each group's map.
- Key symbol cards: hill, flat land, river, pond, trees, path.
- For blind or low-vision children: the tactile Little Hill map from grade 1 (or a raised-line copy) and tactile key symbols (a pebble for a hill, a piece of felt for flat land, a pipe cleaner for a river, a smooth plastic lid for a pond). They can feel the sand model and place tactile symbols on a board to make their map.

Steps

✎ Opening (5 min)

1. Show the Little Hill map (or describe it). "Who remembers this? It is Little Hill from above, like a bird flying over it. What does the key tell us?" (What the symbols mean.)
2. "A map is flat. Today we will build Little Hill so it is not flat: a real hill you can touch, a river and a pond. Scientists and map-makers call this a model: a small copy that helps us think about something big."

✎ Main activity (25 min)

1. **Plan (3 min).** Each group agrees where the hill, the flat land, the river and the pond will go. The river must start near the hill and run downhill to the pond or to the edge of the tray ("the sea").
2. **Build (12 min).** Groups push damp sand into a hill (about as high as a hand is wide), smooth flat land, press a channel for the river and lay the blue strip in it, press a hollow for the pond and lay the blue sheet in it. Add sticks for trees and stones for a path if there is time. Each group puts a paper flag on each feature: hill, flat land, river, pond.

3. **Look from above (2 min).** Everyone who can stands and looks straight down; a seated child can look from a chair placed beside the tray. "What does the hill look like from above?" (A round shape, a blob.) "How can a map show it is high?" (A symbol, a colour, a word; accept any idea.)
4. **Draw the map (8 min).** Each group draws its model from above on A3 paper, with a symbol for each feature and a key in the corner using the key symbol cards as a guide. Blind and low-vision children place tactile symbols on a board to match the model.

Keep the sand trays (damp, covered with a cloth) for lesson 3.

✓ Discussion questions (5 min, with answers)

1. "What is the difference between our model and our map?" (The model is bumpy and you can touch the hill; the map is flat and seen from above.)
2. "Why does a map need a key?" (So people know what each symbol means.)
3. "Which way will the river flow?" (Downhill, from near the hill to the pond or the sea.)
4. "Is our model the same size as a real town?" (No, it is much smaller. It is a model.)

✓ Closing check (5 min, with answers)

Each group swaps maps with another group. A child from the visiting group uses the key to point to the hill, the river and the pond on the other group's map, then finds the same three things on that group's sand model. (Points correctly; any matching is fine as long as it uses the key.)

Vocabulary

model, map, key, symbol, hill, flat land, river, pond, from above, downhill

Differentiation

- Support: the adult builds the hill; the child presses the river and the pond and places flags. Maps can use stickers instead of drawn symbols.
- Extension: add a lake, an island (land with water all around it) or a valley between two hills, and add them to the key.
- A partner can build while a child directs by pointing, signing or AAC. Put the tray on a table at a reachable height for a wheelchair user.

⚠ Safety

- Washed play sand only, kept damp. No throwing; hands below shoulder height. Wash hands after the lesson.
- Small stones must be too large to swallow (check your school's rules).
- Mop any spilled water at once.

Teacher notes and misconceptions

- Children may think a map shows everything. A map shows only what the map-maker chose and put in the key.
- Some children may draw the hill from the side (a triangle). That is a useful moment: "Is that how a bird sees it?" Accept both and talk about it.
- There is no right size for the model. The standard leaves out measuring to scale at this age.

Lesson 3: Water and wind move sand

Unit overview - Previous: A model of Little Hill - Next: Fast or slow?

Back to the grade 2 year plan

Goal

Children watch water poured on their sand hill carry sand downhill and drop it at the bottom, and watch an adult show wind moving dry sand inside a closed box. They say that moving water and wind can change the shape of the land.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- The groups' sand trays from lesson 2 (damp, each in a larger tray or on a towel). Take out the paper river and pond first.
- One small watering can with a rose per group (all the same), and one measuring cup so every group uses the same amount of water.
- Paper and crayons for "before" and "after" drawings (or a camera used by the adult).
- For the wind demonstration (adult only): one clear plastic storage box with a clip-on lid, with one small hole cut in one end; a cup of dry play sand heaped into a small hill in the box; a hand balloon pump or a hand-squeezed bellows (no balloon); safety goggles for the adult.
- Towels, a mop, hand-washing sinks.
- For blind or low-vision children: the sand hill to feel before and after (after the water has stopped), and a cup to feel the sand collected at the bottom.

Steps

✎ Opening (5 min)

1. Look at the models. "Last time we built Little Hill. What do you think will happen to our hill when it rains hard?" Take predictions and write them down ("It will get wet", "It will fall down", "Nothing").
2. Groups draw (or the adult photographs) their hill "before".

✎ Main activity (25 min)

1. **Rain on the hill (12 min).** Each group fills the watering can with one measuring cup of water. One child holds the can at the top of the hill, about a hand's height above it, and pours slowly through the rose; then the next child pours a second cupful. Everyone watches the side of the hill and the flat land at the bottom.

2. Ask while they watch: "Where is the water going?" (Down the hill.) "Is it carrying anything?" (Sand.) "Where is the sand stopping?" (At the bottom, on the flat land, in the river or the pond hollow.)
3. **After (3 min).** Groups draw the hill "after" (or the adult photographs it). They point to two things: a place where sand was taken away (often a small channel, or gully, down the side) and a place where sand was dropped (a fan of sand at the bottom).
4. **Wind (adult demonstration, 7 min).** Children watch from at least an arm's length away through the side of the clear box. The adult, wearing goggles, checks the lid is clipped on, then pumps air through the hole towards the small dry sand hill, gently at first and then harder. "What is the moving air doing to the sand?" (Pushing it, blowing it to the other end of the box, making the hill lower or a new shape.) Leave the lid on until the sand has settled.
5. **New word (3 min).** "When water or wind carries soil, sand or rock from one place and drops it in another, scientists call that **erosion**." Write it on the word wall with two arrows: "taken away" and "dropped".

Keep the trays for lesson 5 (smooth the sand and rebuild later).

✓ Discussion questions (5 min, with answers)

1. "Was your prediction right?" (Children compare; any honest answer.)
2. "Where did the sand go?" (Down the hill to the bottom, the flat land, the river or the pond hollow.)
3. "What moved it?" (The water. In the box, the moving air: the wind.)
4. "Where in real life might water carry sand or soil away?" (A hillside in the rain, a riverbank, a beach with waves; accept any sensible idea.)

✓ Closing check (5 min, with answers)

Show the "before" and "after" drawings (or photos) of one group's hill. Each child points to (or describes) one place where sand was taken away and one place where it was dropped, and names what moved it. (Taken away from the side or top of the hill; dropped at the bottom; the water.)

Vocabulary

erosion, carry, drop, gully, downhill, wind, predict, before, after

Differentiation

- Support: the adult pours while the child watches one spot (the bottom of the hill) and says "sand is coming" or "no sand".
- Extension: pour a third cupful from higher up, or on a steeper side of the hill, and say what changed. (Usually more sand moves on the steep side.)
- A partner can pour while a child directs. Children who cannot see the water flow feel the hill before and after, and feel the sand that collected at the bottom.

⚠ Safety

- Wind demonstration: adult only, lid clipped on, adult wears goggles, children at least an arm's length away. Never a hair dryer or an electric fan near water. No balloons.
- Keep the sand damp; no throwing; wash hands afterwards.
- Mop spills at once; wet floors are slippery.

Teacher notes and misconceptions

- Children may think the water "made" new sand. The sand at the bottom is the same sand from the hill: it was carried and dropped.
- Children may think only big floods move land. Even gentle rain moves a little; more water or a steeper slope usually moves more.
- The Erosion article on Wikipedia says physical erosion "proceeds the fastest on steeply sloping surfaces"; the extension activity lets children notice this without being told first.

Lesson 4: Fast or slow?

Unit overview - Previous: Water and wind move sand - Next: Protect the hill

Back to the grade 2 year plan

Goal

Children use information from several sources (source cards read aloud, the class book, and their own sand model) to sort changes to the land into "fast" and "slow", and give evidence from at least two sources.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- Six source cards (below). Each has a calm picture on one side (land only: no injured people and no damaged homes) and the text on the other side, read aloud by the adult.
- Two large sorting mats: "fast" (a picture of a hare) and "slow" (a picture of a snail).
- The groups' "before" and "after" drawings or photos from lesson 3.
- The class information book from lesson 1 (page 5, "Ice").
- Sticky notes in two colours or two shapes: one for "a card or book says", one for "our model showed".
- For blind or low-vision children: real objects to hold for some cards (a stone for the canyon and the rockfall, a handful of dry sand in a tub for the dunes, an ice cube in a cup for the glacier); tactile mats (a smooth card for "fast", a ridged card for "slow"); each picture described aloud.

The six source cards (the author's own text, based on the Wikipedia

articles listed in the unit's Sources)

- **A. The canyon.** Picture: the Grand Canyon, a very deep valley with a river at the bottom. Text: "This is the Grand Canyon in Arizona, in the United States. A river, the Colorado River, carved it, a little at a time, over a very, very long time, longer than anyone could watch."
- **B. The rockfall.** Picture: rocks lying at the bottom of a cliff beside an empty mountain road. Text: "Rocks broke off a cliff and fell down the slope in a few seconds. A rockfall is one kind of landslide."
- **C. The sand dunes.** Picture: sand hills in a desert, with ripples on them. Text: "Wind blows sand into hills called dunes. The wind moves a little sand at a time, and a dune changes its shape slowly."
- **D. The glacier.** Picture: a glacier between two mountains. Text: "A glacier is a huge river of ice. It moves downhill, but so slowly that you cannot see it move."
- **E. The earthquake.** Picture: a long crack across an empty field. Text: "In an earthquake the ground shakes. It happens suddenly. Grown-ups who study earthquakes work hard to help people stay safe."
- **F. The volcano.** Picture: a mountain far away with a cloud of ash above it. Text: "A volcano is an opening in the ground where very hot melted rock, ash and gas come out. When a

volcano erupts, it can change the land very quickly. Grown-ups who study volcanoes watch them closely to help people stay safe."

Steps

✎ Opening (5 min)

1. Before the lesson, tell any child who might find earthquakes or volcanoes upsetting (or whose family has told you so) that they can choose cards A to D only, or help with the mats instead. Never ask a child in front of the class.
2. Show the lesson 3 drawings. "How long did it take the water to move our sand?" (A few minutes; while we watched.) "So was that fast or slow?" (Fast.) "Today we will find out about real changes to land. Some are fast and some are so slow that nobody can watch them happen."

✎ Main activity (25 min)

1. **Read the cards (10 min).** Show each card's picture, then read its text aloud. After each one ask: "Fast or slow? What words told you?" Write the clue words on the board: "a few seconds", "suddenly", "very quickly" (fast); "a little at a time", "a very, very long time", "so slowly that you cannot see it move" (slow).
2. **Sort with evidence (10 min).** Each group gets two cards (children who chose to skip cards E and F get two of A to D). Groups place each card on "fast" or "slow" and stick on a note for each piece of evidence:
    - "A card or book says..." note: the clue words on the card, or page 5 of the class book ("ice ... on high mountains all year").
    - "Our model showed..." note: for example "our water moved sand down the hill" (for the canyon or the rockfall). Each card needs evidence from at least two sources (the card plus the book, the model, or another card).
3. **Expected sorting (5 min).** Check together. Fast: B (rockfall), E (earthquake), F (volcano). Slow: A (canyon), C (dunes), D (glacier). Accept "both" for C if a child says "a big storm could move a lot of sand quickly"; that is a good reason.

✓ Discussion questions (5 min, with answers)

1. "Our water moved sand in a few minutes. Why did the river take so long to make the canyon?" (Rock is much harder than sand; the river wears it away a little at a time.)
2. "Which changes could you watch with your own eyes?" (Fast ones: a rockfall, our sand model. Not the canyon or the glacier.)
3. "How do we know about slow changes if nobody can watch them?" (People study the land and write books and make pictures; we can read and look at more than one source.)
4. "Why is it good to use more than one source?" (If two sources say the same, we can be more sure.)

✓ Closing check (5 min, with answers)

Hold up a card the child has not sorted (or describe it). The child says, signs or points "fast" or "slow" and names two places that helped them know. (As in the expected sorting; any two real sources: the card, the class book, the model, a picture.)

Vocabulary

fast, slow, sudden, canyon, rockfall, landslide, dune, glacier, earthquake, volcano, evidence, source

Differentiation

- Support: sort only B and D (rockfall and glacier) with the clue words underlined and read twice.
- Extension: put the six cards in a line from fastest to slowest and give a reason for one pair.
- Children can sort by pointing, signing or AAC, or ask a partner to place the card. Mats can go on a table for a wheelchair user.

⚠ Safety

- Use calm pictures of land only. Never show injured people, damaged homes or news footage. Never ask whether a child has been in an earthquake, a flood, a landslide or near a volcano.
- Any child can skip cards E and F with no reason given. If a child becomes upset or shares a worrying story, follow your school's care routines.
- Stones used as objects must be too large to swallow.

Teacher notes and misconceptions

- Children may think the canyon was made by one big flood. Wikipedia says the canyon was "carved by the Colorado River"; the unit says "a little at a time, over a very, very long time". The standard leaves out numbers of years at this age, and the canyon's age is still discussed by scientists, so give no number.
- Children may think "slow" means "not happening". The glacier and the dune are moving all the time, just too slowly to see.
- Volcanoes and earthquakes are named here only as fast events. How they happen is left for later grades.

Lesson 5: Protect the hill

Unit overview - Previous: Fast or slow?

Back to the grade 2 year plan

Goal

Children compare ways of protecting a sand hill from poured water, keeping the water the same for every hill, and say which worked better and how they know. They match their designs to real ways people protect land from water and wind.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. The one-to-one assessment (see Assessment in the unit overview) happens during this lesson or the following week.

Materials

- Per group: three identical shallow plates or small trays with a rim, one plastic cup for shaping hills (the "hill cup"), damp washed play sand, three identical clear cups for collecting sand, a small scoop or spoon.
- Per group: protections to choose from: small stones, lolly sticks (to push in as a fence), a square of old cotton cloth.
- For the whole class: one grass square on a plate (a piece of turf about 10 by 10 cm, or grass seed sown about two weeks earlier on damp sand mixed with compost in a small tray), and one plain sand hill beside it for comparison.
- One small watering can with a rose per group (all the same), one measuring cup, and a ruler or stick to hold the can at the same height every time.
- The class results chart (columns: hill, protection, kept its shape?, sand in the cup: a little, some or a lot).
- Three real-solution picture cards (author's descriptions): a row of trees planted along the edge of a field; grass and bushes growing on a steep bank; a long, high earth bank beside a river.
- Towels, a mop, a bucket for used sand, hand-washing sinks.
- For blind or low-vision children: hills to feel before and after (after the water has stopped); the collecting cups to feel how full they are; each picture card described aloud; real objects (a stick, a stone, the cloth, a piece of grass).

Steps

✎ Opening (5 min)

1. "In lesson 3 the water carried sand off our hill. People who live on hills and by rivers have the same problem. Today we are engineers: we will design ways to protect a hill and compare them."

2. "To compare fairly, what must be the same for every hill?" Agree together: same hill (made with the same hill cup), same sand, same water (one measuring cup), same watering can, poured from the same height. "Only the protection changes."

✎ Main activity (25 min)

1. **Make three hills (5 min).** Each group fills the hill cup with damp sand, presses it down, and turns it out onto each plate like a sandcastle: three hills the same size.
2. **Choose and add protections (5 min).** One hill gets **no protection**, so we can compare. The group chooses two protections for the other two hills: stones laid on the slope, a stick fence pushed in around the bottom or across the slope, or the cloth laid over the hill. (Across the class, try to test each one.)
3. **Pour (7 min).** For each hill in turn: one measuring cup of water in the can; the can held at the top of the ruler standing beside the hill; pour slowly through the rose until the can is empty. Everyone watches.
4. **Collect and compare (5 min).** For each hill, scoop the loose sand that washed onto the plate into a clear cup and line the three cups up. Look at each hill: did it keep its shape? Fill in the class results chart with "a little", "some" or "a lot".
5. **The grass square (3 min, adult).** The adult pours one measuring cup the same way onto the grass square and onto the plain sand hill beside it. "What did the roots do?" (Held the soil; less washed away.) Say honestly: "This one is not a perfectly fair test, because the grass square is soil and roots, not our sand. But it gives us a clue."

✓ Discussion questions (5 min, with answers)

1. "Which protection kept the most sand on the hill? How do you know?" (Each group's own result. Evidence: less sand in the cup, the hill kept its shape.)
2. "Why did we keep one hill with no protection?" (To compare; to see if the protection made any difference.)
3. "Did every group get the same result?" (Maybe not. Different groups may have poured differently, or built the fence differently. That is why engineers test more than once.)
4. Show the three real-solution cards. "Which of our designs is most like each one?" (Row of trees: a bit like the stick fence; it slows the wind across a field. Grass and bushes on a bank: like the grass square; roots hold the soil. Earth bank beside a river: like a wall or fence; it holds back the water when the river is high. Accept other good matches.)

✓ Closing check (5 min, with answers)

Each child answers one of these, by saying, signing, pointing or drawing:

- "Which protection worked better in your group, and how do you know?" (Their result, with evidence from the cups or the hill shape.)
- "What did we keep the same?" (The water, the can, the height, the hill size.)
- Pointing to a real-solution card: "What does this protect?" (The field from wind; the bank or slope from rain; the land beside the river from flooding.)

Then begin the one-to-one assessment (see Assessment in the unit overview).

Vocabulary

protect, design, engineer, compare, fair, the same, windbreak, bank, roots, result

Differentiation

- Support: compare only two hills (no protection and stones); the child says "more sand" or "less sand" for each cup.
- Extension: design a new protection from the materials (for example stones and sticks together), test it the same way, and say whether it beat the others.
- A partner can pour while a child directs. Children who cannot see the water flow feel each hill before and after, and compare how full the cups are.

⚠ Safety

- Washed play sand only, kept damp; no throwing; wash hands afterwards.
- Check for grass and soil allergies before the grass square; the adult handles it and children can wear gloves. Wash hands afterwards.
- Lolly sticks are pushed in, not thrown; stones must be too large to swallow.
- Mop spills at once; wet floors are slippery.

Teacher notes and misconceptions

- Children may say "the cloth worked best, so it is the best for real hills". A cloth over a real hill would stop plants growing. The test tells us which worked best on our sand hill, today; real engineers think about more than one thing.
- Results will vary between groups. That is expected and is a good reason to compare and test designs more than once.
- The Windbreak article on Wikipedia describes rows of trees or shrubs that "provide shelter from the wind and to protect soil from erosion", and the Levee article describes a bank beside a river (a dike in American English) that is "often intended to protect against flooding".

Grade 2 Science: Habitats, Seeds and Helpers (5 lessons, about 3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 11 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.
>
> Text-checked by three other agents (Gemini 3.8 Flash, Gemini 4 Carbon and Gemini 4 Argon); see Known gaps.

Back to the grade 2 year plan - Term 3. Builds on grade 1 science: What do plants need?, grade 2 science term 2: Land and water, fast and slow, grade 2 language and literacy term 3: Writing for a reason and the science progression

Big idea

A habitat is a place where living things find what they need. Different places near school, and different places around the world, have different kinds of living things, and some places have many more kinds than others. Plants need light and water to grow well, and we can find this out with a test where we change only one thing. Plants cannot walk, so many of them get help from animals: some seeds have hooks that catch on fur, some seeds are inside fruit that animals eat, and bees and other animals carry pollen from flower to flower. We can build models that work like these animal helpers.

This is the third science unit of grade 2 (term 3). In grade 1 the class tested four bean pots; here the children help plan the test themselves, with three pots for each choice, and say what they keep the same. The grade 2 literacy unit Writing for a reason reads fact pages about what a seed needs and how seeds get about; this unit tests those ideas.

Outcomes

By the end of the unit most children can:

1. Look for living things in two places near school, keep a tally of how many different kinds they found in each, and say which place had more kinds.
2. Compare habitat picture cards and say that different places have different living things, and that some places have more kinds than others.
3. Help plan a plant test that changes only one thing (light or water), say what stays the same and what we will watch, and say why we use more than one pot for each choice.
4. Say from our results that cress seedlings need water to start growing, and light to grow green and strong.
5. Build and test a model seed that sticks to fur, and say how it is like an animal carrying a seed to a new place.
6. Use a model to show how a bee carries pollen from one flower to another.

Prior knowledge

- Grade 1 science term 3: a seed has a tiny plant inside; plants need water and light; plants in the dark grow tall, thin and pale.

- Kindergarten science: living things need food, water and air; animals and plants live in places that give them what they need.
- Grade 2 science term 2: fair comparisons where we keep the water, the can and the height the same.
- Grade 2 mathematics: tally marks and simple bar graphs.
- No reading is needed. Picture cards and the habitat pictures are described aloud by an adult.

Lessons

Each lesson is about 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. Teach about two lessons a week. Lesson 3 must come at least five school days before lesson 5, so that the cress has time to grow, and the watered pots need a short daily check (about 2 minutes) by an adult and a helper.

1. Who lives here?: a habitat hunt in two places near school (for example short mown grass and a flower bed or hedge edge); a tally of how many different kinds of living things each group finds; comparing the two places.
2. Many places to live: five habitat picture cards (a pond, a wood, a rock pool, a sandy desert and a paved car park); counting the kinds in each picture; making a class bar graph; why a place might have more kinds.
3. Planning a fair plant test: asking "Does cress need light?" and "Does cress need water?"; choosing what to change and what to keep the same; setting up three pots for each choice; predictions.
4. Seeds that hitch a ride: how animals carry seeds (hooks on fur, fruit that animals eat, nuts that squirrels hide); building model seeds and testing which ones a "fur coat" carries across the room; the story of how hook seeds gave someone the idea for hook-and-loop fasteners.
5. Pollen helpers and our results: looking at the cress results; a model bee carrying "pollen" (washable ink) from flower to flower; the end-of-unit check.

Materials (whole class unless noted)

- **Lesson 1:** for each group of 4-5, a hoop or a loop of rope about 1 m across, a clipboard with the tally sheet (one column for each place, with rows "plants" and "animals"), a pencil and a magnifying glass; two places near school chosen and checked by the teacher beforehand; sun hats and water bottles if it is sunny; a whistle or bell for gathering.
- **Lesson 2:** five A4 habitat picture cards (listed in Lesson 2), drawn or printed by the teacher; a large class bar graph with five columns; sticky squares; the groups' tally sheets from lesson 1.
- **Lesson 3:** a packet of cress seeds; twelve small clear plastic pots (for example yoghurt pots, washed), plus a few spares; cotton wool; a teaspoon; a jug of water; labels and a marker; one large cardboard box that closes (the "dark box"); a sunny windowsill or a bright table; the class plan chart ("We change... / We keep the same... / We will watch..."); a prediction chart with two columns ("I think..." and "We saw...").
- **Lesson 4:** three seed picture cards (a burdock burr caught in a dog's fur, a blackbird eating a berry, a squirrel burying an acorn); for each group, twelve paper balls about 2 cm across (scrunched scrap paper, the "seeds"), seven short strips of the hook side of a hook-and-loop fastener, eight short pipe cleaner pieces (about 4 cm, cut by an adult, with the cut ends folded over), masking tape, and a shallow tray; one fake-fur mitten or a fluffy sock for the adult's hand (the "fur coat"); a "new field" mat (a sheet or a hoop) about 3 m from the trays; a class results chart; one real hook-and-loop fastener to pass round.

- **Lesson 5:** the cress pots from lesson 3; a ruler; for each group, two paper flowers (each a paper plate with a paper cup centre), one with a yellow washable ink pad in its centre (the "pollen flower") and one with a plain white paper centre; one cotton-wool "bee" on a lolly stick per child (or one per pair); aprons; wipes; the end-of-unit check cards.
- For blind or low-vision children: tactile habitat cards (felt, sandpaper, smooth plastic and bark-like card for each habitat), a seed model they can feel before and after the fur test, a real burr-like fastener to feel, and a pot of cress to touch gently at the end (dry cotton wool versus soft green shoots).
- Hand-washing sinks, paper towels.

⚠ Safety and access

- **Outside (lesson 1).** Use only places the teacher has walked through first for hazards (broken glass, dog mess, nettles or other stinging or poisonous plants, fungi, holes). Agree the boundary and the gathering signal before going out. Hats, sun cream and water as your school requires.
- **Living things.** Look, do not touch. Children do not pick plants or lift stones or logs; if the teacher lifts a log or stone, they put it back gently the same way up. Nothing is taken back to class. If a bee or wasp comes close, stay still or walk slowly away; check care plans for sting allergies and take any prescribed medicine outside, as your school's rules require.
- **Allergies.** Check for grass, pollen, plant and fur allergies before lessons 1, 4 and 5. The "fur coat" is fake fur, worn only by the adult.
- **Seeds.** The adult holds the seed packet and sprinkles the cress seeds. Seeds never go in mouths, noses or ears, and nobody eats the cress grown in class. Wash hands after handling pots and cotton wool.
- **Nuts.** Lesson 4 shows a squirrel and an acorn only as a picture card. No real nuts or acorns come into class.
- **Ink (lesson 5).** Use a washable, non-toxic ink pad; aprons on; wipes ready.
- **Small parts.** Paper balls, pipe cleaners and fastener strips stay on the table; pipe cleaner ends are folded over by an adult so no sharp end shows.
- Children can answer by speaking, signing, pointing, using AAC, drawing, or with a partner who writes for them. Their own way counts.
- Children who are afraid of insects can be the group's tally-keeper or "spotter" from a few steps back.
- Deaf children: show every picture while it is described; face the class when reading aloud; agree a visual gathering signal (a raised hand or a flag) for outside. Blind and low-vision children: use the tactile cards and real objects in Materials; in lesson 1 they can count kinds of things they can touch safely (bark, grass, leaves the teacher has checked) and kinds of bird or insect sounds they hear. Colour is never the only clue: the pale cress is also shorter-leaved and floppy, and the ink "pollen" can be felt as slightly damp.
- Wheelchair users: choose habitat places with a firm, level path; a hoop can be placed at the edge of a path. A partner can do the fur test while the child directs.

Assessment

Watch and listen during lessons, and use the closing checks. During lesson 5 or the following week, see each child for about 3 minutes with the cards, a seed model and two cress pots (answers in brackets):

1. Show the child their group's tally sheet from lesson 1. "Which place had more kinds of living things? How do you know?" (The place with more tally marks; "we counted more".) (Outcome 1.)
2. Show the pond card and the car park card from lesson 2. "Which picture has more kinds of living things? Why might a place have more kinds?" (The pond; any sensible reason such as "more water", "more plants to eat", "more places to hide".) (Outcome 2.)
3. "In our light test, what did we change? What did we keep the same? Why did we use three pots and not one?" (Light or dark; the same water, the same seeds, the same pots; so that one pot that goes wrong does not fool us.) (Outcome 3.)
4. Show one pot from the window and one pot from the dark box, then one watered pot and one dry pot (or photos). "What does cress need? How do you know?" (Light, because the dark box cress is pale and floppy; water, because the dry seeds did not grow.) (Outcome 4.)
5. Show a plain paper seed and a paper seed with hook strips. "Which seed would a dog carry to a new place? Why?" (The hook seed; the hooks catch on the fur, like a burr.) (Outcome 5.)
6. Give the child a cotton-wool bee and the two paper flowers. "Show me how the bee helps the flower." (Touches the pollen flower, then the white flower, and points to the yellow mark.) "What did the bee carry?" (Pollen.) (Outcome 6.)

Sources

Quoted exactly; the unit is not a full alignment to these standards.

- Next Generation Science Standards, grade 2, Interdependent Relationships in Ecosystems: https://www.nextgenscience.org/topic-arrangement/2interdependent-relationships-ecosystems
  - 2-LS2-1: "Plan and conduct an investigation to determine if plants need sunlight and water to grow." Assessment boundary: "Assessment is limited to testing one variable at a time."
  - 2-LS2-2: "Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants."
  - 2-LS4-1: "Make observations of plants and animals to compare the diversity of life in different habitats." Clarification statement: "Emphasis is on the diversity of living things in each of a variety of different habitats." Assessment boundary: "Assessment does not include specific animal and plant names in specific habitats."
- Wikipedia (lead paragraphs and the animal section of Seed dispersal, read 2026-11-11):
  - Habitat: "Fresh-water habitat types include marshes, streams, rivers, lakes, and ponds"; "The habitat of a species is not necessarily found in a geographical area, it can be the interior of a stem, a rotten log, a rock or a clump of moss".
  - Seed dispersal: "Seeds can be transported on the outside of vertebrate animals (mostly mammals)"; such plants "can have a variety of adaptations for dispersal, including adhesive mucus, and a variety of hooks, spines and barbs"; "Seed dispersal via ingestion and defecation by vertebrate animals (mostly birds and mammals), or endozoochory, is the dispersal mechanism for most tree species"; "Seed predators, which include many rodents (such as squirrels) and some birds (such as jays) may

also disperse seeds by hoarding the seeds in hidden caches ... if left uneaten will grow into new plants."
    - Burdock: "Burdock's clinging properties, in addition to providing an excellent mechanism for seed dispersal, led to the invention of velcro."
    - Hook-and-loop fastener: "The original hook-and-loop fastener was conceived in 1941 by Swiss engineer George de Mestral"; "He took a close look at the burs of burdock that kept sticking to his clothes and his dog's fur."
    - Pollination: "Pollinating agents can be animals such as insects, for example bees, beetles or butterflies; birds, and bats; water; wind"; "Pollinating animals travel from plant to plant carrying pollen on their bodies".
    - Cress: "a fast-growing, edible herb".
    - Etiolation: plants grown without light have "long, weak stems; smaller leaves due to longer internodes; and a pale yellow color".

Known gaps and cautions

- One other agent (Gemini 3.8 Flash, at e5ce5d4) text-checked this unit on 2026-11-11 and reported no errors. A second agent (Gemini 4 Carbon, at 625c0f9) text-checked it the same day against the NGSS and Wikipedia sources and reported one catch: lesson 4 did not give each group enough hook strips and pipe cleaner pieces for every round, since fixed. A third agent (Gemini 4 Argon, at 961572c, after the fix) text-checked timings, counts, quotes and links and reported no errors. Those are text checks by AI agents, not a teacher review or classroom test.
- The lesson order, the habitat picture cards and their counts, the seed and bee models, the plant test plan and the assessment items are the author's own choices, not taken from a source.
- The habitat picture cards are made-up pictures. Their counts say how many kinds are drawn in our pictures, not how many live in real ponds, woods or deserts. Real deserts and car parks can have more living things than the pictures show.
- Following the 2-LS4-1 assessment boundary, children are never assessed on plant or animal names; they count "different kinds" by how they look.
- Grade 1 term 3 science already tested what plants need. This unit repeats the question on purpose, but the children plan the test, use three pots for each choice and test one change at a time. Some children may remember the answer; the teacher can say "Let's see if a fairer test agrees."
- Cress usually sprouts within a few days in a warm room, but a cold room can slow it. Plant spare pots. Three pots for each choice is still a small test, not proof; the dark box may also be warmer or cooler than the windowsill.
- The fur test and the bee model are models: they show one way an animal carries seeds or pollen, not everything that happens. Real pollination also needs the pollen to reach the right part of the flower, which is left for later grades in the science progression.
- Seeds carried inside animals are mentioned only as "the seed drops out somewhere else", in a picture card, not tested.
- The habitat hunt depends on the school grounds and the season (the year plan puts it in spring). In winter or in a school with no green space, use a planted pot or tray in class and the lesson 2 cards.
- Timings are untested guesses. Going outside with a full class of about 25 seven-year-olds takes time; lesson 1 may need extra adults or a longer slot.
- No images yet.

Lesson 1: Who lives here?

Unit overview - Next: Many places to live

Back to the grade 2 year plan

Goal

Children look for living things in two different places near school, keep a tally of how many different kinds of plants and animals they find in each, and compare the two places.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- For each group of 4-5: a hoop or a loop of rope about 1 m across, a clipboard with the tally sheet, a pencil and a magnifying glass.
- The tally sheet: two columns, "Place A" and "Place B", and two rows, "plants" and "animals". Children make one tally mark for each new kind they find, and may draw a tiny picture of each kind beside the tally.
- Two places near school, chosen and walked through by the teacher beforehand. Good pairs are very different, for example short mown grass and a flower bed, a hedge edge or an unmown corner. A paved yard with a few weeds in the cracks also works as one of the two places.
- A whistle or bell, or a raised flag for the gathering signal.
- Sun hats and water bottles if it is sunny.
- For blind or low-vision children: a partner who describes what they see, and safe things to touch that the teacher has checked (bark, grass, a leaf still on its plant).

Steps

✎ Opening (5 min)

Show the class the two places on the school map or by pointing from the door. Say: "A **habitat** is a place where a living thing finds what it needs: food, water, shelter and space. Today we are habitat detectives. We will not find out the names of things. We will count how many **different kinds** of living things live in each place."

Model the tally on the board: "If I see one ant, I make one mark for ants. If I see ten more ants, I do not make more marks, because they are the same kind. If I see a beetle, that is a new kind, so I make a new mark." Agree the rules: look, do not touch; do not pick; stay inside the boundary; come back at the signal.

✎ Main activity (25 min)

- **Place A (10 min).** Each group puts its hoop down where the teacher shows. Children look inside the hoop, then around it, using the magnifying glass, and make one tally mark for each new kind of plant and each new kind of animal. Different-looking leaves count as different kinds of plant. Remind them to look low: under leaves, in cracks, on stems.
- **Move (3 min).** Signal, gather, walk together to place B.
- **Place B (10 min).** The same: hoop down, look, tally.
- **Back together (2 min).** Gather in the shade or go back to class.

The teacher may lift one stone or log in each place for the class to look under, then put it back gently the same way up.

✓ Discussion questions (5 min, with answers)

- "Which place had more kinds of living things?" (Usually the flower bed, hedge or unmown corner; any answer that matches the group's tally.)
- "How do you know?" (We made more tally marks there.)
- "Why do you think one place had more kinds?" (More plants, more places to hide, more food, damper soil, fewer feet walking on it; any sensible reason.)
- "Did every group find the same number? Why not?" (No; groups looked in different spots, and some animals moved away or hid.)

✓ Closing check (5 min, with answers)

Each child shows with fingers, or points on the tally sheet:

1. "How many different kinds did your group find in place A?" (Their own count.)
2. "In place B?" (Their own count.)
3. "Which place had more kinds?" (The place with the bigger number.)

Vocabulary

habitat, living thing, kind, tally, compare, more, fewer

Differentiation

- **More help:** count only plants, or only animals; an adult points out where to look.
- **More challenge:** count how many of one kind they can see (for example "about 10 ants") as well as how many kinds; or add a third place.
- Children who are afraid of insects can be the group's tally-keeper or spotter, standing a few steps back.

⚠ Safety

- The teacher walks both places first for hazards (glass, dog mess, nettles or other stinging or poisonous plants, fungi, holes).
- Look, do not touch; no picking; no lifting stones or logs (adult only); wash hands when back in class.
- Bees and wasps: stay still or walk slowly away. Check care plans for sting allergies.
- Sun hats, sun cream and water as your school requires. Keep a clear gathering signal that every child can see or hear.

Teacher notes and misconceptions

- Some children think only animals count as "living things". Point out that grass, weeds and trees are living things too.
- Children may count the same kind twice (two snails = two kinds). Model it again: same kind, one mark.
- A place with lots of one kind (a lawn full of grass) can still have few kinds. That difference is the point of the lesson.
- The numbers are the class's own observations on one day, not a measure of the whole place; animals hide, move and come out at other times.
- If you cannot go outside, use photos of two places near school taken by an adult, count kinds in the photos together, then move straight to lesson 2.

Lesson 2: Many places to live

Unit overview - Previous: Who lives here? - Next: Planning a fair plant test

Back to the grade 2 year plan

Goal

Children compare five habitat pictures, count how many different kinds of living things are drawn in each, show the counts on a class bar graph, and say why some places might have more kinds than others.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- Five A4 habitat picture cards (list below), drawn or printed by the teacher. Each kind is drawn once or more, but children count kinds, not animals.
- A large class bar graph with five columns (pond, wood, rock pool, desert, car park) and sticky squares.
- The groups' tally sheets from lesson 1.
- For blind or low-vision children: tactile versions of the cards, with one small raised shape or texture for each kind, and each card described aloud.

The five habitat picture cards (the author's own pictures)

The names in brackets are for the teacher only. Children are not asked to learn or say them.

- **Card 1, "Duck's pond in Little Hill" (8 kinds):** (a duck, a frog, a dragonfly, a water lily, reeds, a pond snail, a small fish, grass on the bank).
- **Card 2, "Little Hill wood" (9 kinds):** (a tall tree, a fern, moss on a log, bluebells, ivy, a squirrel, an owl, a beetle, a woodlouse).
- **Card 3, "A rock pool by the sea" (6 kinds):** (a crab, seaweed, a limpet, a starfish, a small fish, a sea anemone).
- **Card 4, "A sandy desert" (4 kinds):** (a cactus, a small bush, a lizard, a beetle).
- **Card 5, "The car park behind the market" (3 kinds):** (a pigeon, a weed growing in a crack, an ant).

Steps

✎ Opening (5 min)

Look again at the lesson 1 tally sheets. "Last time, one place had more kinds than the other. Today we visit five more places, in pictures. Some are near Little Hill and some are far away."

✎ Main activity (25 min)

- **Look and count (15 min).** Groups of 4-5 get one card each, then swap after 3 minutes until every group has seen every card (or show each card on a screen for the whole class). For each card, children point to each different kind of living thing and count them together. Remind them: "Same kind, count once."
- **Bar graph (10 min).** Each group sticks one square per kind for the card they counted last, then the class checks every column together. The teacher fixes any column that does not match the agreed count.

✓ Discussion questions (5 min, with answers)

- "Which picture has the most kinds?" (The wood, 9.) "The fewest?" (The car park, 3.)
- "How many more kinds are in the pond picture than in the desert picture?" (8 - 4 = 4 more.)
- "Why might the wood or the pond have more kinds than the car park?" (More plants for food, more water, more places to hide and live; the car park is mostly hard ground.)
- "Are these the real numbers for every pond and every desert?" (No; these are our pictures. Real places can have many more living things, some too small to see.)

✓ Closing check (5 min, with answers)

Point to the bar graph:

1. "Which column is tallest?" (The wood.)
2. "Which has more kinds, the rock pool or the desert?" (The rock pool.)
3. "Point to the place most like our place B from last lesson." (Any sensible choice with a reason.)

Vocabulary

habitat, kind, pond, wood, desert, rock pool, bar graph, most, fewest

Differentiation

- **More help:** count with a counter on each kind; use only three cards.
- **More challenge:** compare two columns with "how many more"; draw a sixth card for another kind of place (for example a park or a field), with the kinds they think they might find.
- Children who find counting busy pictures hard can use the tactile or a larger, clearer copy of each card.

⚠ Safety

- No special hazards. If children talk about wild animals that can hurt people (for example in the desert), say that the animals in our pictures are not dangerous to look at in a picture, and that real wild animals should always be left alone.

Teacher notes and misconceptions

- The 2-LS4-1 assessment boundary says children are not assessed on specific plant and animal names. Use the names only if children ask.
- Children may think deserts have no life at all. The desert card shows that some plants and animals do live there.
- Some children think a car park is not a habitat. Point out that the pigeon, the weed and the ant find what they need there.
- These are made-up pictures, so their numbers show only what is drawn.

Lesson 3: Planning a fair plant test

Unit overview - Previous: Many places to live - Next: Seeds that hitch a ride

Back to the grade 2 year plan

Goal

Children help plan two plant tests, each changing only one thing (light or water), say what stays the same and what they will watch, and set up three pots for each choice.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- A packet of cress seeds (held by the adult).
- Twelve small clear plastic pots (for example washed yoghurt pots), plus a few spares; cotton wool, a teaspoon, a jug of water.
- Labels and a marker.
- One large cardboard box that closes (the "dark box").
- A sunny windowsill or a bright table.
- The class plan chart, with three rows: "We change...", "We keep the same...", "We will watch...".
- The prediction chart, with two columns: "I think..." and "We saw..." (the second column is filled in during lesson 5).
- For blind or low-vision children: a pot of dry cotton wool and a pot of damp cotton wool to feel; the seeds described as "tiny, like grains of sand".

Steps

✎ Opening (5 min)

Remind the class of the grade 1 bean pots: "In grade 1 we found that plants need water and light. Today we plan a better test, with **cress**, a small plant that grows fast. We ask two questions: Does cress need **light**? Does cress need **water**?"

✎ Main activity (25 min)

- **Plan the light test together (8 min).** Ask: "What will we change?" (Light or dark: some pots on the windowsill, some in the dark box.) "What must stay the same?" (The same pots, the same cotton wool, the same amount of seeds, the same water each day, the same room.) "What will we watch?" (Do the seeds grow? How tall? What colour?) Write the answers on the plan chart.
- **Plan the water test (5 min).** Children say it themselves: "We change... (water or no water). We keep the same... (pots, seeds, cotton wool, all on the windowsill). We watch... (do the seeds grow?)."

- **Why three pots? (2 min).** "What if one pot gets knocked over, or its seeds are bad? With three pots, one pot that goes wrong does not fool us."
- **Set up (10 min).** In groups, children push cotton wool into the pots and label them: "light 1, 2, 3", "dark 1, 2, 3", "water 1, 2, 3", "no water 1, 2, 3". The adult wets the cotton wool in the nine pots that get water (four teaspoons each) and sprinkles a small pinch of seeds evenly onto every pot. The three "no water" pots get dry cotton wool and seeds only. Put the "light" and both water-test sets on the windowsill and the "dark" set in the closed box in the same room.

Daily check (about 2 minutes, by an adult and a helper): give each of the nine watered pots four teaspoons of water so the cotton wool stays damp; give the "no water" pots none. Open the dark box only for the check, then close it.

✓ Discussion questions (5 min, with answers)

- "In the light test, which pots get water?" (All of them, the same amount.) "Why?" (So only the light changes.)
- "In the water test, why are all the pots on the windowsill?" (So only the water changes.)
- "What would go wrong if the dark pots got no water?" (We would not know if light or water made the difference.)

✓ Closing check (5 min, with answers)

Each child puts a sticker or a mark on the prediction chart:

1. "What will the dark box cress look like?" (Any prediction; there is no wrong prediction.)
2. "Will the no-water seeds grow?" (Any prediction.)
3. "Tell your partner one thing we keep the same." (Pots, seeds, cotton wool, room, amount of water.)

Vocabulary

cress, test, change, keep the same, predict, light, dark, damp

Differentiation

- **More help:** plan only the light test; use picture cards for "change" and "keep the same".
- **More challenge:** suggest a third test (for example warm and cold) and say what would stay the same; it is not set up here.
- A child who cannot handle pots can label, count the cotton wool pieces or be the "checker" who reads the plan chart back.

⚠ Safety

- The adult holds the seed packet and sprinkles the seeds. Seeds never go in mouths, noses or ears.
- Nobody eats the cress grown in class.

- Wash hands after handling pots and cotton wool. Wipe up spills at once.

Teacher notes and misconceptions

- Seeds can start to grow in the dark, because they do not need light to sprout; what changes is how the seedlings grow. Dark-grown seedlings are usually tall, thin, floppy and pale yellow (see Etiolation in the unit Sources). Expect children to be surprised that the dark seeds grew at all.
- Some children think more water is always better. Four teaspoons a day keeps the cotton wool damp, not flooded.
- Cress usually sprouts within a few days in a warm room; a cold room is slower. Plant one or two spare pots of each kind in case some fail.
- Three pots for each choice is still a small test, not proof. The dark box may also be a little warmer or cooler than the windowsill.

Lesson 4: Seeds that hitch a ride

Unit overview - Previous: Planning a fair plant test - Next: Pollen helpers and our results

Back to the grade 2 year plan

Goal

Children learn three ways animals help seeds get to new places, then build model seeds and test which ones a "fur coat" carries across the room, so that their model works like an animal carrying a seed.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- Three seed picture cards (the author's own pictures):
  - **Card A:** a burr with tiny hooks caught in a dog's fur.
  - **Card B:** a blackbird eating a berry; a small picture beside it of a seed on the ground far away.
  - **Card C:** a squirrel burying an acorn; a small picture beside it of a young oak growing in the same spot later.
- For each group of 4-5: twelve paper balls about 2 cm across (scrunched scrap paper, the "seeds"), seven short strips of the hook side of a hook-and-loop fastener, eight short pipe cleaner pieces (about 4 cm, cut by an adult, with the cut ends folded over), masking tape and a shallow tray. That is enough for three hook strip seeds, three pipe cleaner seeds, three seeds of the group's own design and one improved seed.
- One fake-fur mitten or a fluffy sock for the adult's hand (the "fur coat").
- A "new field" mat (a sheet or a hoop) about 3 m from the trays.
- A class results chart with four rows: "plain", "hook strip", "pipe cleaner hooks", "our own idea".
- One real hook-and-loop fastener to pass round.
- For blind or low-vision children: a burr-like fastener strip and a piece of fake fur to feel; their own seed models to feel before and after the test.

Steps

✎ Opening (5 min)

Quick look at the cress pots (2 minutes): "Has anything happened yet?" Do not explain the results yet.

Then: "Plants cannot walk. So how do their seeds get to a new place where there is room to grow?" Show the three cards and read them:

- Card A: "Some seeds have tiny **hooks**. They catch on an animal's fur. When the animal walks away, the seed goes too, and later it falls off."

- Card B: "Some seeds are inside fruit. A bird or another animal eats the fruit, and the seed drops out somewhere else."
- Card C: "Some animals, like squirrels, hide nuts to eat later. If they forget one, it can grow into a new tree."

✎ Main activity (25 min)

- **Make the seeds (8 min).** Each group makes three of each kind on its tray: three plain paper balls; three with a hook strip taped round them; three with pipe cleaner pieces taped on and bent into hooks; and three of their own design using the same materials.
- **Test (12 min).** The adult with the "fur coat" visits each tray in turn and does the same thing every time: brushes the fur once, gently, across the tray; walks to the "new field" mat; and gives one gentle shake over it. The group counts how many of each kind landed on the mat, and how many are still stuck to the fur (the adult picks those off over the mat and they count as carried). Record on the results chart.
- **Improve (5 min).** Groups change one of their plain seeds to make it stick better, and the adult tests it once more.

Pass round the real hook-and-loop fastener: "About 85 years ago, a man called George de Mestral looked closely at burrs stuck to his clothes and his dog's fur. He saw tiny hooks and used the idea to make this fastener."

✓ Discussion questions (5 min, with answers)

- "Which seeds did the fur carry best?" (Usually the hook strip or pipe cleaner seeds.) "Why?" (The hooks catch on the fur.)
- "Which seeds stayed behind?" (Usually the plain ones.) "What does a plant get from a seed that travels?" (A new place to grow, with room and light.)
- "What did we keep the same in our test?" (One brush, the same mitten, the same walk, one shake.)
- "How is our model like a real animal? How is it different?" (Like: the fur carries hooked seeds to a new place. Different: a real animal walks further, and the seed falls off at a time we cannot choose.)

✓ Closing check (5 min, with answers)

1. Hold up a plain seed and a hook seed. "Which would a dog carry?" (The hook seed.)
2. "Name one other way an animal helps a seed get somewhere new." (Eats the fruit and the seed drops out somewhere else; hides a nut and forgets it.)
3. "What gave someone the idea for this fastener?" (Burrs with hooks.)

Vocabulary

seed, hook, fur, burr, carry, model, new place

Differentiation

- **More help:** test only plain and hook strip seeds; count with counters.
- **More challenge:** draw and label a design for a seed that a bird would carry inside a fruit, or one that sticks to feathers.
- Children with weak hand grip can direct a partner who tapes the hooks on.

⚠ Safety

- No real burrs, nuts or acorns in class (nut allergies and choking).
- Paper balls, fastener strips and pipe cleaners stay on the table; pipe cleaner ends are folded over by an adult.
- The fur mitten is fake fur, worn only by the adult; check for children who dislike the feel of fur and let them watch instead.

Teacher notes and misconceptions

- "Seeds only travel by wind" is a common idea. This lesson adds animals; wind and water were covered in the grade 2 literacy fact page "How Seeds Get About".
- Children may think animals carry seeds on purpose. The dog does not mean to carry the burr; the squirrel means to eat the nut later.
- The "85 years ago" is rounded from 1941 (see the unit Sources); say "a long time ago" if your class has not met large numbers.
- The model test is one comparison on one day, not proof. Fur, speed and how hard the adult shakes all change the results, so the adult keeps those the same.

Lesson 5: Pollen helpers and our results

Unit overview - Previous: Seeds that hitch a ride

Back to the grade 2 year plan

Goal

Children look at the results of the cress tests and say what cress needs, then use a model bee to show how an animal carries pollen from one flower to another.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. Teach this lesson at least five school days after lesson 3.

Materials

- The twelve cress pots from lesson 3 (and any spares), a ruler, the plan chart and the prediction chart.
- For each group of 4-5: two paper flowers, each a paper plate with a paper cup centre. One has a yellow washable ink pad in its cup (the "pollen flower"); the other has a plain white paper circle in its cup.
- One cotton-wool "bee" on a lolly stick per child (or one per pair).
- Aprons and wipes.
- The end-of-unit check cards (see Assessment in the unit overview).
- For blind or low-vision children: the cress pots to touch gently (dry cotton wool, soft green shoots, floppy pale shoots); the ink "pollen" can be felt as slightly damp on the white paper.

Steps

✎ Opening (5 min)

Bring out all twelve pots and the dark box. Open the box last, so everyone sees the dark cress at the same moment. "Look at the plan chart. What did we change? What did we keep the same?"

✎ Main activity (25 min)

- **Our results (10 min).** Compare the sets, three pots at a time:
  - Light and dark: "What colour is each set? Which is taller? Which is stronger?" (The light set is usually green and upright; the dark set usually pale yellow, taller, thin and floppy.) An adult measures the tallest shoot in one pot of each set with the ruler.
  - Water and no water: "Did the dry seeds grow?" (Usually not; they look the same as on the first day.)
  - Fill in "We saw..." on the prediction chart. "Did all three pots in a set do the same? If one was different, what might have happened?"

- **Bee helpers (15 min).** Read: "Flowers make a fine dust called **pollen**. Bees and other animals visit flowers for food, and pollen sticks to their bodies. When they visit the next flower, some pollen rubs off. Pollen moving from flower to flower helps many plants make seeds." Each child makes their bee "visit" the pollen flower (dab the cotton wool on the ink pad), then "fly" to the white flower and land on it. Look: the yellow has moved. Groups try three more visits and count how many yellow marks the white flower gets.

✓ Discussion questions (5 min, with answers)

- "What does cress need to grow green and strong?" (Light.) "To start growing?" (Water.) "How do we know?" (Our results: the dark cress was pale and floppy; the dry seeds did not grow.)
- "Why was it a good idea to change only one thing in each test?" (So we know what made the difference.)
- "What did the bee carry? Where from, and where to?" (Pollen, from one flower to another.)
- "How is our bee like a real bee? How is it different?" (Like: pollen sticks to it and rubs off on the next flower. Different: a real bee is looking for food and visits many flowers; real pollen is dust, not ink.)

✓ Closing check (5 min, with answers)

1. "Tell your partner one thing cress needs, and how we know." (Light or water, with a result.)
2. "Show me with your bee how a bee helps a flower." (From the pollen flower to the white flower.)
3. "Name one way an animal helps a seed and one way an animal helps a flower." (Carries a seed on its fur, or eats fruit, or hides a nut; carries pollen.)

Then begin the one-to-one checks (see Assessment in the unit overview).

Vocabulary

result, pale, upright, floppy, pollen, flower, bee, carry

Differentiation

- **More help:** compare only light and dark; an adult guides the bee's hand movement if needed.
- **More challenge:** add a third flower with a blue ink pad, and see which colours end up where after several bee visits.
- A child who cannot hold a lolly stick can use a cotton-wool mitten or point to where the bee should go while a partner moves it.

⚠ Safety

- Washable, non-toxic ink only; aprons on; wipe hands before touching the cress pots.
- Nobody eats the cress. Afterwards the adult disposes of it, or lets it grow on as a class plant.
- Check for pollen allergies if you bring in real flowers; this lesson uses paper flowers only.

Teacher notes and misconceptions

- Children may say plants "eat soil". Our cress grew on cotton wool with only water and light, which is a good talking point (they still use stored food from the seed at first).
- Some children think bees visit flowers to help them. Bees visit for food; the pollen moving is a side effect that helps the plant.
- Pollen must reach the right part of the right kind of flower to make seeds. That detail is left for later grades.
- If the results do not match (for example a dark pot stayed short), talk about it honestly: "One pot was different. That is why we used three."

Grade 3 Science: Magnets - What Sticks, What Pushes and What Gets Through (5 lessons, about 2-3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 4 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.

Back to the science progression

Big idea

A magnet can push or pull some things without touching them. It only pulls things made of a few metals (in a classroom, almost always iron or steel), so "metal" and "magnetic" are not the same word. Every magnet has two ends (poles): two different poles pull together and two matching poles push apart. Magnets can pull through some materials, and we can test which magnet is strongest with a fair test.

Outcomes

By the end of the unit a student can:

1. Predict, then test, whether twelve everyday objects are attracted to a magnet, and sort the results in a table.
2. Explain, with an example from their own results, why "all metals stick to magnets" is not true.
3. Show attraction and repulsion with two magnets and use the words "north pole", "south pole", "attract" and "repel" correctly.
4. Test whether a magnet still pulls a paper clip through paper, card, plastic, water and aluminium foil.
5. Carry out a fair test of magnet strength, naming the one thing they changed, two things they kept the same, and why they repeated it.
6. Describe how a compass uses a magnet to find north.

Prior knowledge

- Pushes and pulls make things start, stop and turn (kindergarten unit).
- Sorting objects into two groups and recording them in a table.
- No prior knowledge of magnets is assumed. This is the first unit in the science progression with a written fair test that has a measurement.

Lessons

Lesson	Title	Main activity
1	What sticks?	Predict, then test, twelve objects; sort magnetic vs not magnetic
2	Poles: pull together, push apart	Two bar magnets; ring magnets on a pencil; a hanging magnet turns to point north-south

Lesson	Title	Main activity
3	Does it work through things?	Paper clip through paper, card, plastic, water and foil; count sheets of paper
4	A fair test: which magnet is strongest?	Ruler test: how close must a paper clip be before it jumps? Three tries each
5	Using magnets	Floating compass; sorting challenge; end-of-unit check

Materials (per group of 3-4)

- 2 bar magnets with the poles marked (N/S or red/blue), plus one unmarked bar magnet for lesson 2.
- 2-3 different magnets for lesson 4 (for example a horseshoe magnet, a fridge magnet and a small bar magnet). **No small neodymium ("super") magnets or magnetic balls** - see Safety.
- 3 ring (doughnut) magnets and a pencil or wooden dowel that fits through them (lesson 2).
- 20 steel paper clips (check with a magnet first: plastic-coated steel clips are fine).
- A 30 cm ruler, masking tape, string or cotton thread, a sticky-tack blob.
- Lesson 1 objects: steel paper clip, aluminium foil ball, coins (see teacher note), plastic spoon, steel spoon, wooden lolly stick, rubber eraser, iron nail (blunt), drinks can (empty, rinsed), key, glass marble, piece of fabric.
- Lesson 3: paper sheets, a piece of card, a plastic cup, a clear plastic tub with water, aluminium foil.
- Lesson 5: a shallow bowl of water, a slice of cork or a plastic bottle lid, a steel paper clip straightened by the teacher, one shop-bought compass per group if available.

Assessment

- Lesson 1 prediction/result table (look for: predictions made before testing; a result column that is actually filled from the test, even where it disagrees with the prediction).
- Lesson 4 fair-test write-up (look for: one changed thing, two kept the same, three tries, a conclusion that matches the numbers).
- Lesson 5 end-of-unit check: 8 questions, 16 marks, with an answer guide. There is no pass mark; use it to see who needs more time with which idea.

⚠ Safety (read before lesson 1)

- **No small strong magnets.** Small neodymium magnets and magnetic balls are dangerous if swallowed: two or more can pull together through the gut wall and cause serious injury (see the Neodymium magnet source). Use only large classroom magnets too big to swallow, count them out and back in.
- Keep magnets away from phones, bank cards, computers and other electronic devices, and away from anyone with a pacemaker or other implanted medical device.
- Do not let students drop or bang magnets together hard: ceramic magnets chip and the chips are sharp.
- Use blunt nails. In lesson 5 the teacher straightens the paper clip; students do not use sewing needles.
- Wipe up spilled water from lesson 3 and lesson 5 straight away.

Sources

- Magnet: https://en.wikipedia.org/wiki/Magnet
- Magnetism: https://en.wikipedia.org/wiki/Magnetism
- Ferromagnetism (which materials are attracted): https://en.wikipedia.org/wiki/Ferromagnetism
- Iron: https://en.wikipedia.org/wiki/Iron
- Steel: https://en.wikipedia.org/wiki/Steel
- Stainless steel (some types are not magnetic): https://en.wikipedia.org/wiki/Stainless_steel
- Nickel: https://en.wikipedia.org/wiki/Nickel
- Aluminium: https://en.wikipedia.org/wiki/Aluminium
- Copper: https://en.wikipedia.org/wiki/Copper
- Coin (composition varies by country): https://en.wikipedia.org/wiki/Coin
- Magnetic field: https://en.wikipedia.org/wiki/Magnetic_field
- Iron filings: https://en.wikipedia.org/wiki/Iron_filings
- Compass: https://en.wikipedia.org/wiki/Compass
- Earth's magnetic field: https://en.wikipedia.org/wiki/Earth%27s_magnetic_field
- Lodestone: https://en.wikipedia.org/wiki/Lodestone
- Magnetic levitation: https://en.wikipedia.org/wiki/Magnetic_levitation
- Refrigerator magnet: https://en.wikipedia.org/wiki/Refrigerator_magnet
- Neodymium magnet (swallowing hazard): https://en.wikipedia.org/wiki/Neodymium_magnet
- Paper clip: https://en.wikipedia.org/wiki/Paper_clip
- Scientific control (keeping other things the same): https://en.wikipedia.org/wiki/Scientific_control

Known gaps and cautions

- "Magnetic materials" is simplified to iron and steel, with nickel and cobalt mentioned. Why only some metals are magnetic (ferromagnetism) is left for later grades.
- Coins, cans and "stainless" steel give different results in different countries and batches. Test your own objects before lesson 1 and treat a surprising result as good science, not a mistake.
- The compass explanation ("the Earth acts a bit like a giant magnet") is a simplification. A compass needle's north-seeking end points towards the Earth's magnetic pole in the far north, which is not exactly the same place as the geographic North Pole. Grade 3 students only need "points roughly north".
- Magnetic fields are only shown, not explained (optional iron-filings demo in a sealed bag in lesson 2). Field lines come in grades 6-8.
- No educator review yet.

Lesson 1: What sticks?

Unit overview · Next: Lesson 2

Goal

Students predict, then test, whether twelve objects are attracted to a magnet, and find out that only some metals are magnetic.

Materials (per group)

- 1 bar magnet.
- The twelve lesson 1 objects (see the unit overview), in a tray.
- Recording sheet: a table with columns Object | What it is made of | Prediction (sticks / doesn't) | Result (sticks / doesn't).

Steps

✎ Opening (5 min)

Read the safety rules aloud: magnets stay away from phones, tablets and bank cards; no banging magnets together; count magnets out and back in. Hold up a fridge magnet and ask: "Where have you seen magnets at home or at school? What do they stick to?"

✎ Main activity (25 min)

1. Groups look at each object and fill in "What it is made of" and their **prediction** in pen before anyone touches the magnet. Explain: we don't rub out predictions, even wrong ones - that is how we see what we learned.
2. Test each object: bring the magnet close slowly, then touch. Record "sticks" or "doesn't" in the Result column.
3. Groups sort the objects into two hoops or piles: "attracted to the magnet" and "not attracted".
4. Ask each group to circle any object where the result surprised them.

✓ Discussion questions (with example answers)

- Are all the things that stuck made of metal? Yes - in this set, every object that stuck was metal (iron or steel).
- Did every metal object stick? No. Aluminium foil, (usually) the drinks can and many coins did not stick, even though they are metal.
- So is this sentence true: "all metals stick to magnets"? No. Only a few metals do. In the classroom it is nearly always iron or steel. (Nickel and cobalt also stick, but students are unlikely to meet them on their own.)

- Did anything stick that you predicted wouldn't? Answers vary; a common one is a coin or a "silver" can. Praise changing your mind because of evidence.

✓ Closing check (5 min, with answers)

Hold up three objects the class has not tested, for example a steel safety pin (closed), a copper-coloured wire, and a plastic ruler. Students show thumbs up (will stick) or down. Test them in front of the class. **Expected: safety pin sticks (steel); copper wire and ruler do not.** Ask one student to explain the copper wire using today's rule.

Vocabulary

magnet, attract, magnetic, not magnetic, metal, iron, steel, aluminium, prediction, result

Differentiation

- Support: use six objects instead of twelve, with picture labels.
- Stretch: find three objects in the classroom that you predict will stick and three metal objects you predict won't. Test them and record.

⚠ Safety

See the overview. No magnets near the class computer or anyone's phone.

Teacher notes and misconceptions

- **Test every object yourself first.** Coins vary a lot by country and year: some are steel plated with copper or nickel and stick, others are copper, brass or cupronickel alloys and don't. Drinks cans are usually aluminium (don't stick) but some food and drink cans are steel (do stick). "Stainless" spoons may or may not stick depending on the type of stainless steel. Choose objects so that at least two metal objects do **not** stick.
- Common idea: "magnets attract all metal" or "magnets attract anything shiny". The foil ball is there to challenge this.
- Some students think magnets stick to anything heavy or hard. The glass marble and the key are a useful pair.

Lesson 2: Poles: pull together, push apart

Unit overview · Previous: Lesson 1 · Next: Lesson 3

Goal

Students find that each magnet has two poles, that unlike poles attract and like poles repel, and that a freely hanging magnet turns to point roughly north-south.

Materials (per group)

- 2 bar magnets with poles marked (N/S or colours).
- 3 ring magnets and a pencil or dowel standing upright in a lump of sticky-tack or modelling clay.
- 1 unmarked bar magnet, cotton thread, masking tape.
- Teacher only (optional): iron filings sealed inside a clear zip bag that is taped shut, and a bar magnet.

Steps

✎ Opening (5 min)

Hold two bar magnets so that the two N ends face each other and slowly bring them together. Ask: "What do you feel? What do you think will happen if I turn one round?" Take predictions.

✎ Main activity (25 min)

1. **Push and pull.** Groups try all four ways of putting the ends together: N-N, N-S, S-N, S-S. Record each in a table as "pull together" or "push apart".
2. **Floating rings.** Slide ring magnets onto the upright pencil one at a time. If a ring snaps down onto the one below, take it off, turn it over and put it back. Challenge: make all three float. Ask: "What is holding them up?"
3. **Mystery magnet.** Groups use a marked magnet to work out which end of the unmarked magnet is N and which is S, then label it with tape. (The end that pushes away the N of the marked magnet is also N.)
4. **Hanging magnet.** Tie thread round the middle of the marked bar magnet so it hangs level, away from other magnets and metal furniture. Let it stop turning. Which way does the N end point? Compare with the other groups.
5. Optional teacher demo: lay the sealed bag of iron filings over a bar magnet. The filings gather most at the ends. Ask: "Where is the magnet strongest?"

✓ Discussion questions (with example answers)

- Which pairs pulled together and which pushed apart? N-S and S-N pulled together (attract). N-N and S-S pushed apart (repel).

- Can you write that as a rule? Different poles attract; the same poles repel.
- Why do the ring magnets float? Their matching poles face each other and push apart, and the push is strong enough to hold up the ring's weight.
- Which way did the hanging magnets point? All roughly the same way, with the N end towards the north side of the room. (Check this with a compass beforehand so you can say which wall is north.)
- Where is a bar magnet strongest? At its ends (poles), shown by where most filings or paper clips gather.

✓ Closing check (5 min, with answers)

Draw two bar magnets on the board in three arrangements: (a) N facing S, (b) S facing S, (c) N facing N. Students write "attract" or "repel" for each. **(a) attract, (b) repel, (c) repel.**

Vocabulary

pole, north pole, south pole, attract, repel, compass direction (north)

Differentiation

- Support: give a two-row picture rule card ("different - pull", "same - push") to use while testing.
- Stretch: with three ring magnets floating, predict what happens if you press the top ring down and let go, then try it. (It bounces back up.)

⚠ Safety

See the overview. Iron filings stay sealed in a bag that is taped shut; students never handle loose filings (they get into eyes and skin and are very hard to remove from magnets).

Teacher notes and misconceptions

- Common idea: "the bigger magnet always wins" or "N is the strong end". The poles of a magnet are equally strong; size and material change overall strength (lesson 4).
- A magnet's N pole is short for "north-seeking pole": the end that turns towards the north. Students don't need the explanation of why (the Earth's magnetic field) until lesson 5, and then only simply.
- Old magnets can lose strength or even have their poles mislabelled. Check your set with a compass first.
- Steel furniture, radiators and other magnets nearby can stop the hanging magnet pointing north. Hang it from a wooden or plastic support.

Lesson 3: Does it work through things?

Unit overview · Previous: Lesson 2 · Next: Lesson 4

Goal

Students test whether a magnet still pulls a paper clip through different materials, and count how many sheets of paper it can pull through.

Materials (per group)

- 1 bar magnet, 2 steel paper clips.
- A piece of card, a plastic cup, a clear plastic tub of water, a square of aluminium foil, 20 sheets of thin paper.
- Teacher only: a steel baking tray or steel tin lid (check with a magnet that it sticks).
- Recording sheet: Material | Prediction (pulls through / doesn't) | Result.

Steps

✎ Opening (5 min)

Put a paper clip on top of a book and move a magnet under the book's cover. Ask: "Did the magnet have to touch the clip? What is in between?" Take predictions about other materials before testing.

✎ Main activity (25 min)

1. **Through materials.** For each material, students predict, then test:
2. card: clip on top, magnet slid underneath;
3. plastic cup: clip inside, magnet outside, drag the clip up the side;
4. water: clip in the bottom of the tub of water, magnet against the outside of the tub, drag the clip up the side;
5. aluminium foil: wrap the clip loosely in foil and try to pick it up.
6. **Counting sheets.** Put the magnet flat on the table. Lay sheets of paper on top of it one at a time and put a clip on top. After each sheet, slide the magnet slowly sideways. Does the clip follow? Record the largest number of sheets where the clip still follows.
7. Groups write their sheet count on the board.
8. **Teacher demo.** Put the steel tray between the magnet and a clip. Ask the class to predict, then show: the magnet sticks to the tray and barely pulls the clip at all.

✓ Discussion questions (with example answers)

- Which materials did the magnet pull through? Card, plastic, water and aluminium foil (and paper, up to a point).
- Why didn't the foil stop it? Foil is metal. Aluminium isn't magnetic, so the pull goes through it, like through paper (link to lesson 1).

- Why did the steel tray stop it? Steel is magnetic, so the magnet pulled on the tray instead of the clip.
- Did every group get the same sheet count? Why not? No. Different magnets, different paper thickness, sliding faster or slower. That is a hint for tomorrow: to compare magnets fairly we must keep those things the same.

✓ Closing check (5 min, with answers)

A student says: "A magnet can't pull through water because water stops things." Who agrees? Ask someone to describe today's test that shows this is wrong. **The clip moved up the side of the tub through the water.**

Vocabulary

through, material, magnetic, not magnetic, distance, gap

Differentiation

- Support: test only card, water and foil.
- Stretch: does it work through your hand? (Yes - try it with one clip on the back of a flat hand and the magnet underneath. Hands are not magnetic.)

⚠ Safety

See the overview. Wipe up water straight away. Keep the water tub away from any electrical sockets and devices.

Teacher notes and misconceptions

- Common idea: "magnets only work if they touch" - the opening book demo challenges this. Another is "metal blocks magnets" - the foil test shows only magnetic metals do.
- Results for the sheet count vary widely; that is useful. Don't present any number as "right".
- Some flexible fridge magnets only pull on one face and are very weak at a distance. If a group uses one, expect a small sheet count.

Lesson 4: A fair test: which magnet is strongest?

Unit overview · Previous: Lesson 3 · Next: Lesson 5

Goal

Students carry out a fair test to compare the strength of different magnets, measuring the distance at which a paper clip jumps to each magnet, and repeat each test three times.

Materials (per group)

- 2-3 different magnets (for example horseshoe, bar, fridge magnet).
- 1 steel paper clip, a 30 cm ruler, masking tape.
- Recording sheet: a table with one row per magnet and columns Try 1 | Try 2 | Try 3 | Middle number (cm).

Steps

✎ Opening (5 min)

Hold up two magnets. "Which one is stronger? How could we find out in a way that is fair?" Collect ideas. Remind the class of yesterday: groups got different sheet counts partly because they did things differently.

✎ Main activity (25 min)

1. **Set up.** Tape the ruler flat to the table. Put the first magnet at the 0 cm end, with one pole touching the 0 mark. Put the paper clip at the 15 cm mark.
2. **Test.** Slowly push the clip towards the magnet with a pencil tip, a little at a time. As soon as the clip jumps to the magnet, stop. Read the ruler where the clip was just before it jumped (to the nearest half centimetre). Record it as Try 1.
3. **Repeat.** Do it two more times with the same magnet. Then do three tries with each other magnet.
4. **Middle number.** For each magnet, put the three tries in order and circle the middle one. Write it in the last column.
5. **Fair test talk.** As a group, fill in: "We changed ____. We kept ____ and ____ the same. We did it three times because ____."

Example results (for teacher reference; yours will differ)

Magnet	Try 1	Try 2	Try 3	Middle number
Horseshoe	4 cm	5 cm	4 cm	4 cm
Bar	3 cm	3.5 cm	2.5 cm	3 cm

Magnet	Try 1	Try 2	Try 3	Middle number
Fridge magnet	0.5 cm	0.5 cm	0.5 cm	0.5 cm

Here the horseshoe magnet is strongest because the clip jumped from furthest away.

✓ Discussion questions (with example answers)

- What did you change? The magnet.
- What did you keep the same? The same paper clip, the same ruler, the same table, starting at 15 cm, pushing slowly, using the same kind of end (a pole) facing the clip.
- Why did we do three tries? The numbers wobble a little each time (pushing speed, reading the ruler). Three tries and the middle number make the result more trustworthy than one try.
- Is the biggest magnet always the strongest? Not necessarily. A small magnet made of a stronger material can beat a bigger one. Use your data.
- What would be unfair? For example, using a heavier clip for one magnet, or pushing the clip fast for one and slowly for another.

✓ Closing check (5 min, with answers)

Show this table: Magnet A tries 6, 5, 6 cm; Magnet B tries 2, 9, 3 cm. "Which magnet is stronger, and is anything strange?" **A is stronger (middle 6 cm vs B's middle 3 cm). B's 9 cm try is very different from the others, so it was probably a mistake (for example, the clip was bumped). It is a reason to repeat, not to pick the biggest number.**

Vocabulary

fair test, change, keep the same, measure, centimetre, repeat, result, middle number, strongest

Differentiation

- Support: test two magnets only; pre-printed sentence frames for the fair test talk.
- Stretch: plan a second fair test of a different question, for example "Does a thicker paper clip jump from further away?", naming what to change and what to keep the same.

⚠ Safety

See the overview. Push the clip with a pencil, not fingers, so fingers do not get pinched between clip and magnet.

Teacher notes and misconceptions

- This is the first fair test with a measurement in the science progression. Spend time on "what we kept the same"; it matters more than the answer.
- "Middle number" is the median of three. You don't need the word at this age; it avoids the arithmetic of an average.

- A horseshoe magnet has both poles side by side; place it so both poles face the clip, and write that down as one of the things kept the same for that magnet.
- Magnets pick up strength differences very sensitively near the poles; half-centimetre reading is enough for this age.

Lesson 5: Using magnets

Unit overview · Previous: Lesson 4

Goal

Students make a simple floating compass, use magnets to solve a sorting problem, and complete the end-of-unit check.

Materials (per group)

- 1 bar magnet, a shallow plastic bowl of water, a slice of cork or a plastic bottle lid.
- 1 steel paper clip, straightened by the teacher before the lesson, with any sharp ends taped.
- A shop-bought compass (one per group, or one for the class).
- Sorting tray: a mixture of about 10 steel paper clips, 10 aluminium foil balls, 10 plastic buttons and 10 dried beans or pasta shapes, mixed in one tub. A plastic sandwich bag.
- End-of-unit check sheets.

Steps

✎ Opening (5 min)

Show a shop-bought compass. Turn it slowly; the needle keeps pointing the same way. Ask: "What do you think is inside it? Which lesson does this remind you of?" (The hanging magnet in lesson 2.)

✎ Main activity (25 min)

1. **Magnetise the clip.** Stroke the straightened clip with one end (pole) of the bar magnet about 30 times, always in the same direction, lifting the magnet away at the end of each stroke. Test: will it now pick up another paper clip? (A weak pick-up is enough.)
2. **Float it.** Lay the clip on the cork or bottle lid, floating in the middle of the bowl, away from other magnets and steel. Wait until it stops turning. Compare its direction with the shop-bought compass. Mark the north-pointing end with a dot of marker.
3. **Sorting challenge.** "A recycling centre has mixed up steel, aluminium, plastic and food scraps. Use only the magnet to get the steel out without the magnet touching the clips." Hint if needed: put the magnet inside a plastic bag, pull out the clips, then hold the bag over a tray and pull the magnet out of the bag so the clips drop off.
4. **End-of-unit check** (15 min, individually; below).

✓ Discussion questions (with example answers)

- Why does the floating clip turn? Stroking made it into a weak magnet. The Earth acts a bit like a giant magnet, so a free magnet turns to point roughly north-south.

- Why must the compass be away from other magnets and steel? They pull on the needle more strongly than the Earth does, so it points the wrong way.
- Why use a bag in the sorting challenge? So the clips can be dropped off easily; magnets hold steel clips tightly.
- What was left in the tub after the magnet? Aluminium, plastic and beans/pasta. A magnet can't sort those, because none of them are magnetic.

✓ End-of-unit check (8 questions, 16 marks)

1. Circle the objects a magnet will attract: steel paper clip, plastic ruler, iron nail, aluminium foil, wooden spoon. (2 marks)
2. Mia says, "All metal objects stick to magnets." Is she right? Explain using an example. (2 marks)
3. Two bar magnets are placed with N facing S. Do they attract or repel? What if they are placed with S facing S? (2 marks)
4. Name one material a magnet can pull a paper clip through, and one that would stop it. (2 marks)
5. Sam tests three magnets with the ruler test. Magnet X: 2, 2, 3 cm. Magnet Y: 5, 6, 5 cm. Magnet Z: 1, 1, 1 cm. Which magnet is strongest? How do you know? (2 marks)
6. In the ruler test, name the one thing that was changed and two things that were kept the same. (2 marks)
7. Why did we do each ruler test three times? (2 marks)
8. A hiker's compass is pointing the wrong way. She notices her phone and a magnet-clasp bag are right next to it. What should she do, and why? (2 marks)

Answer guide

1. Steel paper clip and iron nail (1 mark each, 2 marks in total; take 1 mark off, to a minimum of 0, for each wrong object circled).
2. No (1). Any correct example of a non-magnetic metal, for example aluminium foil, an aluminium can, a copper or brass coin from their own test (1).
3. N-S attract (1); S-S repel (1).
4. Through: any of paper, card, plastic, water, aluminium foil, a hand (1). Stop: a sheet of steel or iron, such as a steel tray or tin lid (1). Accept "lots of thick paper" for the stop answer only if they explain the gap became too big.
5. Magnet Y (1), because the clip jumped from furthest away / its middle number (5 cm) is the biggest (1).
6. Changed: the magnet (1). Kept the same: any two of the same clip, same ruler, same starting point, same slow pushing, same end/pole facing the clip, same table (1 for both).
7. The results change a little each time (1), so repeating makes the result more trustworthy / lets us spot a mistake (1).
8. Move the phone and bag away from the compass (1), because magnets (and magnetic things nearby) pull on the compass needle more strongly than the Earth does (1).

There is no pass mark. Note which questions each student missed: Q1-2 point back to lesson 1, Q3 to lesson 2, Q4 to lesson 3, Q5-7 to lesson 4, Q8 to lesson 5.

Vocabulary

compass, magnetise, north, Earth's magnetism, sort, separate, recycle

Differentiation

- Support: read the check questions aloud; accept spoken or drawn answers.
- Stretch: explain why scrapyards and recycling centres use large magnets, and what they still need another method for (aluminium cans; the grade 5 dissolving unit returns to separating mixtures).

⚠ Safety

See the overview. The teacher straightens and tapes the paper clips; no sewing needles. Wipe up water straight away. Count magnets back in.

Teacher notes and misconceptions

- Magnetising by stroking gives only a weak magnet, and some clips work better than others. Test the method the day before. If a clip won't float steadily, the bottle lid usually works better than cork.
- Common idea: "the compass points to the North Pole because there's a big magnet there". The simple version ("the Earth acts a bit like a giant magnet") is enough at grade 3; the Earth's magnetic north pole is not exactly the geographic North Pole and it moves slowly.
- The sorting challenge previews separating mixtures in grade 5.

Grade 3 Science: Weather Over a Season (5 lessons, about 2-3 weeks, plus a short daily record)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 12 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.
>
> Text-checked by two other agents (Gemini 3.8 Flash and Gemini 4 Argon); see Known gaps.

Back to the grade 3 year plan - Term 2. Builds on kindergarten science: Using our senses and watching the weather, grade 2 science: Land and water, fast and slow, grade 3 science term 1: Magnets, grade 3 mathematics term 1: Equal groups and arrays and the science progression

Big idea

Weather is what the air outside is like at one place and one time: how warm it is, whether rain or snow is falling, where the wind is coming from and what the sky looks like. Scientists measure the weather every day and write it in tables, so that they can see patterns. The patterns let us say what the weather is **usually** like in each season, and make a careful guess about what might come next. The usual weather of a place over many years is its **climate**, and different places in the world have very different climates. People cannot stop storms or floods, but they can design things that make the harm smaller, and we can test which design works better.

This is the second science unit of grade 3 (term 2). In kindergarten the class kept a picture weather chart. Now the class measures the weather with simple instruments, writes numbers in a table and draws bar graphs and pictographs. The daily record started in lesson 1 keeps going for the rest of the term (and can go on all year), so that by the end of the season the class has its own data.

Outcomes

By the end of the unit most children can:

1. Read a thermometer in degrees Celsius, a rain gauge in millimetres and a wind streamer with a compass, and write the readings in the class weather table.
2. Read a weather table for one week and answer questions such as "Which day was warmest?" and "How much rain fell in all?"
3. Make a pictograph or a bar graph from a weather table, and answer "how many more" questions from it.
4. Use a table of usual weather in each season to say what the weather is usually like in summer and winter, and explain why "usually" is not the same as "always".
5. Combine a picture card and a fact card to describe the climate of a place, and say the difference between weather and climate.
6. Test two designs that keep flood water away from a model house, and make a claim about which works better, giving evidence from the test.

Prior knowledge

- Kindergarten science: a daily weather chart with picture cards; counting sunny, cloudy and rainy days.
- Grade 1 science: the Sun's daily pattern; long and short days in different seasons. Grade 1 society: maps and globes.
- Grade 2 science term 2: comparing ways of protecting a sand hill from poured water, keeping the water the same each time.
- Grade 3 science term 1: a compass needle points north.
- Mathematics: reading scales in ones and twos; tally marks; simple bar graphs and pictographs (grade 2); counting in twos and fives (grade 3 term 1).
- Children read short labels and numbers in tables. Fact cards are read aloud by an adult.

Lessons

Each lesson is about 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. Teach about two lessons a week. From lesson 1 on, two weather helpers (a new pair each week) take the readings every school day at the same time, with an adult, and write them in the class weather table (about 3 minutes).

1. Measuring the weather: weather words; reading a thermometer, a rain gauge and a wind streamer with a compass; setting up the weather station; the first row of the class weather table.
2. Tables and graphs: reading a made-up week of weather in Little Hill; a pictograph of twenty days' weather; a bar graph of rain.
3. What is each season usually like?: a made-up table of usual weather in each season in Little Hill; a bar graph of temperatures; comparing three summers to see that "usually" is not "always"; making careful predictions.
4. Climates around the world: weather and climate; three climate picture cards and fact cards (a tropical rainforest climate, a desert climate and a tundra climate); finding them on a globe; combining the clues to describe each one.
5. Keeping flood water out: weather hazards (gently); testing two model flood barriers around a model house; a claim with evidence; looking at other designs (lightning rods and strong roofs); the end-of-unit check.

At the end of the term (or of the season), use 20 minutes to make a class bar graph of the class's own records (for example, the number of rainy days each week) and compare it with the Little Hill table from lesson 3.

Materials (whole class unless noted)

- **Lesson 1:** an outdoor thermometer with a plastic case and a large Celsius scale (spirit-filled, not mercury); a rain gauge (a straight-sided clear plastic bottle, cut by an adult, with the cut edge covered in tape, the top turned upside down as a funnel, and a ruler taped on the outside with 0 at the bottom of the water space; or a bought plastic rain gauge); a cup of water for the demonstration; a wind streamer (a ribbon about 50 cm long tied to a stick or a fence); a compass (one from the magnets unit); four direction cards (N, E, S, W); a large class weather table (columns: date, temperature in °C, rain in mm, wind from, sky); sky picture cards (sunny, cloudy, rain, snow, fog); a large teaching thermometer picture with a moving strip; for each pair, a thermometer practice sheet (six thermometer pictures to read).

- **Lesson 2:** the Little Hill week table (in Lesson 2) on the board and one copy for each pair; the twenty-day weather list and a blank pictograph sheet for each pair; for each pair, a blank bar graph sheet (five days along the bottom, rain in mm up the side in twos from 0 to 14); pencils and coloured pencils; squared paper for stretch; the class weather table.
- **Lesson 3:** the Little Hill season table and the "three summers" table (in Lesson 3) on the board and one copy for each pair; for each pair, a blank bar graph sheet (four seasons along the bottom, temperature in °C up the side in twos from 0 to 24); six prediction cards; pencils; the class weather table.
- **Lesson 4:** a globe; a world map; three A4 climate picture cards and three climate fact cards (in Lesson 4); the Little Hill season table from lesson 3; for each group of 4-5, a "climate clues" sheet; pencils; the class weather table.
- **Lesson 5:** for each group of 4-5, a shallow plastic tray or box about 30 cm long with a rim at least 5 cm high, damp washed play sand, a small wooden block or a plastic brick (the "house"), a square of paper towel about 5 cm across under the house (at least three per group, one for each pour), a plastic jug with 200 ml of water marked on it, a pouring cup, a lump of modelling clay (latex-free, about the size of a tennis ball), eight lolly sticks, a book or block about 3 cm thick to tilt the tray; a few spare paper towel squares; a results chart; three design picture cards (a flood barrier, a lightning rod on a roof, a roof tied down with strong straps); aprons, cloths and a bucket for wet sand.
- For blind or low-vision children: a talking thermometer or a large tactile thermometer model with a sliding strip and raised marks every 2 °C; a rain gauge ruler with raised marks every 10 mm; a ribbon streamer they can hold to feel which way it is blown; tactile bar graphs (stuck-on card squares); tactile climate cards (for example warm damp leaves texture, dry sand, cold smooth plastic); the tray test can be checked by feeling whether the paper towel is wet.
- Hand-washing sinks, paper towels.

⚠ Safety and access

- **Outside (lesson 1 and the daily record).** The weather station is in a place the teacher has checked, inside the school grounds, where children can stand safely. Readings are taken with an adult. Nobody climbs to reach the instruments; the thermometer and gauge are fixed at a height children can reach from the ground.
- **The rain gauge.** An adult cuts the bottle and covers the cut edge with tape. Children never cut it. Empty it after each reading.
- **Thermometer.** Use a plastic-cased spirit thermometer, never a mercury or a glass one. Never look at the Sun; the thermometer goes in the shade.
- **Bad weather.** In storms, lightning or ice, nobody goes out: the adult takes the reading later, or the table says "not read today". That is honest data too.
- **Feelings (lessons 4 and 5).** Some children may have lived through a flood, a storm, a fire or other hard weather. Tell families before lesson 5 what it is about. Talk about hazards calmly, with no frightening pictures or stories. Any child may sit out the talk and do the tray test only, or be a helper. Never ask children about their own homes or experiences.
- **Water and sand (lesson 5).** Aprons on; wipe spills at once so the floor is not slippery; sand stays in the trays and away from faces. Wash hands.
- **Modelling clay.** Check for latex and wheat allergies (some home-made dough contains wheat).
- Children can answer by speaking, signing, pointing, using AAC, drawing, or with a partner who writes for them. Their own way counts.

- Deaf children: show every picture and table while it is described; face the class when reading fact cards aloud. Blind and low-vision children: use the tactile materials above; a partner reads the numbers aloud.
- Colour is never the only clue: bar graphs use a label on each bar, and sky cards have a picture and a word.
- Wheelchair users: put the weather station on a firm, level path at a height they can reach; trays go on a table they can reach.

Assessment

Watch and listen during lessons, and use the closing checks. During lesson 5 or the following week, see each child for about 3 minutes with the materials listed (answers in brackets):

1. Show the teaching thermometer picture set to 14 °C and the rain gauge with water at 6 mm. "What is the temperature? How much rain fell?" (14 °C; 6 mm.) Hold the streamer so it blows towards the south (or show a picture of this). "Where is the wind coming from?" (From the north.) (Outcome 1.)
2. Show the Little Hill week table from lesson 2. "Which day was coldest? How much rain fell in all?" (Wednesday, 8 °C; 18 mm.) (Outcome 2.)
3. Show the child's own pictograph from lesson 2. "How many more cloudy days than sunny days?" (3.) (Outcome 3.)
4. Show the Little Hill season table from lesson 3. "What is summer usually like in Little Hill?" (Warm, about 22 °C, with few rainy days, about 5.) "Will every summer day be 22 °C?" (No; that is what is usual, and some days and some summers are warmer or cooler.) (Outcome 4.)
5. Show the desert picture card and fact card from lesson 4. "Tell me about the climate there." (Very dry, little rain; any detail from the cards.) "What is the difference between weather and climate?" (Weather is what it is like today; climate is what it is usually like over many years.) (Outcome 5.)
6. Show the class results chart from lesson 5. "Which barrier worked better? How do you know?" (The one where the paper towel under the house stayed driest; any answer that matches the class's results and gives that evidence.) (Outcome 6.)

Sources

Quoted exactly; the unit is not a full alignment to these standards.

- Next Generation Science Standards, grade 3, Weather and Climate: https://www.nextgenscience.org/topic-arrangement/3weather-and-climate
  - 3-ESS2-1: "Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season." Clarification statement: "Examples of data could include average temperature, precipitation, and wind direction." Assessment boundary: "Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change."
  - 3-ESS2-2: "Obtain and combine information to describe climates in different regions of the world."
  - 3-ESS3-1: "Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard." Clarification statement: "Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods."

    - ESS2.D: "Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next." "Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years."
    - ESS3.B: "Humans cannot eliminate natural hazards but can take steps to reduce their impacts."
- Wikipedia (lead paragraphs, read 2026-11-12):
    - Weather: "Weather refers to day-to-day temperature, precipitation, and other atmospheric conditions, whereas climate is the term for the averaging of atmospheric conditions over longer periods of time."
    - Climate: "Climate is the long-term weather pattern in a region, typically averaged over 30 years."
    - Wind direction: "Wind direction is generally reported by the direction from which the wind originates. For example, a north or northerly wind blows from the north to the south".
    - Rain gauge: it is used "to determine the depth of precipitation (usually in mm)".
    - Tropical rainforest climate: "high mean annual temperatures, small temperature ranges, high humidity, and rain that falls throughout the year with no dry season"; "usually found within 10 to 15 degrees latitude of the equator".
    - Desert climate: "The typically bald, rocky, or sandy surfaces in desert climates are dry and hold little moisture, quickly evaporating the already little rainfall they receive."; "There are two variations of a desert climate according to the Köppen climate classification: a hot desert climate (BWh), and a cold desert climate (BWk)."
    - Tundra climate: "located in high latitudes and high mountains"; "at least one month has an average temperature high enough to melt snow 0 °C (32 °F), but no month with an average temperature in excess of 10 °C (50 °F)"; "Rainfall and snowfall are generally slight".
    - Lightning rod: "If lightning hits the structure, it is most likely to strike the rod and be conducted to ground through a wire, rather than passing through the structure, where it could start a fire or cause electrocution."
    - Flood barrier: "Flood barrier may also refer to barriers placed around or at individual buildings to keep floodwaters from entering the buildings."

Known gaps and cautions

- Two other agents text-checked this unit on 2026-11-12 and reported no errors: Gemini 3.8 Flash (at 903d528) and Gemini 4 Argon (at 823de91). Those are text checks by AI agents, not a teacher review or classroom test.
- Little Hill is a made-up place, and all its weather numbers (the week table, the twenty days, the season table and the three summers) are made up by the author to be easy to graph. They are examples, not real data.
- The climate cards describe climate types from Wikipedia, not named countries or peoples. The fact cards say nothing about how people live there, to avoid passing on stereotypes. A teacher may add real places from a good atlas.
- The season table fits a place with four clear seasons, like many places in North America and Europe. In the southern half of the world the seasons fall in different months, and many places near the equator have wet and dry seasons instead. Teachers there should use their own seasons.
- The unit does not explain **why** seasons happen (the tilt of the Earth); that is left for grade 5 in the science progression.

- Following the 3-ESS2-1 assessment boundary, the unit does not teach or assess climate change.
- Averages are not taught: "usual" temperatures are given in the table, and children compare them, but they do not calculate a mean. Wind speed and humidity are not measured.
- The tray test is a model: real flood barriers are much bigger and water pushes harder on them. Two designs and one pour each is a small test, not proof. The lesson builds on grade 2's sand-hill test, so some children may remember the idea; the new part is a claim about merit with evidence.
- Lightning rods and strong roofs are discussed from picture cards only; nothing electrical is tested.
- The lesson order, the instruments, the made-up data, the card wording and the assessment items are the author's own choices, not taken from a source.
- Timings are untested guesses. Going outside to the weather station with a full class takes time.
- No images yet.

Lesson 1: Measuring the weather

Unit overview - Next: Tables and graphs

Back to the grade 3 year plan

Goal

Children learn to read a thermometer, a rain gauge and a wind streamer with a compass, set up the class weather station, and write the first row of the class weather table.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- An outdoor thermometer with a plastic case and a large Celsius scale (spirit-filled, not mercury), fixed in the shade at a height children can read from the ground.
- A rain gauge: a straight-sided clear plastic bottle cut by an adult, with the cut edge covered in tape, the top turned upside down as a funnel, and a ruler taped on the outside with 0 at the bottom of the water space. A bought plastic rain gauge also works. Put it in an open place away from walls and trees, standing firmly (for example in a pot of sand).
- A cup of water, to show how the rain gauge works.
- A wind streamer: a ribbon about 50 cm long tied to a stick or a fence.
- A compass (one from the magnets unit) and four direction cards (N, E, S, W).
- The class weather table on a large sheet, with five columns: date, temperature in °C, rain in mm, wind from, sky.
- Sky picture cards, each with a picture and a word: sunny, cloudy, rain, snow, fog.
- A large teaching thermometer picture with a moving strip (a red paper strip that slides up and down a card thermometer marked every 2 °C from -10 to 40).
- For each pair: a thermometer practice sheet with six thermometer pictures to read (answers in Closing check), and a pencil.
- For blind or low-vision children: a talking thermometer, or the tactile thermometer model with raised marks every 2 °C; a rain gauge ruler with raised marks every 10 mm; the streamer to hold.

Steps

✎ Opening (5 min)

Ask: "What was the weather like on the way to school today?" Collect words: sunny, cloudy, windy, wet, cold, warm. Say: "In kindergarten we used pictures for the weather. Scientists use **instruments** to measure the weather with numbers. Numbers let us compare one day with another. Today we start our own **weather station**."

Show the three instruments and name them: **thermometer** (how warm or cold), **rain gauge** (how much rain), **wind streamer** and compass (where the wind comes from).

✎ Main activity (25 min)

- **Reading a thermometer (8 min).** Use the teaching thermometer picture. Point out that the numbers go up in twos, and that the marks between the numbers are the odd numbers. Slide the strip to 10, 14, 21 (between 20 and 22) and 0, and read each together: "The top of the red strip is level with... 14 degrees Celsius." Write **°C** and say it. Pairs read the first three pictures on the practice sheet.
- **Reading a rain gauge (5 min).** Show the gauge. Pour in a little water from a cup to show how it works. "The rain falls into the funnel. We read where the top of the water is on the ruler, in **millimetres** (mm). Then we empty it, ready for tomorrow." Read the level together.
- **Wind from... (5 min).** Go outside to the weather station (or look from the window if it is not safe to go out). One child holds the compass flat and the class finds north. Put the four direction cards on the ground around the streamer. "Look which way the ribbon is blown. Weather scientists say where the wind **comes from**, not where it is going. If the ribbon is blown towards the south, the wind is coming from the north: a north wind."
- **First readings (7 min).** With the class watching, two helpers read the thermometer and the rain gauge (if it has had no time to catch rain, write 0), look at the streamer and the sky, and the teacher writes the first row of the class weather table. If there is no wind, write "calm". Agree the daily time for readings, and the first pair of weather helpers.

✓ Discussion questions (5 min, with answers)

- "Why do we read the weather at the same time every day?" (So that days are fair to compare; the afternoon is usually warmer than the early morning.)
- "Why is the thermometer in the shade?" (In the sun it gets warm itself and reads higher than the air; we want the air's temperature.)
- "The ribbon is blowing towards the east. Where is the wind coming from?" (From the west.)
- "Why do we empty the rain gauge after reading it?" (So that tomorrow's number shows only the new rain.)

✓ Closing check (5 min, with answers)

Pairs finish the practice sheet, then check together. The six pictures show:

1. 12 °C (answer: 12)
2. 6 °C (answer: 6)
3. 17 °C, one mark above 16 (answer: 17)
4. 25 °C, one mark above 24 (answer: 25)
5. 0 °C (answer: 0)
6. 30 °C (answer: 30)

Then show with a thumb up or down: "Is a 6 °C day warmer than a 12 °C day?" (Down: no, colder.)

Vocabulary

weather, instrument, thermometer, degrees Celsius (°C), rain gauge, millimetre (mm), wind direction, compass, north, east, south, west

Differentiation

- **More help:** read only the numbered marks (10, 20, 30) first; an adult slides the strip while the child says "higher" or "lower".
- **More challenge:** read a thermometer picture below zero (for example -4 °C) and say what might happen to a puddle on that day (it may freeze).
- Children who use a talking thermometer or the tactile model take a full turn as a weather helper.

⚠ Safety

- Readings outside are taken with an adult. Nobody climbs to reach an instrument.
- Plastic-cased spirit thermometer only; never mercury or glass.
- An adult cuts the rain gauge bottle and tapes the edge.
- Never look at the Sun. In storms, lightning or ice, nobody goes out: write "not read today".

Teacher notes and misconceptions

- Children often read the bottom of the bulb, or the number nearest the top instead of the level of the top. Model "level with the top of the strip".
- The odd numbers are not written on many thermometers. Counting in twos from the last number helps.
- "A north wind blows to the north" is a common mix-up. Keep saying "comes from".
- A compass can be pulled off north by steel nearby (a fence, a car, a radiator); stand a few steps away, as in the magnets unit.
- The table is real data. If a reading is missed, leave the box empty or write "not read"; never make up a number to fill it.

Lesson 2: Tables and graphs

Unit overview - Previous: Measuring the weather - Next: What is each season usually like?

Back to the grade 3 year plan

Goal

Children read a weather table for one week, make a pictograph of twenty days' weather and a bar graph of rain, and answer "how many more" questions from their graphs.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. The weather helpers take today's reading before or after the lesson.

Materials

- The class weather table from lesson 1.
- The Little Hill week table (below) on the board, and one copy for each pair.
- For each pair: the twenty-day weather list (below) and a blank pictograph sheet (four rows: sunny, cloudy, rain, fog; key "one sun, cloud, raindrop or fog picture = 1 day").
- For each pair: a blank bar graph sheet, with the five days (Monday to Friday) along the bottom and "rain in mm" up the side in twos from 0 to 14.
- Pencils and coloured pencils; squared paper for stretch.
- For blind or low-vision children: a tactile copy of the week table (large print or braille), and card squares with sticky backs to build the bar graph by touch.

The Little Hill week table

This is made-up data for the made-up town of Little Hill, in autumn. It is an example, not from a source.

Day	Temperature (°C)	Rain (mm)	Wind from	Sky
Monday	11	0	west	sunny
Tuesday	9	4	west	rain
Wednesday	8	12	south-west	rain
Thursday	12	0	north	cloudy
Friday	10	2	west	rain

The twenty-day weather list

Twenty school days in Little Hill (made up): sunny 5 days, cloudy 8 days, rain 6 days, fog 1 day.

Steps

✎ Opening (5 min)

Look at the class weather table together: "How many days have we recorded so far? What was the warmest reading?" Say: "A **table** keeps numbers tidy in rows and columns. Today we read a whole week of weather from a place called Little Hill, and make **graphs** that show the pattern at a glance."

✎ Main activity (25 min)

- **Reading the week table (8 min).** Read the headings together. Point to a row: "Each row is one day." Point to a column: "Each column is one kind of measurement." Ask pairs, one at a time, and let them point to the answer:
  - "What was the temperature on Thursday?" (12 °C.)
  - "Which day was coldest?" (Wednesday, 8 °C.)
  - "Which day had the most rain?" (Wednesday, 12 mm.)
  - "On how many days did it rain?" (3: Tuesday, Wednesday, Friday.)
  - "Where did the wind usually come from this week?" (The west; on 3 of the 5 days.)
- **Pictograph (8 min).** Pairs draw one picture for each day in the twenty-day list: 5 suns, 8 clouds, 6 raindrops and 1 fog picture, in neat lines so the rows can be compared.
- **Bar graph of rain (9 min).** Model one bar on the board: Tuesday, 4 mm, "two squares up, because each line goes up in twos". Pairs draw the bars for all five days (Monday 0, Tuesday 4, Wednesday 12, Thursday 0, Friday 2) and label each bar with its number. A day with 0 mm has no bar; write 0 above it.

✓ Discussion questions (5 min, with answers)

- "Look at your pictograph. What kind of weather happened most often?" (Cloudy, 8 days.)
- "How many more cloudy days than sunny days?" (3; 8 - 5.)
- "On how many of the twenty days was there no rain?" (14; 5 + 8 + 1, or 20 - 6.)
- "How much rain fell in the whole week?" (18 mm; 0 + 4 + 12 + 0 + 2.)
- "Which is quicker for seeing the wettest day: the table or the bar graph?" (Usually the bar graph: the tallest bar shows it at once. Any reason is fine.)

✓ Closing check (5 min, with answers)

Each child answers on paper, aloud or by pointing at their graphs:

1. "How many more rain days than sunny days?" (1; 6 - 5.)
2. "How much more rain fell on Wednesday than on Tuesday?" (8 mm; 12 - 4.)
3. "What was the difference between the warmest and the coldest day?" (4 °C; 12 - 8.)

Vocabulary

table, row, column, pictograph, bar graph, key, scale, most, fewest, how many more, in all

Differentiation

- **More help:** use the pictograph only; count rows by touching each picture; an adult draws the bar graph scale lines in ones instead of twos.
- **More challenge:** make a pictograph where one picture means 2 days (a half picture for 1 day), or draw a bar graph of the temperatures on squared paper.
- Children who find drawing hard can stick on picture cards or card squares.

⚠ Safety

- No special hazards. Coloured pencils stay on the table.

Teacher notes and misconceptions

- Children may count the squares instead of reading the scale. Ask "What number is at the top of this bar?"
- A 0 mm day is often forgotten in a bar graph, or given a small bar. "No rain, no bar" helps.
- The week table has a "rain" day (Friday) with only 2 mm: a light shower still counts as rain.
- Little Hill data are made up to be easy to graph. Real weather is usually messier, which children will see in their own class table.

Lesson 3: What is each season usually like?

Unit overview - Previous: Tables and graphs - Next: Climates around the world

Back to the grade 3 year plan

Goal

Children use a table of usual weather in each season to make a bar graph, say what each season is usually like, compare three summers to see that "usually" does not mean "always", and make careful predictions.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- The class weather table.
- The Little Hill season table and the three summers table (below) on the board, and one copy of each for each pair.
- For each pair: a blank bar graph sheet with the four seasons (winter, spring, summer, autumn) along the bottom and "usual afternoon temperature in °C" up the side in twos from 0 to 24.
- Six prediction cards (below), large enough for the class to see.
- Pencils and coloured pencils.
- For blind or low-vision children: tactile or large-print copies of the tables, and card squares with sticky backs for the bar graph.

The Little Hill season table

Made-up data for the made-up town of Little Hill: what a month in each season is usually like, from many years of records. It is an example, not from a source.

Season	Usual afternoon temperature (°C)	Rainy days in a month	Snowy days in a month
Winter	4	10	3
Spring	12	8	0
Summer	22	5	0
Autumn	14	12	0

The three summers table

Made-up data: the same summer month in three different years in Little Hill.

Year	Afternoon temperature that month (°C)	Rainy days
First year	21	4
Second year	24	7

Year	Afternoon temperature that month (°C)	Rainy days
Third year	22	5

The prediction cards

Each card names a season in Little Hill and two possible tomorrows. Children choose the one that is **more likely**.

1. Winter: 3 °C or 25 °C? (3 °C.)
2. Summer: 22 °C or 2 °C? (22 °C.)
3. Winter: snow or no snow? (No snow is more likely: snow falls on about 3 days of a month, so most days have none.)
4. Autumn: a rainy day or a dry day? (A dry day is a little more likely: about 12 rainy days in a month of about 30, so about 18 dry days.)
5. Spring: 12 °C or 30 °C? (12 °C.)
6. Summer: snow or no snow? (No snow; the table shows 0 snowy days.)

Steps

✎ Opening (5 min)

Ask: "Is it warmer here in summer or in winter?" Say: "Weather changes every day, but there are **patterns**. People in Little Hill have kept weather records for many years, so they know what each **season** is **usually** like. Scientists use patterns like these to make careful guesses, called **predictions**, about what weather might happen next."

✎ Main activity (25 min)

- **Reading the season table (6 min).** Read the headings. Ask:
  - "Which season is usually warmest?" (Summer, 22 °C.)
  - "Which is usually coldest?" (Winter, 4 °C.)
  - "Which season usually has the most rainy days?" (Autumn, 12.)
  - "When does snow usually fall?" (Only in winter.)
- **Bar graph of temperatures (10 min).** Pairs draw one bar for each season and write its number on top: winter 4, spring 12, summer 22, autumn 14. Model the first bar: "4 is two squares up, because the lines go up in twos."
- **Three summers (5 min).** Look at the three summers table. "Was every summer the same?" (No: 21, 24 and 22 °C; 4, 7 and 5 rainy days.) "But were they all warm?" (Yes, all much warmer than winter's 4 °C.) Say: "That is what **usually** means. Each summer is a bit different, but the pattern stays the same."
- **Predictions (4 min).** Show the six prediction cards one at a time. Children vote for the more likely tomorrow with a thumb up for the first choice or a thumb down for the second, and one pair explains using the table.

✓ Discussion questions (5 min, with answers)

- "How many degrees warmer is summer than winter, usually?" (18 °C; 22 - 4.)

- "Which two seasons are most alike in temperature?" (Spring and autumn, 12 and 14 °C.)
- "If it is summer, could tomorrow still be cold and rainy?" (Yes, it could; it is just less likely. A prediction is a careful guess, not a promise.)
- "How could our own weather table help us one day?" (After many weeks and years, it shows what our seasons are usually like.)

✓ Closing check (5 min, with answers)

Each child writes or says one sentence for each:

1. "In Little Hill, winter is usually..." (Cold, about 4 °C, sometimes snowy; any answer that fits the table.)
2. "In Little Hill, summer is usually..." (Warm, about 22 °C, with fewer rainy days; any answer that fits the table.)
3. True or false: "Every summer in Little Hill is exactly 22 °C." (False; the summers were 21, 24 and 22 °C.)

Vocabulary

season, winter, spring, summer, autumn (fall), usually, pattern, predict, prediction, likely

Differentiation

- **More help:** draw only the summer and winter bars; use the words "warm" and "cold" before numbers.
- **More challenge:** make a second bar graph of rainy days in each season, or work out how many dry days there usually are in an autumn month of 30 days (18).
- Children may answer the prediction cards by pointing, signing or using AAC.

⚠ Safety

- No special hazards.

Teacher notes and misconceptions

- Some children think a prediction is always right, or that a wrong forecast means scientists "lied". Stress "careful guess using patterns".
- "Fall" and "autumn" mean the same season; use the word your school uses.
- Seasons fall in different months in different parts of the world (see Known gaps in the unit overview). Do not teach the months of each season as a fact for everyone.
- Little Hill numbers are made up. Real records for your area may be online from your national weather service; a teacher may compare them in a later lesson.

Lesson 4: Climates around the world

Unit overview - Previous: What is each season usually like? - Next: Keeping flood water out

Back to the grade 3 year plan

Goal

Children learn the difference between weather and climate, and combine a picture card and a fact card to describe three very different climates in the world, finding where each is usually found on a globe.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- A globe and a world map.
- Three A4 climate picture cards, drawn or printed by the teacher (described below), each with a title.
- Three climate fact cards (below), read aloud by an adult.
- The Little Hill season table from lesson 3.
- For each group of 4-5: a "climate clues" sheet with three boxes, one for each climate, and two lines in each box: "From the picture we found..." and "From the fact card we found...".
- Pencils; the class weather table.
- For blind or low-vision children: tactile climate cards (for example a damp leafy texture for the rainforest, dry sand for the desert, cold smooth plastic and short soft moss-like felt for the tundra), and a globe with a raised line round the middle (string or tape) for the equator.

The climate cards

The picture cards show land and weather only, with no people, so that nobody is shown as a stereotype. The fact cards use words from Wikipedia (see Sources in the unit overview), made simpler for grade 3.

- **Picture card A, tropical rainforest climate:** tall green trees close together, rain falling, a wet muddy path. **Fact card A:** "It is warm all year. It is very damp. Rain falls all through the year, and there is no dry season. This climate is usually found near the equator."
- **Picture card B, desert climate:** sand and rocks, very few plants, a clear blue sky. **Fact card B:** "It is dry. Very little rain falls, and the rain that does fall dries up quickly. The ground is often bare rock or sand. Some deserts are hot and some are cold."
- **Picture card C, tundra climate:** flat land with low plants and moss, patches of snow, a grey sky. **Fact card C:** "It is cold. Even in the warmest month it is never more than 10 °C, but there is at least one month warm enough to melt snow. Not much rain or snow falls. This climate is found far to the north or south, near the cold ends of the globe, and high up on mountains."

Steps

✎ Opening (5 min)

Look at today's row in the class weather table. Say: "This is today's **weather**. Weather is what it is like outside today. **Climate** is what the weather of a place is **usually** like over many, many years, about thirty years. Little Hill's season table shows Little Hill's climate: warm summers, cold winters, rain in every season." Ask: "Is 'it is raining now' weather or climate?" (Weather.) "Is 'it usually snows here in winter' weather or climate?" (Climate.)

✎ Main activity (25 min)

- **Clue hunt (15 min).** Each group gets the three picture cards in turn (about 5 minutes each; pass them round). For each card, the group finds two clues in the picture and writes or draws them in the "From the picture" line. Then the adult reads the matching fact card aloud and the group adds one clue to the "From the fact card" line.
- **On the globe (5 min).** Together, find the equator on the globe (the line round the middle). "Fact card A says rainforest climates are usually near the equator." Point to a band near it. "Fact card C says tundra is far to the north or south, near the cold ends, and high on mountains." Point to the far north. Say: "Deserts can be in many places, hot or cold, so the fact card does not give one place."
- **Putting clues together (5 min).** Each group chooses one climate and makes two sentences that use both cards, for example "In the rainforest climate it is warm all year (fact card) and the trees are close together and green (picture)."

✓ Discussion questions (5 min, with answers)

- "Which climate gets the least rain?" (The desert.)
- "Which climate is warm all year?" (The tropical rainforest climate.)
- "Which is never warmer than 10 °C?" (The tundra.)
- "Why did we use both the picture and the fact card?" (The picture shows some things, the fact card tells things a picture cannot, such as 'all year' or 'never more than 10 °C'. Two sources together tell us more.)
- "Is Little Hill's climate most like any of these?" (Not really: it has warm summers and cold winters; any sensible answer.)

✓ Closing check (5 min, with answers)

Read each sentence. Children hold up one finger for A (rainforest), two for B (desert) or three for C (tundra), or a closed fist for "weather" if it is not about a climate:

1. "Very little rain falls, and the ground is often bare." (B, two fingers.)
2. "It rains all through the year, and it is warm." (A, one finger.)
3. "Even the warmest month is cold." (C, three fingers.)
4. "It is foggy this morning." (Weather, a fist.)

Vocabulary

climate, weather, equator, globe, tropical rainforest, desert, tundra, dry, damp, all year

Differentiation

- **More help:** use only cards A and B, which are the most different; the adult reads every clue line.
- **More challenge:** compare one climate with Little Hill's season table: what is the same and what is different?
- Groups may draw their clues instead of writing them.

⚠ Safety

- No special hazards. Do not show frightening pictures of storms or hazards in this lesson.

Teacher notes and misconceptions

- "All deserts are hot" is common. Fact card B says some are cold; this comes from the Desert climate source.
- Children may think a climate means a whole country. Many countries have more than one climate; the cards describe climate types, not countries.
- Do not add sentences about how people live in these climates, what they wear or what homes they have; the unit leaves that out on purpose (see Known gaps in the unit overview).
- The "about thirty years" in the opening comes from the Climate source.

Lesson 5: Keeping flood water out

Unit overview - Previous: Climates around the world

Back to the grade 3 year plan

Goal

Children learn that people cannot stop weather hazards but can make the harm smaller. They test two model flood barriers around a model house, keeping the water the same, and make a claim about which design works better, giving evidence from their test.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. The one-to-one assessment (see Assessment in the unit overview) happens during this lesson or the following week.

Materials

- For each group of 4-5: a shallow plastic tray or box about 30 cm long with a rim at least 5 cm high; damp washed play sand; a small wooden block or a plastic brick (the "house"); squares of paper towel about 5 cm across (one under the house for each pour, so at least three per group); a plastic jug with 200 ml of water marked on it; a pouring cup; a lump of latex-free modelling clay about the size of a tennis ball; eight lolly sticks; a book or a block about 3 cm thick to tilt the tray.
- A few spare paper towel squares.
- A results chart on the board with three rows (no barrier, lolly-stick wall, clay wall) and three columns for the paper towel: dry, damp, wet.
- Three design picture cards: a flood barrier (a low wall in front of a door and a row of sandbags), a lightning rod on a roof with a wire to the ground, and a roof tied down with strong straps.
- Aprons, cloths and a bucket for wet sand.
- For blind or low-vision children: the child feels the paper towel square after each pour (dry, a little damp, wet) and feels the barriers before pouring.

Steps

✎ Opening (5 min)

Tell families beforehand what the lesson is about. Any child may choose to be a helper or do only the tray test, with no reason needed.

Say calmly: "Sometimes weather is so strong that it can cause harm: very heavy rain can make rivers or streets flood, strong winds can lift roofs, and lightning can strike buildings. We call these **weather hazards**. People cannot stop the weather. But engineers **design** things that make the harm smaller. Today we test designs that keep flood water away from a house." Do not ask children about their own homes or experiences.

✎ Main activity (25 min)

Groups build a sand "town" in one half of the tray: a flat, low area with the house standing on a paper towel square in the middle. The "river" end is the other, empty end of the tray. Tip the tray up slightly at the river end (rest that end on the book or block) so that water poured there runs down towards the house.

- **No barrier (5 min).** Pour 200 ml of water slowly from the cup into the river end. Wait 30 seconds. Lift the house: is the paper towel dry, damp or wet? Record it. Put a new dry paper towel square under the house and smooth the sand.
- **Lolly-stick wall (8 min).** Push the eight lolly sticks side by side into the sand between the river and the house, as a wall. Pour the same 200 ml the same way, from the same place, at the same speed. Wait 30 seconds. Check the paper towel and record. Remove the sticks, change the paper towel and smooth the sand.
- **Clay wall (8 min).** Roll the clay into a long sausage and press it into the sand between the river and the house as a wall, pressing it down so there are no gaps underneath. Pour, wait, check and record as before.
- **Class chart (4 min).** Each group adds its three results to the class results chart.

✓ Discussion questions (5 min, with answers)

- "What did we keep the same each time?" (The amount of water, 200 ml; where and how fast we poured; the house; the tray and its tilt; how long we waited.)
- "Which design kept the house driest? How do you know?" (Usually the clay wall; any answer that matches the chart, with the paper towel as evidence.)
- "Make a claim: 'The ... wall is better because ...'." (For example, "The clay wall is better because the paper towel stayed dry, and water got through the gaps between the lolly sticks." Any claim with evidence from the chart.)
- "Did the barrier stop the rain?" (No; it kept water away from the house. It made the harm smaller.)
- Show the other two design cards. "What hazard does each one make less harmful?" (The lightning rod: lightning; it gives lightning a path to the ground through a wire instead of through the building. The strapped roof: strong wind; it keeps the roof from being lifted off.)

✓ Closing check (5 min, with answers)

Children answer by saying, signing or pointing:

1. "What did the barrier protect?" (The house.)
2. "Which hazard does a lightning rod help with?" (Lightning.)
3. "Did we change the amount of water between tests?" (No; it was always 200 ml.)

Then use the one-to-one assessment in the unit overview.

Vocabulary

hazard, flood, barrier, design, engineer, claim, evidence, lightning rod, fair test

Differentiation

- **More help:** test only no barrier and the clay wall; an adult pours.
- **More challenge:** design a third barrier with the same materials (for example clay pressed along the bottom of the lolly sticks) and test it the same way; or say one good and one bad thing about each design (for example, clay works well but takes longer to build).
- Children who prefer not to touch wet sand can pour, time the 30 seconds or record.

⚠ Safety

- Aprons on. Wipe spills straight away so the floor is not slippery.
- Sand stays in the trays and away from faces; wash hands afterwards.
- Check for latex and wheat allergies before using modelling clay.
- Talk about hazards calmly; no frightening pictures or stories. Any child may step out of the talk. Never ask about children's homes or experiences.

Teacher notes and misconceptions

- Some children think barriers stop the rain itself. Stress that the rain still falls; the barrier changes where the water goes.
- The lolly-stick wall usually leaks between the sticks and underneath; that is a useful result, not a failure.
- If results differ between groups, say so honestly: the sand, the tilt or the pouring may not have been quite the same. One test is not proof.
- In grade 2 the class protected a sand hill from water. Here the new idea is making a claim about which design is better, using evidence.
- The tray is a model. Real flood barriers are much larger, and real water pushes much harder.

Grade 3 Science: Life Cycles and Traits (5 lessons, about 4-5 weeks, plus a short daily watering job)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 12 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.
>
> Text-checked by four other agents (Gemini 3.5 Flash, Gemini 3.8 Flash, Gemini 4 Argon and Gemini 4 Carbon); see Known gaps.

Back to the grade 3 year plan - Term 3. Builds on kindergarten science: Living things and their needs, grade 1 science: Plants, light and water, grade 2 science: Habitats, seeds and helpers, grade 3 science term 2: Weather over a season and the science progression

Big idea

Every plant and animal has a **life cycle**: it begins, it grows, it can make young of its own, and in the end it dies. The young grow and the same pattern starts again. Life cycles are different: a bean grows from a seed, a frog starts as an egg and lives in water as a tadpole, and a caterpillar turns into a butterfly inside a chrysalis. But they all have the same four parts: birth, growth, reproduction and death.

Young plants and animals look like their parents, but not exactly, and brothers and sisters are not exactly the same as each other. A **trait** is something about a living thing that we can observe, such as its fur colour or how tall it grows. Many traits come from the parents. Some traits can also be changed by where a living thing lives and what it gets: a bean plant that gets too little water stays small.

This is the third science unit of grade 3 (term 3). The class plants bean seeds in lesson 1 and sets up a fair comparison: half the plants get plenty of water and half get a little. The plants grow while the class learns about life cycles, and in lesson 5 the class measures them and uses the results as evidence.

Outcomes

By the end of the unit most children can:

1. Put the stages of a bean plant's life cycle in order (seed, seedling, adult plant, flowers, pods with seeds, the old plant dies) and say what happens at each stage.
2. Name the stages in the life cycles of a frog, a butterfly and a chicken, and draw one of them as a life-cycle wheel.
3. Say what every life cycle has in common (birth, growth, reproduction and death) and give one way that two life cycles are different.
4. Use a table about a made-up rabbit family to say which traits each young rabbit shares with each parent, and that no young rabbit is exactly like its parents or the others.
5. Measure bean plants grown from one packet to the nearest centimetre, record the heights in a table and a dot plot, and say that plants of the same kind are not all the same.

6. Use the results of the class water test to explain that the environment (how much water a plant gets) can change a trait (how tall it grows), giving evidence from the test.

Prior knowledge

- Kindergarten science: living things need food, water and air; plants need light and water.
- Grade 1 science: the baby plant and food store inside a soaked bean seed; a seed needs water to start growing, and a young plant needs light and water; comparing two plants with words such as "taller" and "paler".
- Grade 2 science term 3: seeds are spread by animals and wind; animals help some plants make seeds by carrying pollen.
- Grade 3 science term 2: tables, bar graphs and "usually"; a fair comparison changes only one thing.
- Mathematics: measuring length to the nearest centimetre with a ruler (grade 2); reading and making tables, tally charts and bar graphs.
- Children read short labels and numbers. Cards with more text are read aloud by an adult.

Lessons

Each lesson is about 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5. Bean plants need time to grow, so spread the lessons out: lessons 1 and 2 in week 1, lesson 3 in week 2, lesson 4 in week 3, and lesson 5 in week 4 or 5, when the plants with plenty of water are about 15-25 cm tall. From lesson 1 on, two plant helpers (a new pair each week) water the plants every school day with an adult, following the watering chart (about 3 minutes).

1. Planting a fair test: is a seed alive?; planting bean seeds in twelve cups; the "plenty of water" group and the "a little water" group; keeping everything else the same; a seed in a jar so roots can be seen; predictions.
2. The life cycle of a bean plant: looking inside a soaked bean seed again (first done in grade 1); six life-cycle picture cards in order; flowers, pollen and pods; why a life cycle is drawn as a circle; checking the seed in the jar.
3. Animal life cycles: frog, butterfly and chicken stage cards; making a life-cycle wheel; comparing the three; birth, growth, reproduction and death in every life cycle.
4. Like their parents, but not exactly: traits; the Brook Farm rabbit family table; measuring the class bean plants; a dot plot of heights; plants of the same kind are not all the same.
5. Can the environment change a trait?: measuring both groups of bean plants; a results table and a bar graph; a claim with evidence; sorting trait cards into "from the parents" and "changed by the environment"; the end-of-unit check.

Materials (whole class unless noted)

- **Lesson 1:** a packet of dwarf French bean seeds sold for growing (about 30 seeds, so there are spares); twelve clear or white plastic cups (about 250 mL) with drainage holes made by an adult, each on a saucer or tray lid; potting compost (peat-free if possible), put into the cups by an adult before the lesson; a sticky label and a marker pen for each cup (P1-P6 and L1-L6); two trays to hold the cups, labelled "Plenty of water" and "A little water"; a plastic measuring cup marked in mL (or a 5 mL spoon); a small watering can or jug; a clear jar, a paper towel and two bean seeds for the seed in a jar; the class watering chart (in Lesson 1); a magnifying glass for each pair; aprons; a pencil and a prediction slip for each pair; paper towels for spills.

- **Lesson 2:** for each pair, a bean seed soaked in water overnight by an adult, a paper plate and a magnifying glass; six bean life-cycle picture cards (seed, seedling, young plant, plant with flowers, plant with pods, dry old plant) on the board and one small set for each pair (in Lesson 2); a fresh green bean pod from a shop, to open and look at (not to eat); for each pair, a life-cycle ring sheet (six boxes in a circle joined by arrows) and a pencil; the seed in a jar; the bean cups; the watering chart; paper towels.
- **Lesson 3:** frog, butterfly and chicken stage cards (four cards each; in Lesson 3), a large set on the board and a small set of all twelve for each group of four; for each child, a blank life-cycle wheel sheet (a large circle drawn on paper, divided into four parts, with arrows round the edge), a pencil and coloured pencils; the "same and different" table on the board; the four word cards "birth", "growth", "reproduction" and "death"; the six bean cards from lesson 2; the bean cups, the seed in a jar and the watering chart; latex-free, wheat-free modelling clay for tactile modelling.
- **Lesson 4:** the Brook Farm rabbit family cards (two parent cards and four young rabbit cards with simple drawings) and the rabbit table (in Lesson 4) on the board and one copy for each pair; the bean cups from the "plenty of water" tray; for each pair, a 30 cm ruler and a pencil; a class height table and a large dot plot line marked in centimetres from 0 to 30; sticky dots or a marker for the dot plot; the Brook Farm bean table (in Lesson 4), in case the class plants have not grown; the frog and chicken stage cards from lesson 3; the watering chart.
- **Lesson 5:** all twelve bean cups; for each pair, a 30 cm ruler and a pencil; the class results table on the board and one copy for each pair; for each pair, a blank bar graph sheet (twelve plants along the bottom, height in cm up the side in twos from 0 to 30) and coloured pencils; the Brook Farm results table (in Lesson 5), in case the class plants have not grown well; the prediction slips from lesson 1; the claim frame on the board; eight trait sort cards and two heading cards ("From the parents", "Changed by the environment"); the rabbit table from lesson 4, the bean and frog cards and the class dot plot for the end-of-unit check; the watering chart.
- **For blind or low-vision children (all lessons):** tactile picture cards (raised outlines made with glue lines or wiki sticks, with a Braille or large-print label); a ruler with raised marks every centimetre or a talking tape measure; plants can be felt gently, leaves held between finger and thumb; large-print tables.

⚠ Safety and access

- **Seeds.** Never eat seeds, and never drink the soaking water. Seeds sold for growing can be treated with chemicals, and raw beans contain a toxin: "Symptoms can be induced from as few as four to five raw beans" (Wikipedia, for raw red kidney beans, the same species as the French bean). Adults hand out seeds and count them back in. Wash hands after handling seeds.
- **Allergies.** Beans are legumes, like peas and peanuts. Check with families and the school nurse before the unit. A child with a legume allergy does not touch the seeds, pods or plants unless the school nurse says it is safe; they can be the recorder, the measurer's reader or the watering chart keeper. The fresh pod in lesson 2 is only for looking at.
- **Compost.** An adult opens the bag and fills the cups before lesson 1, outside or in an airy place, without shaking up dust. Children wear aprons, keep compost away from faces and wash hands after touching it.
- **Water.** Wipe spills at once so the floor is not slippery. Put the trays where they cannot be knocked off.

- **Living animals.** This unit uses pictures only. Never collect frogspawn, tadpoles, caterpillars or eggs from the wild; in some places it is against the law, and the animals can die.
- **Death and feelings (lessons 2, 3 and 5).** Some children may have lost a pet or a person. Talk about death in the life cycle calmly and briefly, as something that happens to every living thing. Never ask children about their own pets, families or losses. Any child may sit out the talk and help with the cards instead. If some plants in the "a little water" group wilt or die, say so plainly: that is a result.
- **Families and bodies.** The unit does not cover human reproduction (the standard says the same), and the trait examples are plants and animals only. Never compare children's own traits, bodies or heights, and never ask which traits a child got from which family member.
- Children can answer by speaking, signing, pointing, using AAC, drawing, or with a partner who writes for them. Their own way counts.
- Deaf children: show every card and table while it is described; face the class when reading cards aloud. Blind and low-vision children: use the tactile materials above; a partner reads numbers aloud.
- Colour is never the only clue: the two trays have word labels and letters (P and L), bars on graphs have labels, and the rabbit cards have words as well as drawings.
- Wheelchair users: put the plant trays on a table they can reach; bring a cup to the child for measuring.
- Finger-free measuring: a partner holds the ruler and the child says when the top of the plant lines up, or reads a talking tape measure.

Assessment

Watch and listen during lessons, and use the closing checks. During lesson 5 or the following week, see each child for about 3 minutes with the materials listed (answers in brackets):

1. Give the child the six bean life-cycle cards, mixed up. "Put them in order. What happens at the end?" (Seed, seedling, young plant, plant with flowers, plant with pods, dry old plant; the old plant dies, and the seeds in the pods can grow into new plants.) (Outcome 1.)
2. Give the child the four frog cards, mixed up. "Put them in order and name the stages." (Egg, tadpole, froglet, adult frog.) (Outcome 2.)
3. "What do the life cycles of a frog and a chicken have in common?" (Both are born, grow, can make young and die; both start as eggs.) "What is one difference?" (A tadpole lives in water and changes shape a lot; a chick looks like a small hen; any correct difference.) (Outcome 3.)
4. Show the Brook Farm rabbit table from lesson 4. "Look at Bramble. Which parent is Bramble like? Is Bramble exactly like either parent?" (Brown fur like Hazel; floppy ears and no nose spot like Pip; no, Bramble is not exactly like either one.) (Outcome 4.)
5. Show the class dot plot from lesson 4 (or the Brook Farm bean table). "All these plants came from one packet. Are they all the same height? Is that surprising?" (No, they are different heights; plants of the same kind are not all the same.) (Outcome 5.)
6. Show the class results table from lesson 5. "Which group grew taller? What made the difference? How do you know?" (Usually the plenty-of-water group; the water was the only thing that was different, so the water made the difference; any answer that matches the class's own results and uses them as evidence.) (Outcome 6.)

Sources

Quoted exactly; the unit is not a full alignment to these standards.

- Next Generation Science Standards, grade 3, Inheritance and Variation of Traits: Life Cycles and Traits: https://www.nextgenscience.org/topic-arrangement/3inheritance-and-variation-traits-life-cycles-and-traits
  - 3-LS1-1: "Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death." Clarification statement: "Changes organisms go through during their life form a pattern." Assessment boundary: "Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction."
  - 3-LS3-1: "Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms." Clarification statement: "Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans." Assessment boundary: "Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples."
  - 3-LS3-2: "Use evidence to support the explanation that traits can be influenced by the environment." Clarification statement: "Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight."
  - LS1.B: "Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles."
  - LS3.A: "Many characteristics of organisms are inherited from their parents." "Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment."
  - LS3.B: "Different organisms vary in how they look and function because they have different inherited information." "The environment also affects the traits that an organism develops."
- Wikipedia (lead paragraphs, read 2026-11-12):
  - Germination: "Germination is the process by which an organism grows from a seed or spore."
  - Pollination: "Pollination is the transfer of pollen from an anther of a plant to the stigma of a plant, later enabling fertilisation and the production of seeds. Pollinating agents can be animals such as insects, for example bees, beetles or butterflies; birds, and bats; water; wind; and even plants themselves."
  - Fruit: "In botany, a fruit is the seed-bearing structure in flowering plants (angiosperms) that is formed from the ovary after flowering."
  - Tadpole: "A tadpole or polliwog (also porwigle) is the larval stage in the biological life cycle of an amphibian."
  - Pupa: insects with a pupal stage "go through four distinct stages in their life cycle, the stages thereof being egg, larva, pupa and imago (adult)", and "The pupae of different groups of insects have different names such as chrysalis for the pupae of butterflies".
  - Phytohaemagglutinin: it "is found in the highest concentrations in uncooked red kidney beans (Phaseolus vulgaris)"; "Symptoms can be induced from as few as four to five raw beans."

Known gaps and cautions

- Four other agents (Gemini 3.5 Flash, Gemini 3.8 Flash, Gemini 4 Argon and Gemini 4 Carbon, all at 067e8fa) text-checked this unit on 2026-11-12. Three reported no errors; Carbon reported three small fixes (a wrong grade 2 term number, the seed in a jar missing from lesson 3 materials, and the end-of-unit check items missing from lesson 5 materials), now fixed. Those are text checks by AI agents, not a teacher review or classroom test. No teacher has reviewed or tried it.
- The Brook Farm rabbit family, the Brook Farm bean tables and all names in them are made up for this unit. They are examples, not data from a source. They are there in case the class plants grow badly or slowly.
- The watering amounts (20 mL every school day for the "plenty" group, and 20 mL on Mondays only for the "a little" group) are my starting suggestion, not from a source. Cups, compost and classrooms differ: if the "plenty" cups stand in water, give less; if the "a little" plants all die in the first week, give the "a little" group 20 mL twice a week and record the change. Holidays and weekends need a plan.
- Bean seeds usually come up in one to two weeks in a warm room, but not every seed grows. Two seeds go in each cup; if both grow, measure the taller one and say so in the results.
- The source's second example of the environment changing a trait (a pet dog that becomes overweight) is not used, so that the class does not talk about bodies and weight. The unit uses only the plant example.
- 3-LS3-1 asks for evidence that traits are inherited from parents. The unit shows patterns in a made-up table; it does not explain how inheritance works (the standard's assessment boundary leaves this out too).
- Other grade 3 life-science standards (3-LS2-1 groups of animals, and 3-LS4-1 to 3-LS4-4 fossils, survival, habitats and change) are not in this unit.
- "Birth" for a plant is explained as the seed starting to grow (germination). This is my wording for young children, not a quotation.
- The frog, butterfly and chicken stage descriptions are simplified. Some frogs skip the tadpole stage (the Wikipedia tadpole article says so), and the unit mentions this only in the teacher notes.

Lesson 1: Planting a fair test

Unit overview - Next: The life cycle of a bean plant

Back to the grade 3 year plan

Goal

Children plant bean seeds in twelve cups and set up a fair comparison: six cups will get plenty of water and six will get a little water, and everything else stays the same. They write a prediction, and they set up a seed in a jar so that the roots can be seen.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- A packet of dwarf French bean seeds sold for growing (about 30 seeds, so there are spares). An adult hands out the seeds and counts them back in.
- Twelve clear or white plastic cups (about 250 mL), each with three small drainage holes in the bottom made by an adult, and each on a saucer or tray lid. An adult fills them with potting compost (peat-free if possible) to about 2 cm from the top before the lesson.
- A sticky label and a marker pen for each cup. Labels: P1, P2, P3, P4, P5, P6 ("plenty") and L1, L2, L3, L4, L5, L6 ("a little").
- Two trays to hold the cups, with word labels: "Plenty of water" and "A little water".
- A plastic measuring cup marked in mL, or a 5 mL spoon (four spoons make 20 mL).
- A small watering can or jug of water.
- For the seed in a jar: a clear jar (plastic if possible), a paper towel and two bean seeds.
- The class watering chart on a large sheet (below).
- A magnifying glass for each pair.
- Aprons for everyone.
- For each pair: a prediction slip and a pencil.
- Paper towels for spills.
- For blind or low-vision children: a ruler with raised marks; a cup with a raised label (a sticky dot for P, two for L).

The class watering chart:

Day	"Plenty of water" cups P1-P6	"A little water" cups L1-L6
Monday	20 mL each	20 mL each
Tuesday	20 mL each	none
Wednesday	20 mL each	none
Thursday	20 mL each	none
Friday	20 mL each	none

The prediction slip: "We think the plants with _____ water will grow taller, because _____." Children can draw instead of writing.

Steps

✎ Opening (5 min)

1. Hold up one bean seed. Ask: "Is this alive?" Let children talk to a partner, then share. Accept all answers.
2. Explain: "A seed is alive, but it is waiting. Inside it is a tiny baby plant and a store of food. When it gets water and warmth, it starts to grow. Scientists call this **germination**. In this unit we will watch bean plants start their lives, and learn about the lives of animals too."
3. Pass round seeds for pairs to look at with magnifying glasses. Remind everyone: "We never eat seeds or put them in our mouths. Some raw beans can make people ill."

✎ Main activity (25 min)

1. **Our question.** Write on the board: "Does the amount of water change how tall a bean plant grows?" Ask: "How could we find out?" Take ideas.
2. **A fair test.** Explain: "We will grow two groups of plants. One group gets plenty of water and one group gets only a little. To be fair, only the water is different. What else must stay the same?" Collect ideas and write them as a list: the same kind of seed (from one packet), the same compost, the same size of cup, the same window and light, the same warm room, the same number of seeds in each cup.
3. **Labelling.** Give each pair one cup. (With 12 pairs, every pair has a cup; with fewer, some pairs have two; with more, two pairs share.) The teacher hands out labels P1 to P6 and L1 to L6. Pairs stick the label on their cup and put it in the right tray: P cups in the "Plenty of water" tray, L cups in the "A little water" tray.
4. **Planting.** An adult gives each pair two seeds. Show how to plant: make a hole with one finger about 3 cm deep (about as deep as the first joint of a finger), drop in one seed, cover it. Do the same for the second seed on the other side of the cup. "Why two seeds?" (In case one does not grow.)
5. **The first watering.** Every cup gets 20 mL today, so that every seed can start. The teacher or a helper measures it. Show the class how much 20 mL looks like in the measuring cup.
6. **The watering chart.** Show the chart and read it together. Ask: "Which group gets water every day? Which gets water only on Mondays?" Choose the first two plant helpers. Explain that they will water with an adult each school day, and tick the chart.
7. **A seed in a jar.** While pairs wash their hands, the teacher folds a damp paper towel round the inside of the jar and pushes two seeds between the towel and the glass, about halfway down. Put 2 cm of water in the bottom so the towel stays wet. "In this jar we can see what happens under the ground."
8. **Predictions.** Pairs fill in the prediction slip. Collect the slips to look at again in lesson 5.

Put both trays side by side at the same window, where they will not be knocked.

✓ Discussion questions (5 min)

- "Why do both trays go at the same window?" (So that light is the same for both groups; only the water is different.)

- "If we put the 'plenty' cups in a warm room and the 'a little' cups in a cold room, would our test be fair?" (No. Then two things would be different, and we would not know which one made the difference.)
- "What do you think will happen to the seed in the jar first?" (Accept predictions. Usually a root comes out first.)

✓ Closing check (5 min)

Ask each question; children answer with thumbs up or down, or in their own way (pointing, signing, AAC).

1. "Our test changes only one thing. Is that thing the water?" (Yes.)
2. "Do the L cups get water every day?" (No, only on Mondays, after the first watering today.)
3. "Is a seed alive?" (Yes. It has a tiny baby plant inside that can grow.)
4. "Can we eat the seeds?" (No, never.)

Vocabulary

seed, germination, fair test, prediction, compost, millilitre (mL)

Differentiation

- **Support:** give the prediction slip with the two choices drawn ("plenty" as a full jug, "a little" as a jug with a drop) to circle. Pair a child who needs help with planting with a confident partner.
- **Stretch:** "What other things could we test, one at a time?" (For example light or warmth.) Write one as a new fair-test question.
- **Tactile:** blind or low-vision children find their cup by the raised label and feel the depth of the hole with a finger before dropping the seed in.

⚠ Safety

- Never eat seeds or put them in mouths. An adult counts seeds out and back.
- Adults make the drainage holes and fill the cups with compost before the lesson, outside or in an airy place, without shaking up dust. Aprons on; keep compost away from faces; everyone washes hands after planting.
- Check for allergies to beans, peas or peanuts before the lesson. A child with a legume allergy does not touch seeds; they can label cups, read the chart or measure the water.
- Wipe spills straight away.

Teacher notes and misconceptions

- **"Seeds are not alive."** Many children think seeds are like stones. The seed in a jar helps: when a root comes out, ask "Could a stone do that?"
- **Fair tests.** Children often want to change many things at once. Keep returning to "What is the one thing we are changing?"

- **The watering amounts** are a starting suggestion (see Known gaps in the unit overview). If water stands in the saucers of the P cups, give less and write the change on the chart. Honest changes are part of science.
- **Weekends and holidays.** Plants in the P group may dry out over a long break. Ask an adult to water on the last day before a break and the first day back, and note it on the chart.
- Keep the spare seeds in their packet, out of reach, in case some cups do not grow. Seeds that have not come up after two weeks can be replaced; write this down.

Lesson 2: The life cycle of a bean plant

Unit overview - Previous: Planting a fair test - Next: Animal life cycles

Back to the grade 3 year plan

Goal

Children look inside a soaked bean seed again, put six picture cards of a bean plant's life in order, and learn why a life cycle is drawn as a circle: the old plant makes seeds, and the seeds grow into new plants.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- For each pair: a bean seed (from the same packet) soaked in water overnight by an adult, a paper plate and a magnifying glass.
- Six bean life-cycle picture cards (below), large on the board, and one small set for each pair. The teacher draws them simply, or uses photographs the school has permission to use. Each card has a picture and a label.
- A fresh green bean pod from a shop, to open and look at (not to eat).
- For each pair: a life-cycle ring sheet (six empty boxes in a circle, joined by arrows going round) and a pencil.
- The seed in a jar from lesson 1.
- The two trays of bean cups and the watering chart.
- Paper towels.
- For blind or low-vision children: tactile versions of the six cards (raised outlines with a Braille or large-print label) and a ring sheet with raised boxes and arrows.

The six bean life-cycle picture cards:

Picture	Label
a bean seed	Seed
a seed with a root and a small shoot with two leaves	Seedling
a bigger plant with many leaves	Young plant
the plant with small white or pink flowers	Flowers
the plant with long green pods hanging down	Pods with seeds
a dry, brown, bent plant with dry pods	The old plant dies

The table shows the correct order, from top to bottom, then back to the seed. Put no numbers or letters on the cards, so that nothing gives the order away, and give each pair its cards shuffled.

Steps

✎ Opening (5 min)

1. Look at the seed in a jar together. Ask: "What has happened since last time?" (Usually a root has come out; maybe a small shoot.) "Which way is the root growing?" (Down.)
2. Look at the bean cups. Has anything come up yet? (Probably not yet; bean shoots usually show after one to two weeks.)
3. Say: "Today we find out about the whole life of a bean plant, from seed to seed."

✎ Main activity (25 min)

1. **Inside a seed (6 min).** Each pair gets a soaked seed on a paper plate. Show how to rub off the seed coat (the skin) with a thumb and gently open the seed into its two halves. With magnifying glasses, pairs find the tiny baby plant at one edge. Ask: "What do you remember from grade 1? What is the rest of the seed for?" (It is the food store that feeds the baby plant until it has leaves.) Everyone washes hands afterwards; the seeds go in the bin.
2. **Ordering the cards (8 min).** Give each pair a shuffled set of the six cards. "Put them in the order a bean plant lives its life." Walk round and ask pairs to explain their order.
3. **Talk it through (6 min).** Build the order together on the board, talking about each card:
    - **Seed.** The seed is waiting.
    - **Seedling.** With water and warmth, the seed starts to grow: a root goes down and a shoot goes up. This is germination. For a plant, this is its **birth**.
    - **Young plant.** The plant makes more leaves and grows taller. This is **growth**.
    - **Flowers.** The grown-up plant makes flowers. Insects such as bees can carry pollen from flower to flower, and some plants pollinate themselves. Pollen helps the flower make seeds. (Remind children of the model bee from grade 2.)
    - **Pods with seeds.** Each flower can turn into a pod. A pod is the bean plant's **fruit**: it holds the seeds. Making new seeds is the plant's **reproduction**.
    - **The old plant dies.** At the end of the season a bean plant dries up and dies. This is its **death**. But its seeds can grow into new bean plants next year.
4. **Opening a pod (2 min).** The teacher opens the fresh bean pod and shows the small seeds lined up inside. "Each of these could grow into a new bean plant." Pass it round on a paper towel to look at, not to eat.
5. **A circle (3 min).** Ask: "After the last card, what comes next?" (A seed again.) Pairs write or draw the six stages in the boxes of the ring sheet, going round with the arrows. "We draw a life cycle as a circle, because it starts again."

✓ Discussion questions (5 min)

- "Why is the life cycle a circle and not a line?" (Because the seeds from the old plant grow into new plants, and the pattern starts again.)

- "Which card shows the bean plant's birth? Which shows reproduction?" (Seedling, when the seed starts to grow; pods with seeds.)
- "Does the bean plant die before or after it makes seeds?" (After. That is why there are new bean plants each year.)
- "Is a bean pod a fruit?" (Yes, to a scientist: a fruit is the part of a flowering plant that holds the seeds.)

✓ Closing check (5 min)

Hold up two cards at a time. Children show with one or two fingers (or point) which comes first.

1. Flowers and Seedling. (Seedling first.)
2. Pods with seeds and Flowers. (Flowers first.)
3. Young plant and Seed. (Seed first.)
4. "What comes after 'The old plant dies'?" (A seed grows into a new plant; the cycle starts again.)

Vocabulary

life cycle, seed coat, seedling, germination, flower, pollen, pod, fruit, birth, growth, reproduction, death

Differentiation

- **Support:** give only four cards first (seed, seedling, flowers, pods), then add the other two.
- **Stretch:** "A sunflower and a bean are both flowering plants. Would a sunflower's life cycle have the same stages?" (Yes: seed, seedling, plant, flower, seeds, the old plant dies; the flowers and seeds look different.)
- **Tactile:** use the tactile cards and the raised ring sheet. A blind child can feel the two halves of the soaked seed and the tiny bump of the baby plant.

⚠ Safety

- Never eat seeds, pods or soaking water. Soaked seeds go in the bin after the lesson. Wash hands afterwards.
- Allergies: a child with a legume allergy does not touch the seeds or the pod unless the school nurse says it is safe. They can be the card checker for their pair.
- Talk about the death of the old plant calmly and briefly. Do not ask about pets or people.

Teacher notes and misconceptions

- **"Fruit means something sweet."** Children often think only sweet things are fruit. To a scientist, a bean pod, a pea pod and a tomato are all fruits, because they hold seeds.
- **"Plants come from the soil."** Remind children that each plant in their cups came from a seed they planted.

- **The baby plant inside the seed** is small and easy to miss. Show it on one seed under a magnifying glass first. If seeds will not open, soak them for longer.
- Some plants (for example many trees) live for many years and make seeds again and again before they die. The bean is a simple example because its whole life cycle fits into one season.

Lesson 3: Animal life cycles

Unit overview - Previous: The life cycle of a bean plant - Next: Like their parents, but not exactly

Back to the grade 3 year plan

Goal

Children put the stages of a frog, a butterfly and a chicken in order, draw one as a life-cycle wheel, and compare the three. They find that the life cycles are different, but every one has birth, growth, reproduction and death.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- Animal stage cards (below): four frog cards, four butterfly cards and four chicken cards. One large set for the board, and one small set of all twelve for each group of four children. Each card has a picture and a label. The teacher draws them simply, or uses photographs the school has permission to use.
- For each child: a blank life-cycle wheel sheet (a large circle divided into four parts, with arrows going round the edge), a pencil and coloured pencils.
- The "same and different" table drawn on the board (below).
- Four word cards: "birth", "growth", "reproduction", "death".
- The six bean life-cycle cards from lesson 2.
- The bean cups, the seed in a jar and the watering chart.
- For blind or low-vision children: tactile versions of the stage cards (raised outlines with a Braille or large-print label) and a wheel sheet with raised lines; modelling clay (latex-free and wheat-free) to make the stages instead of drawing them.

The animal stage cards (in the correct order; give them to groups shuffled, with no numbers on them):

Frog	Butterfly	Chicken
Eggs (frogspawn in water)	Egg (on a leaf)	Egg
Tadpole (lives in water, swims with a tail)	Caterpillar (eats leaves and grows)	Chick (just hatched, fluffy)
Froglet (has legs and a short tail)	Chrysalis (a hard case; the caterpillar changes inside)	Young chicken (growing feathers)
Adult frog (can lay eggs)	Adult butterfly (can lay eggs)	Adult hen (can lay eggs)

The "same and different" table (fill it in together):

Question	Frog	Butterfly	Chicken
Does it start as an egg?			
Does the young one look like the adult?			

Question	Frog	Butterfly	Chicken
Does it change shape a lot as it grows?			
Does the young one live in water?			

Steps

✎ Opening (5 min)

1. Hold up the bean cards in order, quickly. "Last time we learned the bean plant's life cycle. Do animals have life cycles too?" Take ideas.
2. Check the bean cups and the seed in a jar together. Has anything come up? Note it on the board with today's date.

✎ Main activity (25 min)

1. **Sorting (8 min).** Give each group of four a shuffled set of the twelve animal cards. "First sort the cards into three animals. Then put each animal's cards in order." Walk round and ask groups to explain.

2. **Talk it through (7 min).** Build the three life cycles on the board, one column for each animal, talking about each stage:

    - **Frog.** A frog lays many eggs in water, called frogspawn. A tadpole hatches out. It lives in water and swims with its tail, like a small fish. It slowly grows legs and becomes a froglet, and its tail gets shorter. The adult frog can live on land and in water, and lays eggs. Scientists call a big change of shape like this **metamorphosis**.
    - **Butterfly.** A butterfly lays eggs on a leaf. A caterpillar hatches and eats and eats, growing bigger. Then it makes a hard case called a chrysalis. Inside, its body changes completely. An adult butterfly comes out, and it can lay eggs.
    - **Chicken.** A hen lays an egg. A chick grows inside and hatches out. It already looks a bit like a small chicken. It grows feathers and gets bigger, and the adult hen can lay eggs.

3. **Life-cycle wheels (10 min).** Each child chooses one of the three animals (or the bean) and draws its life cycle on a wheel sheet: one stage in each part, going round with the arrows, with a label for each stage. "Why does the arrow go back to the start?" (The adult lays eggs, and the cycle starts again.)

✓ Discussion questions (5 min)

Fill in the "same and different" table together, one row at a time. (Answers: starts as an egg: yes, yes, yes. Young one looks like the adult: no, no, a little. Changes shape a lot: yes, yes, no. Young one lives in water: yes, no, no.)

Then put up the four word cards: birth, growth, reproduction, death.

- "Where is the birth in each life cycle?" (When the young one hatches from the egg; for the bean, when the seed starts to grow.)

- "Where is the growth?" (Tadpole to frog; caterpillar getting bigger; chick to hen; seedling to plant.)
- "Where is the reproduction?" (The adult lays eggs; the bean plant makes seeds.)
- "What happens at the end of every life cycle?" (Death. Every living thing dies in the end. Some live a short time and some live many years. Its young carry on the cycle.)

✓ Closing check (5 min)

Ask each question. Children answer by pointing to a card on the board, or in their own way.

1. "Point to the stage that comes after the tadpole." (Froglet.)
2. "Point to the stage that comes before the adult butterfly." (Chrysalis.)
3. "Which animal's young looks most like its parent?" (The chicken.)
4. "Name one thing all these life cycles have." (Any of: birth, growth, reproduction, death; or "they go round in a circle".)

Vocabulary

life cycle, frogspawn, tadpole, froglet, caterpillar, chrysalis, hatch, metamorphosis, birth, growth, reproduction, death

Differentiation

- **Support:** give a group one animal's four cards at a time. Give the wheel sheet with the stage labels already written, to draw pictures beside.
- **Stretch:** "Is a tadpole a fish?" (No. It looks a bit like one and lives in water, but it is a young frog.) Or: add a fourth column to the table for the bean plant.
- **Tactile:** use the tactile stage cards. Children can model each stage with clay instead of drawing (an egg, a tadpole with a tail, a froglet with legs, a frog).

⚠ Safety

- Pictures only: never collect frogspawn, tadpoles, caterpillars or eggs from the wild. In some places it is against the law, and the animals can die.
- Check the clay for latex and wheat (some home-made dough contains wheat).
- Talk about death calmly and briefly, as part of every life cycle. Never ask children about their own pets or losses. Any child may sit out and sort the cards instead.
- This lesson is about animals only. If children ask about people, say simply that people have a life cycle too (babies grow into adults), and move on; the details of human reproduction are not part of this unit.

Teacher notes and misconceptions

- **"A caterpillar and a butterfly are different animals."** Many children think this. The cards help: it is one animal at two stages of its life.
- **"A chick grows from the yolk like a seed."** Keep it simple: a chick grows inside the egg and hatches out. Eggs from a shop do not have chicks in them.

- **Not every frog has tadpoles.** A few kinds of frog hatch from the egg as tiny froglets. The frog here is a common example, not the only kind.
- The words "larva" and "pupa" are the scientific names for the caterpillar and chrysalis stages. Use them for stretch only.
- The stages are simplified: real animals change little by little, and the cards show only four moments.

Lesson 4: Like their parents, but not exactly

Unit overview - Previous: Animal life cycles - Next: Can the environment change a trait?

Back to the grade 3 year plan

Goal

Children learn what a trait is. They use a table about a made-up rabbit family to find which traits the young share with each parent, and see that no young rabbit is exactly like its parents or the others. Then they measure the class bean plants and see that plants from one packet are not all the same height.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Materials

- The Brook Farm rabbit family: six cards (two parents and four young rabbits), each with a simple drawing and the rabbit's name and traits in words. One large set for the board.
- The Brook Farm rabbit table (below) on the board, and one copy for each pair.
- The six bean cups from the "Plenty of water" tray (P1-P6).
- For each pair: a 30 cm ruler and a pencil.
- The class height table on the board (two columns: cup, height in cm).
- A large dot plot line on the board or on paper, marked in centimetres from 0 to 30, and sticky dots or a marker.
- The Brook Farm bean table (below), in case the class plants have not grown yet.
- The frog and chicken stage cards from lesson 3 (for the opening).
- The watering chart.
- For blind or low-vision children: tactile rabbit cards (fur texture for colour: smooth fabric for white, rough fabric for brown; ears made of card that stand up or hang down; a raised dot for the nose spot); a ruler with raised marks or a talking tape measure; a dot plot made with pins or stickers on a corkboard so it can be felt.

The Brook Farm rabbit table (made up for this unit):

Rabbit	Fur colour	Ears	White spot on nose	Tail
Hazel (parent)	brown	stand up	yes	white
Pip (parent)	white	floppy	no	white
Bramble (young)	brown	floppy	no	white
Clover (young)	white	stand up	yes	white
Fern (young)	brown	stand up	no	white
Moss (young)	white	floppy	yes	white

The Brook Farm bean table (made up; ten bean plants from one packet, all given plenty of water, measured after three weeks):

Plant	1	2	3	4	5	6	7	8	9	10
Height (cm)	9	12	10	14	11	12	13	10	12	11

Steps

✎ Opening (5 min)

1. Hold up the frog cards. "Does a baby frog look like its parents?" (Not at first; a tadpole looks very different. An adult frog looks like its parents.) "Does a chick look like its parents?" (Quite a lot.)
2. Explain: "Something we can observe about a living thing, like its colour, its shape or how tall it grows, is called a **trait**. Today we look at which traits young animals and plants share with their parents."

✎ Main activity (25 min)

1. **The rabbit family (10 min).** Put up the rabbit cards and the table. Read the table together: Hazel and Pip are the parents, and Bramble, Clover, Fern and Moss are their young. Pairs answer, using their copy of the table:
    - "Which young rabbits have brown fur like Hazel?" (Bramble and Fern.)
    - "Which young rabbits have floppy ears like Pip?" (Bramble and Moss.)
    - "Which young rabbits have a white spot on the nose like Hazel?" (Clover and Moss.)
    - "Which trait do all six rabbits share?" (A white tail.)
    - "Is any young rabbit exactly the same as Hazel? As Pip? As each other?" (No. Each young rabbit has some traits like Hazel and some like Pip, and no two are the same.)
2. **Measuring the bean plants (10 min).** Bring out the six P cups. Show how to measure: stand the ruler on the compost next to the stem, with 0 at the compost, and read the number at the top of the highest leaf or the tip of the shoot, to the nearest centimetre. If two seeds grew in a cup, measure the taller one. Two pairs measure each cup, one after the other, and compare: "Did you get the same number? If not, measure again together." Write each height in the class height table. (Measure only the P cups today; the L cups wait until lesson 5.)
3. **A dot plot (5 min).** Each pair puts a dot above their plant's height on the dot plot line. If two plants have the same height, the second dot goes above the first. If the class plants have not grown yet, use the Brook Farm bean table instead.

✓ Discussion questions (5 min)

- "All these bean plants came from one packet and had the same water, light and compost. Are they all the same height?" (No. Usually they are different.)
- With the Brook Farm table: "What is the tallest? The shortest? Which height is most common?" (14 cm; 9 cm; 12 cm, three plants.)

- "Why might plants from one packet be different?" (Each seed is a little different, just as the young rabbits are; and small things in each cup can be different too, such as how deep the seed was planted. Scientists call differences in a group of the same kind **variation**.)
- "Are the young rabbits different from each other for the same reason?" (Partly: each one got a different mix of traits from its parents.)

✓ Closing check (5 min)

Ask each question; children answer on fingers, by pointing to the table, or in their own way.

1. "How many young rabbits have stand-up ears?" (2: Clover and Fern.)
2. "Is Moss exactly like Pip?" (No. Moss has white fur and floppy ears like Pip, but a white nose spot like Hazel.)
3. "Look at the Brook Farm bean table. How many centimetres taller is the tallest plant than the shortest?" (5 cm: 14 - 9 = 5.)
4. "What is a trait?" (Something we can observe about a living thing, such as its colour, shape or height.)

Vocabulary

trait, parent, young, similar, variation, centimetre, dot plot

Differentiation

- **Support:** use only two traits from the rabbit table (fur colour and ears). Hold the ruler steady for the child and let them read the number.
- **Stretch:** "Hazel and Pip have more young next year. Could one have brown fur and floppy ears? Could one have spotted fur?" (Brown fur and floppy ears is a mix we have already seen in Bramble. Spotted fur is not in the table, so we cannot tell from this table. This table is made up and too small to predict from.)
- **Tactile:** use the tactile rabbit cards: feel the fur texture, the ears and the nose dot. A blind child measures with a talking tape measure or a raised-mark ruler, with a partner checking the reading.

⚠ Safety

- Handle the plants gently: hold the ruler next to the stem, not against it.
- Wash hands after touching compost.
- Use only the made-up rabbit family and the plants. Never ask children which traits they got from which family member, and never compare children's own looks or heights. Some children are adopted, fostered or live with other family, and this is a private matter.

Teacher notes and misconceptions

- **"The young are always a half-and-half mix."** Children may expect each young rabbit to be exactly between the parents (for example light brown). The table shows that traits often come in whole: brown or white, not a mixture. This is a pattern in a made-up table, not a rule; real families vary.
- **"All plants of one kind are the same."** The dot plot helps: the plants are the same kind, but not the same height.
- The standard leaves out how inheritance works and predicting traits. Keep to observing patterns. The stretch question is about why we cannot predict from a small made-up table.
- If two pairs measure the same cup differently, that is useful: talk about where to put 0 and which leaf counts as the top.

Lesson 5: Can the environment change a trait?

Unit overview - Previous: Like their parents, but not exactly

Back to the grade 3 year plan

Goal

Children measure both groups of bean plants, record the results in a table and a bar graph, and use them as evidence for a claim: the amount of water (part of the environment) changed how tall the plants grew. They sort trait cards into traits that come from the parents and traits changed by the environment.

Length

About 40 minutes: Opening 5, Main activity 25, Discussion 5, Closing check 5.

Teach this lesson in week 4 or 5, when most plants in the "Plenty of water" group are about 15-25 cm tall.

Materials

- All twelve bean cups (P1-P6 and L1-L6) in their two trays.
- For each pair: a 30 cm ruler and a pencil.
- The class results table on the board (below), and one copy for each pair.
- For each pair: a blank bar graph sheet (the twelve cups P1-P6 and L1-L6 along the bottom, height in cm up the side in twos from 0 to 30) and coloured pencils.
- The Brook Farm results table (below), in case the class plants have not grown well.
- The prediction slips from lesson 1.
- The claim frame on the board (below).
- Eight trait sort cards (below) and two heading cards: "From the parents" and "Changed by the environment". One large set for the board; one small set for each group of four.
- For the end-of-unit check: the rabbit table from lesson 4, the bean and frog cards, and the class dot plot.
- The watering chart.
- For blind or low-vision children: a ruler with raised marks or a talking tape measure; a bar graph made from stacks of interlocking cubes (one cube for every 2 cm) so that it can be felt; tactile or large-print sort cards.

The class results table:

Cup	P1	P2	P3	P4	P5	P6	L1	L2	L3	L4	L5	L6
Height (cm)												

The Brook Farm results table (made up; six plants with plenty of water and six with a little water, from one packet, measured after four weeks):

Cup	P1	P2	P3	P4	P5	P6	L1	L2	L3	L4	L5	L6
Height (cm)	18	21	19	22	20	20	8	10	7	9	11	9

The claim frame: "The plants with _____ water grew taller. Our evidence: _____. The only thing that was different was _____."

The eight trait sort cards (made up for this unit; the answer is in brackets and is not on the card):

1. Clover the rabbit has white fur, like Pip. (From the parents.)
2. Tibbs the Brook Farm kitten has stripes, like its mother. (From the parents.)
3. A Brook Farm lamb has a black face, like its mother. (From the parents.)
4. A sunflower grown from a seed of a yellow sunflower has yellow petals. (From the parents.)
5. A bean plant that got only a little water stayed small. (Changed by the environment.)
6. A bean plant kept in a dark shed grew pale and thin. (Changed by the environment.)
7. A bean plant on a windowsill leaned towards the window. (Changed by the environment.)
8. The Brook Farm sheepdog learned to come when the farmer whistles. (Changed by the environment: it learned it.)

Steps

✎ Opening (5 min)

1. Bring out both trays and stand them side by side. Ask: "What do you notice?" Let children talk to a partner. (Usually the P plants look taller and greener; some L plants may be small, droopy or dead.)
2. Read out two or three prediction slips from lesson 1. "Today we find out if our predictions were right, using measurements."

✎ Main activity (25 min)

1. **Measuring (8 min).** Measure every cup the same way as in lesson 4: ruler on the compost next to the stem, 0 at the compost, the top of the highest leaf or shoot, to the nearest centimetre; the taller plant if two grew. Each pair measures one cup (with fewer than 12 pairs, some measure two). If a plant has died or never came up, write 0 and a note: "did not grow". Write every height in the class results table.
2. **Bar graph (9 min).** Pairs copy the results into their own table and draw a bar for each cup on the bar graph sheet. They colour the P bars in one colour and the L bars in another, and write P or L under each bar so that colour is not the only clue. If the class plants have not grown well, use the Brook Farm results table instead, and say so.
3. **A claim with evidence (3 min).** Pairs complete the claim frame together, by writing, drawing or telling an adult. (Example with the Brook Farm table: "The plants with plenty of water grew taller. Our evidence: the shortest P plant was 18 cm and the tallest L plant was only 11 cm. The only thing that was different was the water.")
4. **Sorting traits (5 min).** Read each sort card aloud. Groups of four put each card under one of the two headings. Go through the answers together.

✓ Discussion questions (5 min)

- "Were our predictions right?" (Compare with the slips. Either answer is fine; scientists change their ideas when the evidence says so.)
- "All twelve seeds came from one packet. So why were the L plants shorter?" (Because they got less water. The water is part of their environment. The environment changed a trait: how tall they grew.)
- "Were all the P plants exactly the same height?" (Usually not. That is the variation we saw in lesson 4. But the P plants were taller as a group.)
- "Can a trait come from the parents AND be changed by the environment?" (Yes. A bean plant gets its kind of leaves and flowers from its parents, but how tall it grows also depends on its water and light.)

✓ Closing check (5 min)

Ask each question; children answer by pointing to a heading card, on fingers, or in their own way.

1. "A puppy has long ears like its father. From the parents, or changed by the environment?" (From the parents.)
2. "A plant in a dry pot grew only a few small leaves. Which?" (Changed by the environment.)
3. "In the Brook Farm table, how many centimetres taller is P4 than L4?" (13 cm: 22 - 9 = 13.)
4. "Why was our test fair?" (Only the water was different; the seeds, compost, cups, light and room were the same.)

Then see children one at a time for the end-of-unit check (see Assessment in the unit overview), during this lesson's follow-up time or the next week.

Vocabulary

environment, trait, evidence, claim, results, bar graph, inherited (stretch)

Differentiation

- **Support:** give the bar graph sheet with the P1 bar already drawn as an example. Give the claim frame with the answers as picture choices to circle (a full jug or a jug with a drop; a tall plant or a short plant).
- **Stretch:** "Some traits are **inherited**: they come from the parents. Write one more card of your own for each heading." Or: "What could we test next, keeping everything else the same?" (For example light: one tray at the window and one further away.)
- **Tactile:** use the cube bar graph: one stack of cubes for each cup, one cube for every 2 cm (rounding to the nearest cube). A blind child compares the stacks by touch.

⚠ Safety

- Handle the plants gently. Wash hands after touching compost.

- If some L plants wilted or died, say so plainly and calmly: that is a result of the test. It is fine to water all the plants well after the lesson and see whether the small ones recover.
- Use only plant and animal examples. Never compare children's own traits, bodies or heights.
- At the end of the unit, plants can be planted outside by an adult, given to the school garden, or composted.

Teacher notes and misconceptions

- **"The L plants were just bad seeds."** Ask: "Did the P seeds and the L seeds come from the same packet?" (Yes.) "Then what was different?" (The water.) This is why the fair test matters.
- **"Environment means nature or forests."** Here, a living thing's environment means everything around it and everything it gets: water, light, food, warmth, and even what it learns.
- **Results that do not match.** Sometimes one L plant grows taller than a P plant. That is real data. Look at the whole group, not one plant, and talk about why one plant might be different (a seed planted shallower, or a cup nearer the window).
- **Card 8** shows that learning counts too: the sheepdog was not born knowing the whistle. The standard's core idea says characteristics can come from the environment, "which can range from diet to learning".
- Card 6 builds on grade 1, where children saw that a plant needs light to grow green, and card 7 on the plant bending towards a window.

Grade 4 Science: Electric Circuits (5 lessons)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 4 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.

Back to the science progression

Big idea

Electricity only does a job (lighting a bulb, sounding a buzzer) when there is a complete loop from one end of a battery, through the parts, and back to the other end. Some materials let electricity through (conductors) and some do not (insulators). A switch is just a deliberate gap we can open and close.

Outcomes

By the end of the unit a student can:

1. Build a working circuit from one cell, one bulb and two wires, and explain why it works using the word "loop" (or "complete circuit").
2. Predict and then test whether ten everyday objects are conductors or insulators, and record the results in a table.
3. Build a simple switch and show that it works wherever it is placed in a single loop.
4. Carry out a fair test (number of bulbs in a single loop vs brightness), naming the one thing changed and two things kept the same.
5. Draw a circuit with standard symbols and build a circuit from a drawing.

Prior knowledge

- Grade 3 fair test idea (change one thing, keep the rest the same).
- Sorting objects into groups and recording them in a two-column table.
- No prior knowledge of electricity is assumed.

Lessons

Lesson	Title	Main activity
1	Make it light	Find ways to light a bulb with one cell and two wires
2	Conductors and insulators	Predict, then test, ten objects in a gap in the circuit
3	Switches	Make a paper-clip switch; doorbell with a buzzer
4	A fair test: more bulbs	Does adding bulbs in one loop change brightness?
5	Drawing and designing circuits	Circuit symbols; design challenge; end-of-unit check

Materials (per group of 3-4)

- 2 × AA (1.5 V) cells in battery holders with leads. **Not** button cells, not rechargeable lithium packs, never mains power.

- 3 × small torch bulbs in holders, matched to the cells: about 1.5 V bulbs for the one-cell circuits in lessons 1-4. Two fresh AA cells give about 3 V, which is above a 2.5 V bulb's rating (it may burn out quickly), so for two-cell circuits use bulbs rated about 3-3.5 V. Keep spares.
- 1 buzzer rated for 1.5-3 V.
- 6 wires with crocodile clips.
- Paper clips, 2 brass paper fasteners (split pins), a small piece of card.
- Test objects (lesson 2): coin, plastic spoon, metal spoon, pencil (wooden end), pencil lead/graphite (see teacher note), rubber band, aluminium foil, paper, key, eraser, wooden lolly stick, glass marble.

Assessment

- Lesson 2 table and lesson 4 fair-test write-up (look for: one changed variable named, two controlled variables named, a conclusion that matches the results).
- Lesson 5 end-of-unit check: 8 questions, 16 marks, with an answer guide.

⚠ Safety (read before lesson 1)

- Only use low-voltage cells (AA or similar). **Never** experiment with wall sockets, plugs or mains appliances; the unit should say this out loud.
- **Do not use button cells.** If swallowed they can cause severe internal burns, injury or death (see the Button cell source). Keep them out of the classroom kit.
- **Short circuits:** a wire joined straight from one end of a cell to the other, with no bulb or buzzer, lets a large current flow and makes the wire and cell hot. Show students what this looks like on paper, never build it. If a wire or cell feels warm, unclip it and tell the teacher.
- Do not open, cut or bite cells. Remove cells from holders at the end of the lesson.

Sources

All checked to load on 4 November 2026.

- Wikipedia: Electric circuit
- Wikipedia: Electrical network
- Wikipedia: Electric current
- Wikipedia: Electrical conductor
- Wikipedia: Insulator (electricity)
- Wikipedia: Switch
- Wikipedia: Short circuit (overheating and fire risk)
- Wikipedia: Battery (electricity)
- Wikipedia: AA battery
- Wikipedia: Button cell (ingestion hazard)
- Wikipedia: Incandescent light bulb
- Wikipedia: Buzzer
- Wikipedia: Series and parallel circuits
- Wikipedia: Light-emitting diode (one-way behaviour, teacher note only)
- Wikipedia: Electrical injury (background for the mains warning)

Known gaps and cautions

- **Labelled simplifications:** "electricity flows round the loop" is used without explaining current, voltage or electrons; those come in grade 10. We say a cell "pushes" electricity; this is a model, not the full story.
- "Brightness" in lesson 4 is judged by eye on a 0-3 scale. This is a deliberate discussion point (it's a rough measure), not a hidden flaw.
- Parallel circuits are only mentioned as an extension; the main unit uses single loops (series).
- If you use LED bulbs instead of filament bulbs, they only work one way round; see the lesson 1 teacher note.
- No images yet; teachers will need to draw the circuits on the board.
- No standards alignment and no educator review.

Lesson 1: Make it light

Unit overview · Next: Lesson 2

Goal

Students light a bulb using one cell and two wires, and explain that it only works when there is a complete loop.

Materials (per group)

- 1 AA cell in a holder, 1 bulb in a holder, 2 crocodile-clip wires.
- Recording sheet: two boxes, "Lit" and "Not lit", for drawings.

Steps

✎ Opening (5 min)

Read the safety rules aloud (see the unit overview): cells only, never wall sockets; no button cells; never join a wire straight across a cell. Ask: "What things in your home need electricity? Which ones use batteries?"

✎ Main activity (25 min)

1. Challenge: "Make the bulb light using only these parts." Give no instructions about how.
2. Every time a group tries an arrangement, they draw it in "Lit" or "Not lit". Aim for at least two of each.
3. When most groups have a lit bulb, ask them to unclip **one** clip. What happens? Clip it back.
4. Groups compare drawings with another group: what do all the "Lit" drawings have in common?

✓ Discussion questions (with example answers)

- What do all the working circuits have in common? There is an unbroken path from one end of the cell, through the bulb, back to the other end.
- Why did the bulb go out when you unclipped one clip? The loop was broken, so electricity couldn't get all the way round.
- Does it matter which wire goes to which end of the cell? For a filament bulb, no: it lights either way round.

✓ Closing check (5 min, with answers)

Draw on the board: (a) a cell with one wire to a bulb and nothing back; (b) a full loop; (c) a loop with both wires on the same end of the cell. Which bulb lights? **Only (b).** (a) has a gap; in (c) the path doesn't go from one end of the cell to the other.

Vocabulary

cell (battery), bulb, wire, circuit, complete circuit / loop

Differentiation

- Support: give a photo or drawing of one working circuit to copy, then ask them to find a different working arrangement.
- Stretch: light two bulbs from one cell. Is each as bright as one bulb alone? (Sets up lesson 4.)

⚠ Safety

See the overview. Collect cells at the end of the lesson.

Teacher notes and misconceptions

- Common idea: "electricity only needs one wire, like a hose." The unclip test in step 3 challenges this directly.
- Strictly, a "battery" is two or more cells; everyday speech calls one AA a battery. Both words are fine at this age.
- If your kit uses LEDs, they light only one way round (current in one direction). Turn this into a question rather than calling it a fault.

Lesson 2: Conductors and insulators

Unit overview · Previous: Lesson 1 · Next: Lesson 3

Goal

Students predict, then test, which materials let electricity through, and record results in a table.

Materials (per group)

- Working circuit from lesson 1 with a third wire added so there is a gap between two crocodile clips (the "tester").
- Test objects: coin, plastic spoon, metal spoon, wooden lolly stick, rubber band, aluminium foil, paper, key, eraser, glass marble (10 objects).
- Results table: Object | Material | Prediction (lights / doesn't) | Result.

Steps

✎ Opening (5 min)

Show the tester. Touch the two free clips together: the bulb lights. Ask: "What if we put something in the gap?"

✎ Main activity (25 min)

1. Groups fill in the "Prediction" column for all 10 objects **before** testing. No changing predictions afterwards.
2. Test each object by clipping both clips onto it (or holding them firmly against it). Record the result.
3. Sort objects into two groups: "lets electricity through" (conductors) and "doesn't" (insulators).

✓ Discussion questions (with example answers)

- What do the conductors have in common? They are all metal (coin, metal spoon, foil, key).
- Were any of your predictions wrong? Which surprised you? Answers vary; common surprises: coins with dirty or painted surfaces, or foil with a plastic coating not conducting well.
- Why are wires covered in plastic? The metal inside carries electricity; the plastic is an insulator that stops it going where we don't want it, including into our hands.

✓ Closing check (5 min, with answers)

1. A new object: a paper clip. Conductor or insulator? **Conductor (metal).**

2. A plastic ruler? **Insulator.**
3. Name one material that is a conductor and one that is an insulator. **e.g. copper/steel/aluminium; plastic/wood/rubber/glass/paper.**

Vocabulary

conductor, insulator, material, prediction, result

Differentiation

- Support: give picture cards of the objects and a two-column sorting mat.
- Stretch: test a pencil lead (graphite) with the teacher (see note). Is it a metal? Does the "all conductors are metal" rule still hold?

⚠ Safety

Only test with the low-voltage tester. Explain that **water and human bodies can conduct** mains electricity, which is why we never test anything near wall sockets; we do not test wet objects or people in this lesson.

Teacher notes and misconceptions

- Graphite (pencil "lead") conducts but is not a metal. With one AA cell and a thin pencil lead the bulb may be very dim or not visibly lit; a short, thick piece works better. Use it as an "exceptions exist" moment, not a required result.
- Students sometimes think "shiny = conductor." A plastic object painted silver is a good counter-example if you have one.

Lesson 3: Switches

Unit overview · Previous: Lesson 2 · Next: Lesson 4

Goal

Students build a simple switch, explain it as "a gap we can open and close", and show it works anywhere in a single loop.

Materials (per group)

- 1 AA cell in a holder, 1 bulb, 1 buzzer, 4 crocodile-clip wires.
- Switch kit: a piece of card about 5 cm × 8 cm, 2 brass paper fasteners (split pins), 1 metal paper clip.

Steps

✎ Opening (5 min)

Ask: "How do you turn on a light at home without unplugging anything?" Link back to lesson 1: unclipping a wire turned the bulb off. A switch does the same job without unclipping.

✎ Main activity (25 min)

1. **Build the switch:** push both fasteners through the card about 3 cm apart. Hook the paper clip round one fastener so it can swing to touch the other. Open the fastener legs flat underneath.
2. Clip one wire to each fastener (underneath). Put the switch into the loop with the cell and bulb. Swing the paper clip: on, off.
3. **Does position matter?** Move the switch to a different place in the loop (before the bulb, after the bulb). Record: does it still control the bulb?
4. **Doorbell:** replace the bulb with the buzzer. The switch is now a doorbell button. If the buzzer is silent, try turning it round (many buzzers only work one way round, like LEDs).

✓ Discussion questions (with example answers)

- Explain how your switch works. When the paper clip touches both fasteners the loop is complete (metal conducts). When it is swung away there's a gap of air, which is an insulator, so the loop is broken.
- Did it matter where in the loop you put the switch? No. In a single loop, a break anywhere stops the whole loop.
- Why is the card a good base? Card is an insulator, so the electricity only goes through the paper clip, not across the card.

✓ Closing check (5 min, with answers)

1. In a switch, what is the "off" gap filled with? **Air (an insulator).**
2. Would a plastic paper clip work? **No, plastic is an insulator.**
3. A circuit has the switch between the cell and the buzzer. If we move the switch to the other side of the buzzer, will it still work? **Yes.**

Vocabulary

switch, open (off), closed (on), buzzer

Differentiation

- Support: pre-punch the holes in the card; pair with a confident builder.
- Stretch: design a "pressure switch" that turns on when something is stood on it (e.g. two foil strips separated by a sponge with a hole). Draw first, then build.

⚠ Safety

Brass fastener points are sharp; an adult can pre-punch holes with a sharp pencil. Same cell rules as lesson 1.

Teacher notes and misconceptions

- "Open" and "closed" are backwards from a door: an **open** switch is **off**. Say this explicitly; it confuses adults too.
- Some students think electricity is "used up" before the far side of the bulb, so the switch "after" the bulb shouldn't work. Step 3 tests this.

Lesson 4: A fair test: more bulbs

Unit overview · Previous: Lesson 3 · Next: Lesson 5

Goal

Students plan and carry out a fair test: does adding more bulbs to a single loop change how bright each bulb is?

Materials (per group)

- 1 AA cell in a holder, 3 identical bulbs in holders, 5 wires, a switch.
- Brightness scale card: 0 = off, 1 = dim glow, 2 = medium, 3 = bright.
- Planning sheet: question; what we change; what we keep the same; prediction; results table (Number of bulbs | Brightness, observer 1 | observer 2 | observer 3); conclusion.

Steps

✎ Opening (5 min)

Remind students of the grade 3 fair test: change **one** thing, keep the rest the same. Ask the question and have them write a prediction with a reason.

✎ Main activity (25 min)

1. **Plan:** fill in "What we change" (number of bulbs: 1, 2, 3) and "What we keep the same" (same cell, same type of bulb, same wires, same room light).
2. **Test:** build the loop with 1 bulb. Each group member rates brightness on the 0-3 scale **without telling the others**, then records. Repeat with 2 bulbs in the loop, then 3.
3. **Record and conclude:** "When we added more bulbs in one loop, each bulb got _____."

✓ Discussion questions (with example answers)

- What happened to brightness as you added bulbs? Each bulb got dimmer (typically 3 → 2 → 1, or 3 → 1 → 0 with a weak cell).
- Did all observers give the same number? Why not? Often not; judging brightness by eye is rough and depends on the observer. That's why we use more than one observer, and why scientists use meters (grade 10).
- What would have made the test unfair? Using a new cell for the 3-bulb test; using different types of bulb; moving to a sunnier spot.

✓ Closing check (5 min, with answers)

1. What did you change? **The number of bulbs.**

2. Name two things you kept the same. **Any two of: cell, bulb type, wires, room light, observers.**
3. Write one sentence conclusion. **"More bulbs in one loop made each bulb dimmer."** (Accept any conclusion that matches the group's own data.)

Vocabulary

fair test, variable, prediction, observer, conclusion, brightness

Differentiation

- Support: provide the planning sheet with "What we change" already filled.
- Stretch: try two cells with one bulb. Brighter or dimmer? (Only with bulbs rated for 3 V; check the rating with the teacher first.) Or try a **parallel** circuit: two bulbs each with their own loop to the cell. Compare brightness to the single loop.

⚠ Safety

Same as lesson 1. Do not add more cells than the bulbs are rated for: a bulb run above its rating can blow and get hot.

Teacher notes and misconceptions

- The explanation (each bulb adds resistance, so less current flows round the loop) is beyond grade 4. Accept "the cell has to push through more bulbs."
- If a group's data shows no change, check that bulbs are identical and the cell isn't flat; a flat cell gives 0 for everything.

Lesson 5: Drawing and designing circuits

Unit overview · Previous: Lesson 4

Goal

Students draw circuits with standard symbols, build a circuit from a drawing, and use what they know in a small design challenge. Ends with the unit check.

Materials (per group)

- Kit from lessons 1-4 (cell, bulbs, buzzer, wires, card switch).
- Symbol sheet (draw on the board): cell (long and short line), bulb (circle with a cross), switch (a line with a gap and a hinged line), buzzer, wire (straight lines with right-angled corners).
- Design brief cards (see below).

Steps

✎ Opening (10 min)

Show the symbols. Ask: "Why might engineers use symbols instead of drawing a realistic picture?" (Faster, clearer, anyone in the world can read them.) Draw lesson 1's circuit with symbols together.

✎ Main activity (20 min)

1. **Build from a drawing:** each group gets a symbol drawing (cell, switch, two bulbs in one loop) and builds it. Partner group checks.
2. **Design challenge** (choose one):
3. Lighthouse: a bulb at the top of a paper tower, with a switch at the bottom.
4. Door alarm: a buzzer that sounds when a door (a card flap) opens. Hint: the flap pushes two pieces of foil apart or together.
5. Quiz board: correct answers complete the loop and light the bulb.
6. Draw the design with symbols **before** building. Then build and test.

✓ Discussion questions (with example answers)

- Did your circuit work first time? What did you change? Answers vary; most common fixes are loose clips and a gap in the loop.
- Where is the switch in your design, and why there? e.g. "At the bottom of the lighthouse, so the keeper can reach it." (Any position works electrically; this is a design choice.)

✓ End-of-unit check (25 min, 8 questions, 16 marks)

1. Draw a circuit (symbols) with one cell, one bulb and one switch. **(3)**
2. A bulb doesn't light. Give two possible reasons. **(2)**
3. Sort into conductors and insulators: copper, rubber, aluminium, wood, steel, plastic. **(3)**
4. Why are electrical wires covered in plastic? **(2)**
5. What does a switch do in a circuit? **(1)**
6. In a fair test, why should you only change one thing? **(2)**
7. Amira adds a third bulb to a loop with two bulbs. Predict what happens to the brightness of each bulb. **(1)**
8. Why must you never experiment with wall sockets? **(2)**

Answer guide

1. Closed loop containing the cell symbol, a bulb symbol and a switch symbol, all connected: 1 mark per correct symbol in a complete loop.
2. Any two: a gap or loose clip; switch open; flat cell; broken bulb; an insulator in the loop; both wires on the same end of the cell.
3. Conductors: copper, aluminium, steel. Insulators: rubber, wood, plastic. Half a mark per correctly sorted material (6 × ½ = 3).
4. Plastic is an insulator (1); it stops electricity reaching us / going where it shouldn't (1).
5. It opens or closes a gap in the loop / turns the circuit on and off.
6. So you know which change caused the result (1); otherwise the result could be caused by something else (1).
7. Each bulb gets dimmer.
8. Mains electricity is much more powerful than a cell (1) and can seriously hurt or kill (1).

Vocabulary

symbol, circuit diagram, design, test, improve

Differentiation

- Support: give the symbol sheet during the check; read questions aloud.
- Stretch: draw a circuit where one switch controls two bulbs, and another where each bulb has its own switch (the second needs parallel loops).

⚠ Safety

Same as lesson 1. Foil in the door alarm must not join the two ends of the cell directly with nothing else in the loop (that's a short circuit).

Teacher notes and misconceptions

- Students often draw wires as wiggly lines; straight lines are a convention, not a rule of physics.

- Accept realistic pictures on question 1 for partial credit if the loop is correct; the symbols are the teaching point.

Grade 5 Science: Dissolving, Separating and Changes That Cannot Be Undone (5 lessons, about 3 weeks)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 4 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules.

Back to the science progression

Big idea

When some solids are stirred into water they dissolve: they seem to vanish, but they are still there, and the total mass stays the same. Mixtures can be separated by sieving, filtering, using a magnet or evaporating the water, and the right method depends on the materials. Dissolving, melting and evaporating can be undone. Burning, rusting and the fizz of bicarbonate of soda with vinegar make new materials, and cannot be undone.

Outcomes

By the end of the unit a student can:

1. Say which of several solids dissolve in water and which do not, using evidence (clear liquid with nothing settling, versus cloudy or settling).
2. Explain, using a weighing, that a dissolved solid is still there.
3. Plan and run a fair test of one thing that changes how fast sugar dissolves, changing one variable and keeping the others the same.
4. Choose and use a method (sieve, filter, magnet, evaporation) to separate a mixture, and explain why filtering cannot remove dissolved salt.
5. Sort changes into "can be undone" (reversible) and "makes a new material" (irreversible), and give at least two signs that a new material has formed.
6. Record results in a table and say how sure they are and why.

Prior knowledge

- Grade 2: solids and liquids; melting and freezing can be undone; some changes (cooking an egg) cannot.
- Grade 4: evaporation and the water cycle; reading a thermometer; fair tests with one changed variable.
- Reading a scale in grams and a timer in seconds.

Lessons

Lessons are 45-60 minutes. Set up the rusting jars (Lesson 4) at the end of Lesson 1, so they have about a week to change.

1. Where did it go? - dissolving tests with six solids, and weighing water before and after salt dissolves.

2. Faster dissolving - a fair test: stirring, warm water or smaller pieces.
3. Getting it back - sieving, filtering, magnets, and evaporating salty water to get the salt back.
4. New materials - bicarbonate of soda and vinegar, a candle burning (adult demonstration), and the rusting jars.
5. Mystery mixture - separate a four-part mixture, sort change cards, then the end-of-unit check.

Materials

For a class of about 30 in groups of 4-5:

- Clear plastic cups (about 200 ml), teaspoons, stirring sticks, trays, paper towels, cloths.
- Solids to test: table salt, granulated sugar, sugar cubes, dry sand, plain flour, small gravel or aquarium pebbles, chalk dust or crushed chalk (optional).
- Lesson 1: a kitchen scale reading to 1 g (one per group if possible, or one teacher scale at the front).
- Lesson 2: thermometers, a jug of warm tap water (an adult checks it is comfortable to touch), cold tap water, timers.
- Lesson 3: sieves or colanders, funnels, filter papers or coffee filters, plain steel paper clips (not iron filings), a strong but not tiny magnet per group, saucers or shallow dishes, a sunny sill or warm room.
- Lesson 4: bicarbonate of soda, white vinegar, a small plastic bottle and a balloon, safety goggles; for the teacher only: a candle in a stable holder, a lighter, a heatproof mat, and a fire blanket or whatever your school requires. Rusting jars: steel wool or plain (not galvanised or stainless) steel nails, three small jars or cups per group.
- Lesson 5: a bag of mystery mixture per group (see Lesson 5), change cards.

Assessment

- Lessons 1-4: listen to explanations during practical work; look at group results tables.
- Lesson 5: a 10-question end-of-unit check (20 marks) in Lesson 5. It is formative: use it to see what to revisit, not to grade students.

Sources

- Wikipedia, Solubility
- Wikipedia, Solution (chemistry)
- Wikipedia, Saturation (chemistry)
- Wikipedia, Suspension (chemistry)
- Wikipedia, Mixture
- Wikipedia, Conservation of mass
- Wikipedia, Sieve
- Wikipedia, Filtration
- Wikipedia, Magnetic separation
- Wikipedia, Evaporation
- Wikipedia, Crystallization
- Wikipedia, Physical change
- Wikipedia, Chemical change
- Wikipedia, Sodium bicarbonate
- Wikipedia, Vinegar

- Wikipedia, Combustion
- Wikipedia, Candle
- Wikipedia, Rust
- Wikipedia, Steel wool
- Wikipedia, Fire blanket

Known gaps and cautions

- Particles are left out on purpose. In the science progression the particle model comes in grades 6-8. Here, "the salt is still there" rests on evidence students can see: the mass stays the same, the water tastes salty (do not taste it in class), and evaporation brings the salt back.
- "Reversible" is simplified. Dissolving is undone by evaporating the water, but the salt comes back as crystals, not as the same grains. Some changes are hard to class (for example, cooking an egg is irreversible, but students may argue about melting chocolate that sets dull).
- Flour in water is a suspension, not a solution; chalk too. Students often call cloudy mixtures "dissolved". Lesson 1 uses "clear, with nothing settling after 5 minutes" as the working test.
- Results in Lesson 2 vary with room temperature and how hard students stir. Compare within one class on one day, and repeat if time allows.
- Burning is a teacher demonstration only. Check your school's fire and naked-flame rules before Lesson 4; leave the candle out if they do not allow it.
- No images yet. No educator review.

Lesson 1: Where did it go?

Back to the unit

Goal

Students test six solids in water and sort them into "dissolves" and "does not dissolve" using a clear rule. They weigh water before and after salt dissolves, and find that the mass does not change: the salt is still there.

Materials

Per group:

- Six clear cups, each with 150 ml of tap water (mark a line on the cups).
- Six labelled teaspoons of solid on paper or in small pots: salt, sugar, sand, plain flour, small gravel, crushed chalk (or swap chalk for coffee granules if you prefer a coloured example).
- Stirring sticks, a timer, a tray, paper towels.
- A results table (below).

For the weighing (one per group, or one teacher demonstration at the front):

- A kitchen scale reading to 1 g, a cup of 200 ml water, 10 g of salt measured out on paper.

For the rusting jars set up at the end (see Step 6): plain soap-free steel wool, three small jars or cups per group, salt, gloves.

Steps

✎ Opening (5 minutes)

Stir a spoon of sugar into a clear cup of water in front of the class until it disappears. Ask: "Where has the sugar gone? Is it still in the cup? How could we find out without tasting it?" Collect ideas on the board (look closely, weigh it, get it back somehow). Tell students we will try two of these today and the third in Lesson 3.

✎ Main activity (35-40 minutes)

1. **Predict.** Each group ticks "I think it will dissolve" or "I think it won't" for each solid before testing.
2. **Test.** Add one level teaspoon of each solid to its own cup. Stir for 1 minute (one student times), then leave it for 5 minutes without touching.
3. **Decide with a rule.** Write the class rule on the board: It has dissolved if the liquid is clear (it may be coloured) and nothing settles on the bottom after 5 minutes. Hold each cup up to the light.

Solid	Prediction	Clear after 5 min?	Anything settled?	Dissolved?
Salt				

Solid	Prediction	Clear after 5 min?	Anything settled?	Dissolved?
Sugar				
Sand				
Flour				
Gravel				
Chalk				

Expected results: salt and sugar dissolve (clear). Sand and gravel sink straight away. Flour and chalk make the water cloudy and slowly settle; by the rule they have not dissolved, even though they "spread out". 4. **Weigh it.** Put the cup of 200 ml water on the scale and write down the reading (for example 215 g, cup and water together). Put the paper of 10 g salt on the scale beside the cup and read the total (225 g). Tip the salt into the water, keep the empty paper on the scale, stir until no grains are left, and read again. It should still read 225 g, or within 1 g. Ask: "If the salt had really vanished, what would the scale say?" (About 215 g: the cup and water, plus the little the empty paper weighs.) 5. **Tidy.** Pour the salt and sugar water down the sink. Let sand, gravel and chalk settle, pour off the water, and put the solids in the bin (not the sink). 6. **Set up the rusting jars for Lesson 4.** Wearing gloves, each group puts a small ball of steel wool into three jars: **A** dry, with a lid on; **B** half-covered with tap water; **C** half-covered with salty water (one teaspoon of salt). Label them, add the date, and put them where they will not be knocked over. Each student draws what the steel wool looks like now.

✓ Discussion questions (with example answers)

- Flour made the water cloudy. Why don't we count it as dissolved? - You cannot see through it, and the flour slowly settles on the bottom. Salt water stays clear and nothing settles.
- How do we know the salt is still there? - The scale showed the same mass after the salt disappeared. (Also: salt water tastes salty, but we never taste things in science lessons.)
- Was our test fair? - Mostly: same amount of water, same spoon, same stirring time. It was less fair if some groups stirred harder or used heaped spoons.
- Coffee granules made brown water. Did they dissolve? - Yes, if it is clear brown with nothing settling. Clear does not mean colourless.

✓ Closing check (5 minutes, with answers)

1. Name one solid that dissolved in water. (Salt or sugar.)
2. Name one that did not. (Sand, gravel, flour or chalk.)
3. Water and cup weigh 215 g. You add 10 g of salt and it dissolves. What does the scale show now? (225 g.)
4. What is our rule for "dissolved"? (Clear, maybe coloured, and nothing settles after 5 minutes.)

Vocabulary

dissolve, solution, soluble, insoluble, mixture, settle, mass, gram

Differentiation

- **Support:** test three solids (salt, sand, flour) instead of six; give a results table with pictures; the teacher does the weighing at the front.
- **Stretch:** keep adding level teaspoons of salt to 150 ml of water, stirring 1 minute each time, until some salt stays on the bottom. Count the spoons. The water is now saturated. Does sugar take more or fewer spoons?

⚠ Safety

- Never taste or drink anything in the science lesson, even salt or sugar water. Use cups that are clearly not drinking cups if you can.
- Wipe spills straight away; wet floors are slippery.
- Chalk and flour dust: crush chalk inside a bag, not in the open air, and keep dust away from faces. Check for wheat or coeliac needs before using flour (gloves or a swap to cornflour).
- Salt or sand in the eyes: rinse with clean water and tell an adult. Wear goggles if your school requires them for practical work.
- Steel wool: wear gloves (it splinters into fingers), use soap-free steel wool, and keep it away from eyes.
- Do not pour sand, gravel or chalk down the sink.

Teacher notes and common misconceptions

- **"It melted."** Students often say sugar "melts" in water. Melting needs warming and happens to one material on its own (ice to water); dissolving needs a liquid to dissolve into. Gently correct every time.
- **"It disappeared, so it's gone."** The weighing is the evidence that it is still there. If a group's scale changes by 1-2 g, talk about spills, drips and how exact the scale is, rather than accepting "the salt lost weight".
- Hot water was not used today on purpose; temperature is the variable for Lesson 2.
- Keep one cup of salt water (labelled, covered) for Lesson 3.

Lesson 2: Faster dissolving

Back to the unit

Goal

Students plan and run a fair test of one thing that changes how fast sugar dissolves: stirring, water temperature, or piece size. They change one variable, keep the others the same, time the result, repeat it, and say how sure they are.

Materials

Per group:

- Four clear cups with a 150 ml line.
- Sugar cubes, and granulated sugar weighed out to match one cube (weigh a cube first; most are about 3-5 g).
- A thermometer, a timer (seconds), stirring sticks.
- Cold tap water, and warm tap water from a jug the adult has checked is comfortable to touch (about 35-40 °C; never from a kettle).
- A planning sheet and results table (below).

Steps

✎ Opening (5 minutes)

Show two cups: one sugar cube dropped into cold water, one into warm water and stirred. After a minute, ask: "Which dissolved faster? Can we say why?" Students should notice two things changed at once (warm and stirred), so we cannot tell which one mattered. That is today's problem.

✎ Main activity (35-45 minutes)

1. **Choose one variable.** Each group picks one question:
2. Does **stirring** make sugar dissolve faster?
3. Does **warmer water** make sugar dissolve faster?
4. Do **smaller pieces** (granulated sugar versus a cube of the same mass) dissolve faster?
5. **Plan.** On the sheet, groups write:
6. What we change: ...
7. What we keep the same: amount of water (150 ml), amount of sugar (one cube or its mass), and everything else except our variable.
8. What we measure: time in seconds until no sugar can be seen.
9. Prediction: "I think ... will dissolve faster because ..." The teacher checks each plan before groups start. Common gap: groups testing temperature forget to say "no stirring in either cup" (or "stir both the same way").
10. **Measure the temperature** of the water in each cup and write it down, even for groups not testing temperature.

11. **Run it.** Add the sugar to both cups at the same moment. Time until no grains or lumps are visible when the cup is held up to the light. **Stop at 5 minutes** and write "more than 300 s" if it has not finished.
12. **Repeat** with fresh water and sugar. If time allows, do a third run.

Run	Cup 1 (...) time in s	Cup 2 (...) time in s
1		
2		
3		

1. **Share.** Each group reports their question, result and how sure they are. Build one class summary.

Expected results: stirring, warmer water and smaller pieces each make sugar dissolve faster. An unstirred cube in cold water often takes far longer than 5 minutes. Exact times vary a lot between groups.

✓ Discussion questions (with example answers)

- Why did we stop at 5 minutes? - So the lesson fits in the time; "more than 300 s" is still a result. We know that cup was slower.
- Our two runs gave 40 s and 75 s for the same cup. Is that a mistake? - Not necessarily. Stirring speed, when we decided "no grains left" and the exact sugar amount vary. That is why we repeat and look for a pattern.
- Did warm water cause the change, or could it be something else? - If nothing else changed (same stirring, same sugar, same water amount), warm water is the best explanation.
- Why does a cube take longer than granulated sugar? - Only the outside of the cube touches the water at first. Small grains have much more surface touching the water.

✓ Closing check (5 minutes, with answers)

1. Sam tests warm versus cold water but stirs only the warm cup. What is wrong? (Two things changed, so Sam can't tell which made the difference.)
2. Name two things to keep the same in the stirring test. (Water amount, sugar amount, water temperature, type of sugar.)
3. Why do we repeat the test? (To check the result was not a one-off and to see how much the times vary.)

Vocabulary

variable, fair test, prediction, repeat, surface, temperature, degrees Celsius, seconds

Differentiation

- **Support:** give a part-filled plan with "what we change" already written for the stirring question; students fill in what stays the same and the times.

- **Stretch:** test three temperatures (cold, cool, warm) and draw a bar chart of the average time for each. Is the pattern a straight line?

⚠ Safety

- Warm tap water only, checked by an adult; no kettles or hot plates.
- Never taste the sugar water. Wipe spills straight away (sugar makes floors sticky and slippery).
- Thermometers: use spirit (red or blue liquid) or digital thermometers, not mercury. Lay them flat so they don't roll off the table.

Teacher notes and common misconceptions

- **"Hot water makes more sugar."** Some students think the sugar grows or multiplies. Weighing (Lesson 1) helps: the same mass goes in either way.
- **Faster is not the same as more.** Warm water also lets more sugar dissolve before it is saturated, but this lesson is only about speed. Keep the two questions separate.
- Deciding "no sugar left" is a judgement. Agree the rule before timing: hold the cup to the light, look at the bottom, no grains.
- Keep a cup of salty water from Lesson 1 (covered) for Lesson 3.

Lesson 3: Getting it back

Back to the unit

Goal

Students separate mixtures at four stations - sieve, filter, magnet and evaporation - and match each method to the materials it works for. They find that filtering cannot remove dissolved salt, but evaporating the water brings the salt back. So dissolving can be undone.

Materials

Set up four stations; groups rotate every 8-10 minutes.

- **Sieve station:** a mixture of dry sand and small gravel in a tub; a kitchen sieve; two empty tubs.
- **Filter station:** a cup of sandy water (stirred), a cup of salty water (from Lesson 1 or freshly made: one teaspoon of salt in 150 ml), funnels, filter papers or coffee filters, clear cups to catch the liquid.
- **Magnet station:** a tub of dry sand with about 20 plain steel paper clips mixed in; a magnet inside a small plastic bag (so clips drop off easily when the magnet is pulled out of the bag); a tray.
- **Evaporation station:** shallow dishes or saucers, salty water, labels, and a warm, sunny sill or a warm (not hot) spot near a radiator. A magnifying glass for looking at crystals later.
- A station sheet for each student (below).

Steps

✎ Opening (5 minutes)

Hold up a tub of sand with paper clips mixed in and a cup of salty water. Ask: "Could we get the paper clips back? Could we get the salt back? Would the same method work for both?" Students guess, then go and find out.

✎ Main activity (35-40 minutes)

At each station, students write the mixture, the method, what happened, and whether it worked.

Station	Mixture	Method	What happened	Worked?
1	sand + gravel	sieve		
2a	sand + water	filter		
2b	salt + water	filter		
3	sand + paper clips	magnet		

Station	Mixture	Method	What happened	Worked?
4	salt + water	evaporation		

1. **Sieve.** Shake the sand and gravel through the sieve over an empty tub. The gravel stays in the sieve because the pieces are bigger than the holes; sand falls through.
2. **Filter.** Fold a filter paper into a cone in the funnel and pour in the sandy water slowly. Sand stays on the paper; clearer water drips through. Now filter the salty water. The liquid that comes through still has the salt in it (it looks the same; we know it is salty, but do not taste it). The dissolved salt passes through the paper with the water.
3. **Magnet.** Sweep the bagged magnet slowly through the sand. Lift it over the tray and pull the magnet out of the bag: the paper clips drop. Count them. Did you find all 20?
4. **Evaporation.** Pour a little salty water into a shallow dish (about 1 cm deep), label it with names and date, and put it in the warm spot. This one takes days. Check it at the start of Lessons 4 and 5. When the water has gone, white salt crystals are left; look at them with a magnifying glass and draw them.

✓ Discussion questions (with example answers)

- Why didn't filtering get the salt out? - The salt is dissolved. It is spread through the water in pieces far too small to be caught by the paper, so it goes through with the water.
- Why did the sieve work for gravel but not for salt water? - Sieves and filters only catch pieces bigger than their holes. Gravel is big; dissolved salt is not.
- Where did the water go from the evaporation dish? - Into the air as water vapour (from grade 4: evaporation). Only the water leaves; the salt stays behind.
- Does this show dissolving can be undone? - Yes. We dissolved salt and then got salt back by evaporating the water. It comes back as crystals, not as the same grains, but it is still salt.

✓ Closing check (5 minutes, with answers)

1. Which method would you use to get iron nails out of sawdust? (A magnet.)
2. Which method would you use to get sand out of water? (Filter it.)
3. Can you filter sugar out of sugary water? Why? (No. The sugar is dissolved, so it goes through the filter with the water. Evaporate the water instead.)
4. Does a magnet pick up every metal? (No. Steel and iron, yes; aluminium, copper and brass, no. Coins vary from country to country.)

Vocabulary

mixture, separate, sieve, filter, filter paper, magnetic, evaporate, crystal, water vapour, residue

Differentiation

- **Support:** give the station sheet with the method already filled in, so students record only what happened and tick "worked" or "didn't work".

- **Stretch:** design a method to get both the salt and the sand out of a sand + salt + water mixture. (Filter to catch the sand, then evaporate the liquid to get the salt.) This is the start of Lesson 5's challenge.

⚠ Safety

- Use plain steel paper clips, not iron filings. Filings get into eyes and skin and are very hard to remove from magnets.
- Use a magnet that is too big to swallow. Keep small, strong (neodymium) magnets out of the classroom: two swallowed magnets can pinch the gut and need surgery.
- Keep magnets away from phones, cards and laptops.
- Evaporation dishes go somewhere warm, never on top of a radiator, heater or lamp. Do not heat salty water on a hob or burner in this lesson.
- Wipe spills; no tasting; sand stays out of the sink.

Teacher notes and common misconceptions

- **"Filtering makes water clean."** Filtered water can look clear but still have dissolved substances (and germs) in it. Never drink it.
- **"The salt evaporated."** Only the water evaporates; the salt is left behind. If students think the salt went into the air, ask why the dish is not empty.
- Evaporation is slow in a cold room. Start the dishes today so there are crystals by Lesson 5. If the room is cold, a warm spot near (not on) a radiator helps.
- "Magnetic" is for iron, steel, nickel and cobalt. Most other metals are not magnetic, which surprises many students.

Lesson 4: New materials

Back to the unit

Goal

Students see three changes that make new materials - bicarbonate of soda with vinegar, a candle burning (teacher demonstration) and steel wool rusting - and compare them with dissolving and melting. They list signs that a new material has formed and explain why these changes cannot be undone.

Materials

- **Fizz (per group):** a small plastic drinks bottle (about 500 ml), a balloon (check latex allergies; use a latex-free balloon if needed), a small funnel, 2 level teaspoons of bicarbonate of soda, about 100 ml of white vinegar, safety goggles for everyone in the group, a tray.
- **Candle (teacher only):** a candle in a stable holder on a heatproof mat, a lighter, a fire blanket or whatever your school requires, a cold metal spoon. Students stay behind a taped line at least 1 metre away.
- **Rusting jars** set up in Lesson 1 (A dry with a lid, B tap water, C salty water), gloves, a magnifying glass.
- The evaporation dishes from Lesson 3.
- A "Signs of a new material" chart (below).

Steps

✎ Opening (5 minutes)

Check the evaporation dishes from Lesson 3: is any salt showing yet? Remind students: dissolving and melting can be undone. Ask: "Can you think of a change you could never undo?" (Toast, a cooked egg, burnt paper, a rusty bike.) Today we look closely at three of these.

✎ Main activity (35-45 minutes)

1. **Fizz in a bottle (groups, 15 minutes).** Goggles on. Pour the vinegar into the bottle. Using the funnel, put 2 teaspoons of bicarbonate of soda into the balloon. Stretch the balloon neck over the bottle top, letting the balloon hang down so no powder falls in yet. Then lift the balloon so the powder drops into the vinegar. Watch and record: fizzing, the balloon filling up, the bottle feeling slightly cold. Ask: "What is inside the balloon?" A gas that was not there before - carbon dioxide. "Can we get the bicarbonate of soda back?" No: if you evaporate the liquid, you get a different white solid, not bicarbonate of soda.
2. **Candle (teacher demonstration, 10 minutes).** Students behind the line. Before lighting, show the candle and ask what it is made of (wax and a wick). Light it. Point out:

3. wax near the flame **melts** and runs down; when it cools it goes hard again (this part can be undone);
4. at the wick, wax is **burning**: there is light and heat, and the candle slowly gets shorter. That wax is not coming back;
5. hold a cold metal spoon briefly above the flame (not in it): it gets a black sooty mark, a new material. Blow out the candle and leave it to cool on the mat.
6. **Rusting jars (groups, 10 minutes).** Gloves on. Compare jars A, B and C with the drawings from Lesson 1. Usually: A (dry) shows little or no change; B (tap water) has orange-brown rust; C (salty water) usually has the most. Rub a little rust between gloved fingers: it is flaky and powdery, not shiny metal. Rust is a new material made from the iron in steel, water and oxygen from the air.
7. **Build the class chart.**

Sign that a new material has formed	Fizz	Candle	Rust
Gas given off (not from boiling)	yes	yes (smoke, invisible gases)	no
Colour change	no	yes (black soot)	yes (orange-brown)
Heat or light given out	no (it feels cold)	yes	no (very slow)
Cannot get the starting materials back	yes	yes	yes

Point out that the fizz felt cold: some new-material changes take in heat instead of giving it out. And no single sign is proof on its own - a fizzy drink gives off bubbles without a new material forming.

✓ Discussion questions (with example answers)

- Melting wax and burning wax both happened in the candle. What is the difference? - Melted wax goes hard again when it cools, so that can be undone. Burnt wax has turned into gases and soot, and does not come back.
- Why do you think jar C rusted most? - Salt water makes steel rust faster. (This is why cars and bridges near the sea or on salted roads rust more.)
- Why did jar A hardly change? - Steel needs water as well as air to rust. Jar A had no water added.
- Is dissolving like burning or like melting? - Like melting: we got the salt back by evaporating the water (Lesson 3).

✓ Closing check (5 minutes, with answers)

1. Name two signs that a new material may have formed. (Any two: gas given off, colour change, heat or light given out, can't get the starting materials back.)
2. Which can be undone: melting chocolate, burning paper, dissolving sugar, rusting a nail? (Melting chocolate and dissolving sugar.)
3. What gas filled the balloon? (Carbon dioxide.)

Vocabulary

reversible, irreversible, new material, burning, combustion, rust, gas, carbon dioxide, soot

Differentiation

- **Support:** give students the chart with pictures in the first column; they tick what they saw.
- **Stretch:** predict what would happen to the balloon with 4 teaspoons of bicarbonate of soda and the same vinegar, then test it if there is time. (Often a bigger balloon, until the vinegar is used up.)

⚠ Safety

- **Goggles** for everyone near the fizz bottles. Vinegar stings eyes: rinse with plenty of clean water and tell an adult.
- Point bottles away from faces; do not shake them or put a cap on them.
- **Balloons:** check latex allergies. Burst or loose balloons are a choking risk; collect them all at the end.
- **Candle: teacher only.** Check your school's naked-flame rules first; leave this part out if they don't allow it. Students stay behind the line; hair tied back, no loose sleeves near the flame; a fire blanket (or what your school requires) within reach; heatproof mat; never leave a lit candle; the spoon gets hot - put it on the mat to cool.
- **Steel wool:** gloves on; wash hands after. Pour rusty water away and wrap the steel wool before putting it in the bin.
- Never taste or smell chemicals up close. Waft gently with a hand if you need to smell vinegar.

Teacher notes and common misconceptions

- **"Melting and burning are the same."** Both happen in a candle, which is why it is a good demonstration. Keep coming back to "can it be undone?"
- **"The wax disappeared."** Burning wax turns into gases (mostly carbon dioxide and water vapour) and soot. It does not vanish; it becomes materials we mostly cannot see.
- **"Rust is a kind of dirt on the metal."** Rust is made from the iron in the steel. Rusty steel gets weaker because metal has been used up.
- The grade 6-8 particle model will later explain why new materials form; here it is enough to recognise and describe them.

Lesson 5: Mystery mixture

Back to the unit

Goal

Students plan and carry out a sequence of methods to separate a four-part mixture, sort change cards into "can be undone" and "makes a new material", and complete the end-of-unit check.

Materials

Per group:

- A "mystery mixture" in a clear tub: about 2 tablespoons each of dry sand, table salt and small gravel, plus 10 plain steel paper clips, all mixed together.
- A sieve, a magnet in a plastic bag, a funnel and filter paper, two clear cups, a shallow dish, about 200 ml of water, a stirring stick, a tray.
- A set of 12 change cards (below), cut out.
- The evaporation dishes from Lesson 3 (should now have salt crystals).
- The end-of-unit check, one per student.

Steps

✎ Opening (5 minutes)

Look at the Lesson 3 evaporation dishes with a magnifying glass. Ask: "We put salty water in. What is left? Where did the water go?" Then show the mystery mixture: "Four materials are hiding in here. Your job is to get each one out on its own. You have every tool from Lesson 3."

✎ Main activity (30-35 minutes, then the check)

1. **Plan the order (5 minutes).** Groups write numbered steps before touching the mixture. The teacher checks the plan. One order that works:
2. Magnet (in its bag) through the dry mixture to take out the paper clips.
3. Sieve to catch the gravel; sand and salt fall through.
4. Add water to the sand and salt and stir: the salt dissolves.
5. Filter: the sand stays on the paper.
6. Pour the salty liquid into a shallow dish and leave it somewhere warm to evaporate. The salt will be back in a few days. Groups may find other orders. If a group sieves first, the paper clips stay in the sieve with the gravel; they can still use the magnet then. If a group adds water first, the magnet and sieve still work but everything is wet and messy - a good thing to discuss.
7. **Carry it out (15 minutes).** Groups label each separated material. Leave the dish of salty water in the warm spot.
8. **Sort the change cards (10 minutes).** Two columns: Can be undone and Makes a new material (cannot be undone). Groups write one reason on any card they argue about.

Card	Answer
Ice melting	can be undone
Freezing juice into a lolly	can be undone
Dissolving sugar in tea	can be undone (evaporate the water)
A puddle drying up	can be undone, but arguable: the water is now vapour, and only comes back if it condenses
Candle wax melting	can be undone
Separating sand and gravel with a sieve	can be undone (mix them again)
Toasting bread	new material
Frying an egg	new material
A bike chain rusting	new material
Bicarbonate of soda fizzing in vinegar	new material
Wood burning on a bonfire	new material
Baking a cake	new material

✓ Discussion questions (with example answers)

- Why does the order of steps matter? - Some steps only work on dry mixtures (sieve, magnet), and the salt only separates from the sand once it is dissolved. Doing things in a sensible order saves mess.
- Which card was hardest to sort? Why? - Often "a puddle drying up": the water seems gone, but it is only water vapour, and it can turn back into liquid (grade 4: condensation).
- Was any change both? - Yes: in a candle, wax melting can be undone but wax burning cannot.

✓ Closing check: end-of-unit check (20-25 minutes)

Use it to see what to revisit, not to grade students. There is no pass mark. 10 questions, 2 marks each, 20 marks in total.

1. You stir a teaspoon of salt into one cup of water and a teaspoon of flour into another. Which one dissolves, and what would you see? (1 mark: salt. 1 mark: salt water is clear with nothing settling; flour water is cloudy and the flour slowly settles.)
2. A cup of water weighs 180 g. You add 15 g of sugar and stir until it dissolves. What does the scale read now? What does this tell you? (1 mark: 195 g. 1 mark: the sugar is still there even though you cannot see it.)
3. Mia tests whether a sugar cube or granulated sugar dissolves faster. She puts the cube in warm water and the granulated sugar in cold water. What is wrong, and how should she fix it? (1 mark: two things changed - piece size and temperature - so she can't tell which made the difference. 1 mark: use water at the same temperature in both cups.)
4. A group timed sugar dissolving. Stirred: 45 s and 52 s. Not stirred: 210 s and 240 s. What do the results show, and why did they do two runs? (1 mark: stirring makes sugar

dissolve faster. 1 mark: to check the result was not a one-off / to see how much the times vary.)

5. Which method would you use to (a) get sand out of water, (b) get iron nails out of sand? (1 mark each: (a) filter; (b) magnet.)
6. Can you get salt out of salty water by filtering? Explain. (1 mark: no. 1 mark: the salt is dissolved, so it goes through the filter paper with the water.)
7. How could you get the salt back from salty water, and where does the water go? (1 mark: leave it in a shallow dish somewhere warm so the water evaporates (or heat it, with an adult). 1 mark: the water goes into the air as water vapour; the salt stays behind.)
8. Sort these: melting butter, burning wood, dissolving salt, a rusting bike. (1 mark: melting butter and dissolving salt can be undone. 1 mark: burning wood and rusting make new materials.)
9. Give two signs that a new material may have formed. (1 mark each, any two: a gas given off (not from boiling); a colour change; heat or light given out; you cannot get the starting materials back.)
10. When a candle burns, give one change that can be undone and one that cannot. (1 mark: wax melting (it goes hard again when it cools). 1 mark: wax burning at the wick (it becomes gases and soot; the candle gets shorter).)

Vocabulary

Revise all unit words: dissolve, solution, insoluble, mixture, filter, sieve, magnetic, evaporate, crystal, reversible, irreversible, new material.

Differentiation

- **Support:** give the mystery-mixture plan as five cut-up step cards to put in order; read the check questions aloud; accept spoken answers.
- **Stretch:** add a fifth material to the mixture (for example a spoon of sugar). Can it be separated from the salt with these tools? (No: both dissolve, both pass through the filter and both are left behind when the water evaporates. Students should say so rather than invent a method.)

⚠ Safety

- Same as Lessons 1 and 3: no tasting; magnet too big to swallow and kept in its bag; plain paper clips, not filings; wipe spills; sand and gravel in the bin, not the sink.
- Evaporation dishes go near, never on, a heater. Do not heat salty water in class unless your school allows it and an adult does it.
- If students mention heating to speed up evaporation, discuss it, but keep it as an adult-only step.

Teacher notes and common misconceptions

- **Sorting cards are for talking, not just scoring.** Several cards are arguable (a puddle drying up is only undone if the water vapour condenses again somewhere). Reward clear reasons.

- **Question 8 split marks.** Give each mark only if both items in that group are right.
- Collect and check that every paper clip and magnet bag comes back.
- Keep the salt dishes: watching crystals appear over the next days links this unit to the grade 4 water cycle and grade 6-8 particle model.

Grade 6 Science — Fungi and decomposition

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (an AI agent) on 2026-11-04. No teacher has checked it yet. Read it fully, adapt it to your class and local rules, and test any practical work yourself before using it with students.

Back to all units

Big idea

Fungi are a separate kingdom of living things — not plants, not animals. Most of them feed by releasing digestive chemicals onto dead or living material and absorbing what dissolves. That habit makes them some of the world's main decomposers, returning nutrients to the soil, and it also explains why people use them (bread, medicine) and fear some of them (food spoilage, crop disease, poisonous mushrooms).

Outcomes

By the end of the unit, students can:

1. Give three ways fungi differ from plants (no photosynthesis; cell walls made of chitin, not cellulose; feed by absorbing food).
2. Name and recognise the three everyday forms of fungi: yeasts, moulds, mushrooms — and explain that a mushroom is only the reproductive part of a larger hidden network (mycelium).
3. Explain, using a simple diagram, how decomposers return nutrients from dead material to soil and then to plants.
4. Plan a fair test that changes one variable, keeps others the same, and records observations over several days.
5. Describe evidence that yeast is alive and produces a gas (carbon dioxide) when given sugar.
6. Give two ways fungi help people and two ways they harm people or crops.

Prior knowledge

- Living things need food and energy; plants make their own food using light.
- Basic idea of a food chain.
- Using a ruler and recording a table.

Lessons (about 50 minutes each)

#	Lesson	Practical?
1	What is a fungus?	Observation (shop mushrooms, hand lens)
2	Decomposers and the nutrient cycle	Leaf-litter observation
3	Mould on bread: a fair test	Set up sealed bags; observe for about 7 days
4	Yeast is alive: the balloon test	Yeast, sugar, warm water, balloons
5	Fungi and people + unit check	Discussion and written assessment

Lesson 3 needs follow-up of about 5 minutes on several later days to record the bags. You can run Lessons 4 and 5 during that week.

Materials (whole unit)

- Shop-bought mushrooms (e.g. button mushrooms), one per group; plastic knives; hand lenses; paper towels
- Trays or paper plates; a bag of leaf litter collected by the teacher from a garden or park (or a school compost heap)
- Bread without preservatives if possible (preservatives slow mould), water spray bottle, zip-seal plastic bags, sticky tape, permanent marker
- Dried baker's yeast (one 7 g sachet per group is plenty), sugar, warm (not hot) water about 35–40 °C, small plastic bottles (about 500 ml), balloons, funnel, measuring spoons, string or tape measure
- Student record sheets (tables are given in each lesson)

Assessment

- Ongoing: closing check questions at the end of each lesson (answers included).
- Lesson 3: the bread-mould record table and conclusion are a practical skills task.
- Lesson 5: a 10-question unit check with an answer guide and simple marking notes.

Sources

These are general references that a teacher can use to check facts. Links were checked to load on 2026-11-04.

- Wikipedia, "Fungus": https://en.wikipedia.org/wiki/Fungus
- Wikipedia, "Hypha": https://en.wikipedia.org/wiki/Hypha
- Wikipedia, "Mycelium": https://en.wikipedia.org/wiki/Mycelium
- Wikipedia, "Chitin": https://en.wikipedia.org/wiki/Chitin
- Wikipedia, "Decomposer": https://en.wikipedia.org/wiki/Decomposer
- Wikipedia, "Nutrient cycle": https://en.wikipedia.org/wiki/Nutrient_cycle
- Wikipedia, "Saccharomyces cerevisiae" (baker's yeast): https://en.wikipedia.org/wiki/Saccharomyces_cerevisiae
- Wikipedia, "Cellular respiration": https://en.wikipedia.org/wiki/Cellular_respiration
- Wikipedia, "Penicillin": https://en.wikipedia.org/wiki/Penicillin
- Wikipedia, "Alexander Fleming": https://en.wikipedia.org/wiki/Alexander_Fleming
- Wikipedia, "Mycorrhiza": https://en.wikipedia.org/wiki/Mycorrhiza
- Wikipedia, "Mushroom poisoning": https://en.wikipedia.org/wiki/Mushroom_poisoning
- Wikipedia, "Amanita phalloides" (death cap): https://en.wikipedia.org/wiki/Amanita_phalloides

A teacher should prefer their national curriculum documents and school science-safety guidance where these exist.

Known gaps and cautions

- **Simplifications (labelled for teachers):** "Fungi absorb their food" is true of nearly all fungi but hides variety. The yeast balloon test is mostly fermentation (respiration without much oxygen), which makes carbon dioxide and a little alcohol; at grade 6 we call it

"respiration" and mention the distinction only in teacher notes. "Kingdom" is used as a simple grouping; modern classification is more complicated.

- **Safety:** mould spores can trigger allergies and asthma. The bread bags stay sealed for the whole experiment and are thrown away sealed. Students never pick or taste wild mushrooms or fungi — some deadly species look like edible ones. An adult prepares the warm water. Check for yeast, wheat/gluten and mushroom allergies before practical lessons.
- Not aligned to any official standard yet. Times are estimates.
- No images are included; teachers will want photos or real specimens of mushrooms, bracket fungi and mould.

Lesson 1: What is a fungus?

Time: 50 minutes

Unit overview · Next: Lesson 2

Goal

Students can give three ways fungi differ from plants and name the three everyday forms of fungi (outcomes 1 and 2).

Materials

- One shop-bought button mushroom per group of 3–4, on a paper towel; plastic knife; hand lens
- Board or slide with three pictures: a loaf of bread rising (yeast), a mouldy orange (mould), a toadstool in a forest (mushroom)
- Optional: a slice of old mouldy bread sealed inside a clear zip bag and taped shut, for looking at only

Steps

1. **Opening (5 min).** Hold up a mushroom. Ask: "Is this a plant? Vote with your hands." Write the vote on the board and say we will vote again at the end.

2. **Main activity (30 min).**

3. Look closely (12 min). Groups cut their mushroom from top to bottom and use the hand lens. They draw it and label: **cap**, **stem (stalk)**, **gills** under the cap. Ask them to look for anything green (there is none) and for roots (there are none — any white threads at the base are hyphae).
4. Teacher explains (8 min). Fungi are their own kingdom of life. Key points, written on the board:
    - Fungi have **no chlorophyll**, so they cannot make food from light.
    - They **feed by absorbing**: they release digestive chemicals (enzymes) onto food outside their body, then soak up the dissolved food.
    - Their bodies are made of tiny threads called **hyphae**. A big tangled network of hyphae is a **mycelium**, usually hidden in soil, wood or food.
    - Their cell walls are made of **chitin** — the same tough material found in insect shells — not cellulose like plants.
    - A mushroom is only the **fruiting body**: the part that makes and releases **spores** (like seeds, but a single cell). Most of the fungus is the mycelium underground.

5. Three forms (10 min). Show the three pictures. Students copy and complete this table:

Form	What it looks like	Example
Yeast	Single cells, too small to see one alone	Baker's yeast that makes bread rise
Mould	Fuzzy threads on food	Green-blue mould on old bread or oranges

Form	What it looks like	Example
Mushroom	Fruiting body above ground	Button mushroom, toadstool, bracket fungus on a tree

6. **Discussion questions (10 min).**
7. "Why can a mushroom grow in a dark cupboard but a bean plant can't?" — Example answer: the mushroom doesn't use light to make food; it absorbs food from what it grows on. The bean plant needs light for photosynthesis.
8. "If you pick a mushroom, have you killed the fungus?" — Example answer: usually not; the mycelium underground is still alive, like picking an apple doesn't kill the tree.
9. "Why do you think fungi grow on dead logs and old food?" — Example answer: that is their food; they digest it and absorb it.
10. **Closing check (5 min).** Vote again: plant or not? Then:
11. Q1. Give two differences between fungi and plants. — Any two: no chlorophyll/can't photosynthesise; absorb food; chitin walls (not cellulose); made of hyphae; reproduce by spores (plants also can, e.g. ferns, so accept this only alongside another difference).
12. Q2. What is the name of the network of threads that makes up most of a fungus? — Mycelium (threads = hyphae).

Vocabulary

- fungus (plural fungi): a living thing that is not a plant or animal and feeds by absorbing food
- hypha (plural hyphae): one tiny thread of a fungus
- mycelium: the network of hyphae that makes up most of a fungus
- spore: a tiny cell a fungus releases to make a new fungus
- chitin: a tough material in fungus cell walls (also in insect shells)
- fruiting body: the part that makes spores, e.g. a mushroom

Differentiation

- Extra support: give a pre-drawn mushroom outline to label; give the table with the "Example" column filled in.
- Extra challenge: fungi are more closely related to animals than to plants. Ask students to list ways a fungus is like an animal (doesn't photosynthesise, eats other things, has chitin like insects) and ways it is not (doesn't move, has cell walls).

⚠ Safety

- Use shop-bought mushrooms only. No one eats anything in this lesson. Wash hands afterwards.
- Never pick or taste wild mushrooms. Some deadly species (such as the death cap) look similar to edible ones, and even experts use careful identification.
- The mouldy-bread bag, if used, stays sealed and is thrown away sealed.
- Ask about mushroom allergies beforehand.

Teacher notes

- Misconception: "Mushrooms are plants because they grow in the ground and don't move." Answer: so do many things; what matters is how they get food and what they are made of.
- Misconception: "Mould is dirt." Answer: mould is a living fungus growing on the food.
- Misconception: "Spores are seeds." Answer: similar job, but a spore is a single cell with no stored food and no baby plant inside.
- Simplification: "kingdom" is a useful grouping for this age; modern biology classifies living things by relatedness in a more complicated tree.

Lesson 2: Decomposers and the nutrient cycle

Time: 50 minutes

Unit overview · Previous: Lesson 1 · Next: Lesson 3

Goal

Students can explain, with a diagram, how decomposers return nutrients from dead material to the soil and to plants (outcome 3).

Materials

- A bag of leaf litter collected by the teacher (top layer of fallen leaves and the darker, crumbly layer underneath), from a garden, park or compost heap
- Trays or paper plates, plastic spoons, hand lenses, disposable gloves
- Sorting sheet with three columns: "Fresh leaves", "Partly broken down", "Crumbly soil-like"

Steps

1. **Opening (5 min).** Ask: "Every autumn, trees drop millions of leaves. Why aren't forests buried metres deep in old leaves?" Collect ideas without correcting yet.

2. **Main activity (30 min).**

3. Leaf-litter sort (15 min). Each group gets a spoonful-sized pile of litter on a tray. Wearing gloves, they sort pieces into the three columns. With the hand lens, they look for: white or yellow threads (fungal hyphae), small animals (woodlice, worms, mites), holes and skeleton-like leaves where only the veins remain. They record what they find in words and sketches.
4. Teacher explains (10 min). Draw the cycle on the board as a loop:
    1. A plant takes **nutrients** (such as nitrogen and phosphorus) from the soil and grows.
    2. The plant (or an animal that ate it) dies, or drops leaves.
    3. **Decomposers** — mainly fungi and bacteria — digest the dead material. Small animals like worms and woodlice help by breaking it into smaller pieces (they are often called detritivores).
    4. Digestion releases the nutrients back into the soil.
    5. New plants take them up. The loop starts again. Explain that fungi are especially good at breaking down tough wood and leaves, which many other living things cannot digest.

5. Students draw (5 min). Each student draws the cycle with at least five labelled arrows.

6. **Discussion questions (10 min).**

7. "Back to the opening question: why aren't forests buried in leaves?" — Example answer: fungi, bacteria and small animals break the leaves down into soil every year.
8. "What would happen to a forest if all the decomposers disappeared?" — Example answer: dead material would pile up; nutrients would stay locked inside it; the soil would run out of nutrients and new plants would struggle to grow.

9. "Which column had the most fungal threads, and why?" — Example answer: usually the partly broken down layer, because fungi are actively digesting it there. (Accept any answer backed by what the group saw.)

10. **Closing check (5 min).**

11. Q1. What is a decomposer? — A living thing that breaks down dead material and returns nutrients to the soil (e.g. fungi, bacteria).
12. Q2. Put in order: plant grows / leaf falls / fungi digest leaf / nutrients in soil. — Plant grows → leaf falls → fungi digest leaf → nutrients in soil → (plant grows again).

Vocabulary

- decomposer: a living thing that breaks down dead material, e.g. fungi and bacteria
- detritivore: a small animal that eats dead material, e.g. worm, woodlouse
- nutrient: a substance living things need to grow, e.g. nitrogen
- leaf litter: the layer of fallen leaves and bits on the ground

Differentiation

- Extra support: provide the cycle diagram with blank labels and a word bank.
- Extra challenge: add the Sun and photosynthesis to the diagram, showing that energy flows through (and leaves as heat) while nutrients go round in a cycle.

⚠ Safety

- Teacher collects the litter beforehand from a place without dog waste, broken glass or sprayed chemicals.
- Gloves on; no hands near faces; wash hands afterwards. Return small animals outside after the lesson.
- Students with asthma or mould allergy should be told in advance; keep the room ventilated and don't shake the litter.

Teacher notes

- Misconception: "Things rot because they get old." Answer: rotting is done by living decomposers. Without them (e.g. in very cold, dry or airless places) things last a very long time.
- Misconception: "Decomposers are bad/dirty." Answer: without them, ecosystems would stop working.
- Misconception: "Plants eat soil." Answer: plants take small amounts of dissolved nutrients and water from soil; most of their body mass comes from carbon dioxide in the air, via photosynthesis.
- Simplification: we show one tidy loop; real nutrient cycles have many branches.

Lesson 3: Mould on bread — a fair test

Time: 50 minutes to set up, then about 5 minutes on 4–5 later days to observe

Unit overview · Previous: Lesson 2 · Next: Lesson 4

Goal

Students plan and run a fair test that changes one variable, keeps others the same, and records observations over several days (outcome 4).

Materials (per group)

- 2 slices of the same bread, from the same loaf (bread without preservatives grows mould faster; note the type used)
- 2 zip-seal plastic bags, clear sticky tape, permanent marker
- Water spray bottle (or a teaspoon of water)
- A ruler or a clear grid sheet with 1 cm squares to lay over the bag
- Record sheet (table below)
- Shared places with different conditions: a warm spot (e.g. on a shelf in the classroom) and a cold spot (a fridge with no food in it, or bags inside a second sealed container - see Safety)

Steps

1. **Opening (5 min).** Ask: "Why do we keep bread in a bag, and why does it go mouldy faster in summer?" Collect ideas. Tell students that mould grows from spores already floating in the air and sitting on the bread — we don't need to add any.

2. **Main activity (30 min).**

3. Choose one question (8 min). Each group chooses ONE of these to test:
    - A. Does moisture affect how fast mould grows? (dry slice vs. slice sprayed with 5 sprays of water)
    - B. Does temperature affect how fast mould grows? (warm shelf vs. fridge; both slices sprayed the same)
4. Plan a fair test (10 min). Students fill in:
    - The one thing we change (independent variable): _____
    - What we measure (dependent variable): how much of the slice is covered with mould
    - Things we keep the same (control variables): at least three, e.g. same bread, same size slice, same type of bag, same amount of water (in B), same light, same days
    - Prediction: "I think ____ will grow mould faster because ____."

5. Set up (12 min). Spray/prepare slices as planned. Place each slice in its own bag, squeeze out most air, seal the zip and **tape it shut**. Label each bag with group name, condition and date. Put bags in their places. **Bags are never opened again.**

6. **Discussion questions (10 min).**

7. "Why do we test only one thing at a time?" — Example answer: if we change two things and one slice gets mouldier, we can't tell which change caused it.

8. "Why do we use bread from the same loaf?" — Example answer: different breads have different ingredients and preservatives, which could change the result; keeping it the same keeps the test fair.

9. "How could we make our result more trustworthy?" — Example answer: repeat with more slices for each condition and compare; other groups doing the same test also helps.

10. **Closing check (5 min).**

11. Q1. In test B, what is the independent variable? — Temperature (warm vs. cold).
12. Q2. Name two control variables. — Any two: same bread/loaf, same slice size, same water, same bag type, same light, same time.

Observation days (about 5 minutes each, e.g. days 2, 3, 5, 7)

Without opening the bags, students lay the 1 cm grid over each bag and count squares that are at least half covered by mould. They also note colours (white, green, blue-green, black) and smell is **not** tested.

Day	Condition 1: squares with mould	Colours seen	Condition 2: squares with mould	Colours seen
0	0	—	0	—
2				
3				
5				
7				

Conclusion (final observation day, 15 min)

Students draw a simple line graph (day on the bottom axis, squares with mould on the side axis, one line per condition) and write:

- "The ____ slice grew mould faster. This supports / does not support my prediction."
- "One reason this might happen is ____."
- "One way our test might not have been fair is ____."

Expected results (for the teacher): moist, warm bread usually grows visible mould within about 3–7 days; dry bread and bread in a fridge grow it much more slowly. Results vary a lot with bread type and room temperature, and no-growth results are still valid data — use them to discuss.

Vocabulary

- variable: anything that can change in an experiment
- independent variable: the one thing we choose to change
- dependent variable: what we measure
- control variables: things we keep the same to make the test fair
- prediction: what we think will happen and why

Differentiation

- Extra support: give the plan with the control variables partly filled in; let students count squares with a partner.
- Extra challenge: test three levels (dry / 3 sprays / 6 sprays) or add a third location (dark cupboard) and explain whether light matters.

⚠ Safety

- **Bags stay sealed and taped for the whole experiment and are thrown away sealed** in the general rubbish (put inside a second bag). Mould spores can trigger allergies and asthma; opening the bags releases them.
- Students with mould allergy or asthma record data from photos of the bags (taken by the teacher or a classmate) instead of handling or sitting near the bags.
- Don't put bags with mould in a fridge that holds food unless it is a dedicated fridge or the bags are inside a second sealed container; check your school's rules.
- Wash hands after handling the bags.

Teacher notes

- Misconception: "The mould came from inside the bread / was created by the water." Answer: spores were already on the bread and in the air; water and warmth let them grow.
- Misconception: "Just scrape off the mould and the rest is fine." Answer: hyphae grow through the food, beyond what you can see; general advice is to throw mouldy bread away.
- Many groups will forget that a fridge is also dark. Use this to discuss a hidden second variable — a great learning moment.
- Simplification: counting covered squares is a rough measure; that's fine for this age and worth discussing as a limitation.

Lesson 4: Yeast is alive — the balloon test

Time: 50 minutes

Unit overview · Previous: Lesson 3 · Next: Lesson 5

Goal

Students describe evidence that yeast is alive and produces a gas (carbon dioxide) when it has sugar (outcome 5).

Materials (per group)

- 2 small clean plastic bottles (about 500 ml), labelled A and B
- 2 balloons (stretch them a few times first so they inflate easily)
- 1 sachet (7 g) dried baker's yeast, split into two equal halves
- 2 teaspoons of sugar
- Warm water at about 35–40 °C (comfortably warm to touch, not hot) — **prepared by an adult**
- Funnel, measuring jug, teaspoon, string and ruler (or tape measure)
- Optional for the class demo: a slice of bread to show the holes made by gas

Steps

1. **Opening (5 min).** Show a slice of bread and ask: "Where do the holes in bread come from?" Then show the dry yeast: "This is a fungus. Is it alive? How could we find out?"

2. **Main activity (30 min).**

3. Set up (10 min). In both bottles, use the funnel to put half the yeast and 100 ml warm water. In bottle A **only**, add 2 teaspoons of sugar. Swirl gently. Stretch a balloon over each bottle's neck. Bottle B (no sugar) is the **control**.
4. Predict (3 min). Students write which balloon will inflate more and why.

5. Observe (15 min). Every 5 minutes, measure around the widest part of each balloon with string and ruler, and note bubbles or foam in the bottle. Record in a table:

Time (min)	A (sugar): balloon size (cm)	A: bubbles?	B (no sugar): balloon size (cm)	B: bubbles?
0				
5				
10				
15				

6. Teacher explains (2 min). Yeast cells use sugar as food to release energy. One waste product is a gas, **carbon dioxide**, which fills the balloon. In bread dough, the same gas makes bubbles that become the holes. Using food to release energy is something all living things do.

Expected result (for the teacher): bottle A foams and its balloon usually starts to inflate within 10–20 minutes; bottle B changes little. If the room is cold or the water was too hot, results may be slow — keep the bottles somewhere warm and check again at the end of the lesson.

1. **Discussion questions (10 min).**
2. "What is the evidence that yeast is alive?" — Example answer: it used food (sugar) and produced a gas; dead things don't do that. With no sugar, little happened.
3. "Why did we have bottle B?" — Example answer: to show that the sugar made the difference, not just the water or the yeast on its own.
4. "What might happen if we used boiling water?" — Example answer: it would kill the yeast, so no gas would be made. (Teacher can demonstrate this safely as an extension.)
5. **Closing check (5 min).**
6. Q1. What gas filled the balloon? — Carbon dioxide.
7. Q2. What does yeast use as food in this test? — Sugar.
8. Q3. How does this explain the holes in bread? — Yeast in the dough makes carbon dioxide bubbles, which get trapped and leave holes when the bread is baked.

Vocabulary

- yeast: a fungus made of single cells, used in baking
- carbon dioxide: a gas made when living things use food for energy
- control: the part of an experiment where we leave out the thing being tested, so we can compare
- respiration: the process of using food to release energy (not the same as breathing)

Differentiation

- Extra support: pre-labelled bottles; a results table with time already filled in; sentence starters ("Balloon A got bigger because…").
- Extra challenge: plan a follow-up test: does the amount of sugar, or the water temperature, change how fast the balloon inflates? Identify the variables.

⚠ Safety

- An adult prepares and pours the warm water; it must not be hot enough to scald (aim for 35–40 °C).
- Check for yeast allergy. Nothing is tasted. Bottles can be emptied down a sink with running water afterwards; wash hands.
- Balloons: check for latex allergy and use latex-free balloons if needed.
- Bottles must have the balloon only on top — never seal a bottle with a cap during this experiment, because gas pressure builds up.

Teacher notes

- Misconception: "Respiration means breathing." Answer: breathing moves air in and out of lungs; respiration is the chemical process in cells that releases energy from food. Yeast respires but has no lungs.

- Misconception: "The sugar fizzed like a fizzy drink." Answer: sugar in water without yeast doesn't produce gas — add a third bottle with sugar and water only, no yeast, if students raise this.
- Simplification: in a balloon-sealed bottle, yeast mostly carries out **fermentation** (respiration with little oxygen), which makes carbon dioxide and a small amount of alcohol. At this level calling it respiration is fine; older students can learn the difference.

Lesson 5: Fungi and people + unit check

Time: 50 minutes (25 min lesson, 25 min unit check)

Unit overview · Previous: Lesson 4

Goal

Students give two ways fungi help people and two ways they harm people or crops (outcome 6), then show what they have learned across the unit.

Materials

- Six "fungus fact cards" (text below), printed, one set per group
- A large two-column sheet per group: "Helpful" / "Harmful"
- Unit check, one copy per student

Steps

1. **Opening (3 min).** Ask: "Are fungi our friends or our enemies?" Quick show of hands.
2. **Main activity (15 min).** Groups read the six cards and sort them into Helpful / Harmful (some can go in both). Then each group writes one sentence per card on why.
3. **Card 1 — Bread and food.** Baker's yeast makes bread rise. Fungi are also used to make soy sauce, some cheeses (the blue veins in blue cheese are a mould) and other foods.
4. **Card 2 — Penicillin.** In 1928, the scientist Alexander Fleming noticed that a mould growing on one of his dishes had stopped bacteria growing around it. The substance it made, penicillin, became one of the first antibiotics — medicines that kill bacteria — and has saved a very large number of lives.
5. **Card 3 — Mycorrhizae (my-co-RYE-zee).** The hyphae of many fungi join with plant roots. The fungus helps the plant take up water and nutrients such as phosphorus; the plant gives the fungus sugars it made by photosynthesis. Most land plants have partnerships like this.
6. **Card 4 — Crop and tree diseases.** Some fungi attack living plants. Rusts and mildews damage crops such as wheat; fungal diseases have killed huge numbers of trees in some countries.
7. **Card 5 — Food spoilage.** Moulds grow on bread, fruit and other food, making it unsafe or unpleasant to eat. Some moulds produce poisons.
8. **Card 6 — Poisonous mushrooms.** A few wild mushrooms are deadly. The death cap can look like edible mushrooms and causes many of the world's deaths from mushroom poisoning. This is why nobody should eat a wild mushroom unless an expert has identified it — and even then, many people simply don't.
9. **Discussion questions (5 min).**
10. "Which card surprised you most?" — Any answer with a reason.

11. "Is one fungus 'good' or 'bad'?" — Example answer: it depends on where it is. Mould on bread is a problem in the kitchen, but the same kind of fungus breaking down fallen leaves in a forest is useful.

12. **Closing check (2 min).**

13. Q1. Name one medicine that came from a fungus. — Penicillin.
14. Q2. How does a mycorrhizal fungus help a plant? — It helps the plant take up water and nutrients (and gets sugar in return).

✓ Unit check (25 min)

1. Give **two** ways a fungus is different from a plant. (2 marks)
2. What is a mycelium? (1 mark)
3. A mushroom is the _____ body of a fungus; it releases _____. (2 marks)
4. Name the three everyday forms of fungi and give one example of each. (3 marks)
5. Explain what decomposers do and why forests need them. (2 marks)
6. Draw a nutrient cycle with at least four labelled stages, including decomposers. (3 marks)
7. Ali tests whether bread goes mouldy faster in a warm place or in a fridge. He puts white bread in the warm place and brown bread in the fridge. Is this a fair test? Explain. (2 marks)
8. In the balloon test, bottle A (yeast, sugar, warm water) blew up its balloon and bottle B (yeast, warm water, no sugar) did not. What does this show? (2 marks)
9. Give one way fungi help people and one way fungi harm people or crops. (2 marks)
10. Your friend finds a mushroom in the park that looks like the ones in the shop and wants to cook it. What would you say, and why? (1 mark)

Total: 20 marks.

Answer guide

1. Any two of: cannot photosynthesise / no chlorophyll; feed by absorbing food (digest outside the body); cell walls made of chitin, not cellulose; body made of hyphae. (1 each)
2. A network of fungal threads (hyphae), usually hidden in soil, wood or food. (1)
3. Fruiting (1); spores (1).
4. Yeast — e.g. baker's yeast; mould — e.g. mould on bread/oranges; mushroom — e.g. button mushroom, toadstool, bracket fungus. (1 per correct form with example)
5. They break down dead material (1) and return nutrients to the soil so new plants can grow; without them dead material would pile up and soil would lose nutrients (1).
6. Award up to 3: plant grows using nutrients from soil; plant/leaf dies or falls; decomposers (fungi/bacteria) break it down; nutrients return to soil. Arrows must form a loop for full marks.
7. No (1). He changed two things — temperature and type of bread — so he can't tell which caused any difference; he should use the same bread in both places (1).
8. Yeast needs sugar (food) to produce gas (1); the gas (carbon dioxide) is evidence yeast is alive / respiring (1).
9. Help: e.g. bread, penicillin, decomposition, mycorrhizae (1). Harm: e.g. food spoilage, crop/tree disease, poisonous mushrooms, allergies (1).
10. Don't eat it — some poisonous mushrooms look like edible ones and can be deadly; only experts can identify them safely (1).

Marking notes: accept clear answers in the student's own words. For question 6, a clear drawing with labels is better than a neat one.

Vocabulary

- antibiotic: a medicine that kills bacteria
- mycorrhiza (plural mycorrhizae): a partnership between a fungus and plant roots
- spoilage: food going bad
- poisonous: can harm or kill if eaten

Differentiation

- Extra support: read the cards aloud; allow the unit check to be answered orally or with a word bank (hyphae, spores, fruiting, decomposer, carbon dioxide, sugar, chitin).
- Extra challenge: research one more fungus (e.g. the fungus used to make a meat substitute, or a fungus that grows on insects) and add a seventh card.

⚠ Safety

- No specimens handled in this lesson. Repeat the rule: never pick or taste wild mushrooms.

Teacher notes

- Misconception: "Antibiotics kill viruses." Answer: they act on bacteria, not viruses such as colds and flu.
- Misconception: "Fleming invented penicillin." Answer: he discovered the mould's effect; other scientists (notably Howard Florey and Ernst Chain's team) later found how to purify and produce it as a medicine.
- Simplification: "Most land plants have mycorrhizal partnerships" is accurate as a general statement; exact percentages vary by source and group of plants.

Grade 7 Science — Photosynthesis and respiration: where a plant's mass comes from

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (an AI agent) on 2026-11-04. No teacher has checked it yet. Read it fully, adapt it to your class and local rules, and test any practical work yourself before using it with students.

Back to all units

Big idea

A tree is mostly made from air. Green plants take in carbon dioxide and water and, using light energy captured by chlorophyll, make sugar (glucose) and release oxygen. This is photosynthesis. All living things, plants included, break down sugar with oxygen to release the energy they need, giving off carbon dioxide and water. This is respiration. It happens day and night. The two processes run in opposite directions, and together they move carbon between the air and living things.

Outcomes

By the end of the unit, students can:

1. Write the word equations for photosynthesis (carbon dioxide + water → glucose + oxygen, needing light and chlorophyll) and for aerobic respiration (glucose + oxygen → carbon dioxide + water, releasing energy).
2. Explain, using van Helmont's willow experiment and the photosynthesis equation, why most of a plant's mass does not come from the soil.
3. Use the iodine test to show starch is present, and explain that plants store some of the glucose they make as starch.
4. Plan and carry out a fair test of how light intensity affects the rate of photosynthesis, using floating leaf discs, and draw a line graph of the results.
5. Use an indicator (bromothymol blue) to show carbon dioxide being taken in or given out, and explain why a plant in the dark adds carbon dioxide to the water.
6. Correct the common ideas that "plants respire only at night", "respiration is breathing" and "plants get their food from the soil".

Prior knowledge

- Plants need light and water to grow well (grade 1); living things need food for energy.
- Fungi and other decomposers release carbon dioxide as they break down dead material (grade 6).
- Fair tests: change one thing, keep the rest the same, repeat (grades 3–6).
- Reading and drawing simple tables and line graphs.

Lessons (about 50 minutes each)

#	Lesson	Practical?
1	Where does a tree come from?	Iodine starch test on foods

#	Lesson	Practical?
2	Leaves make oxygen: floating leaf discs	Leaf discs in light and in the dark
3	More light, faster photosynthesis? A fair test	Lamp at three distances; graph
4	Respiration never stops: the indicator tubes	Bromothymol blue tubes, light and dark
5	Two processes, one carbon cycle + unit check	Discussion and written assessment

Lesson 4 needs a short look at the tubes the next day (about 5 minutes).

Materials (whole unit)

- Lesson 1: dilute iodine solution in dropper bottles (iodine in potassium iodide, as sold for school use); white tiles or saucers; small samples of potato, bread, rice, apple, table salt, sugar, cooking oil; eye protection.
- Lessons 2–3: fresh spinach leaves (or ivy or another soft, thin leaf); a single-hole paper punch; 10 ml plastic syringes without needles; sodium hydrogen carbonate (baking soda); washing-up liquid; clear plastic cups; an LED desk lamp (LEDs stay cool); a ruler or metre stick; a box or cupboard for dark cups; stopwatches.
- Lesson 4: bromothymol blue indicator solution (school-strength); boiling tubes or clear jars with lids or bungs; aluminium foil; pondweed (for example Elodea or Egeria bought from an aquarium shop); one new straw per student; a lamp.
- Student record sheets (tables are given in each lesson).

Assessment

- Ongoing: closing check questions at the end of each lesson (answers included).
- Lesson 3: the results table, line graph and conclusion are a practical skills task.
- Lesson 5: a 10-question unit check (20 marks) with an answer guide and marking notes.

Sources

These are general references that a teacher can use to check facts. Links were checked to load on 2026-11-04.

- Wikipedia, "Photosynthesis": https://en.wikipedia.org/wiki/Photosynthesis
- Wikipedia, "Cellular respiration": https://en.wikipedia.org/wiki/Cellular_respiration
- Wikipedia, "Jan Baptist van Helmont" (willow tree experiment): https://en.wikipedia.org/wiki/Jan_Baptist_van_Helmont
- Wikipedia, "Joseph Priestley": https://en.wikipedia.org/wiki/Joseph_Priestley
- Wikipedia, "Jan Ingenhousz": https://en.wikipedia.org/wiki/Jan_Ingenhousz
- Wikipedia, "Chlorophyll": https://en.wikipedia.org/wiki/Chlorophyll
- Wikipedia, "Chloroplast": https://en.wikipedia.org/wiki/Chloroplast
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- Wikipedia, "Starch": https://en.wikipedia.org/wiki/Starch
- Wikipedia, "Iodine–starch test": https://en.wikipedia.org/wiki/Iodine%E2%80%93starch_test
- Wikipedia, "Lugol's iodine": https://en.wikipedia.org/wiki/Lugol%27s_iodine
- Wikipedia, "Sodium bicarbonate": https://en.wikipedia.org/wiki/Sodium_bicarbonate
- Wikipedia, "Bromothymol blue": https://en.wikipedia.org/wiki/Bromothymol_blue

- Wikipedia, "Elodea": https://en.wikipedia.org/wiki/Elodea
- Wikipedia, "Carbon dioxide": https://en.wikipedia.org/wiki/Carbon_dioxide
- Wikipedia, "Carbon cycle": https://en.wikipedia.org/wiki/Carbon_cycle
- Wikipedia, "Compensation point": https://en.wikipedia.org/wiki/Compensation_point
- Wikipedia, "Fermentation": https://en.wikipedia.org/wiki/Fermentation

A teacher should prefer their national curriculum documents and school science-safety guidance where these exist.

Known gaps and cautions

- **Simplifications (labelled for teachers):** the word equations hide many steps (light-dependent reactions, the Calvin cycle, glycolysis and so on). "Glucose" stands for the sugars plants make. Respiration "releases" energy; it does not "make" it. Anaerobic respiration and fermentation are mentioned only briefly (grade 6 yeast). Leaf discs float because oxygen collects in the air spaces inside the leaf; the rising rate is a rough measure of photosynthesis minus respiration, not a pure measure of photosynthesis.
- **Van Helmont:** he concluded the extra mass came from water. That was partly right: water supplies hydrogen and oxygen, but most of the dry mass comes from carbon dioxide in the air, which he could not know about. Present him as a careful measurer who drew a reasonable but incomplete conclusion.
- **Safety:** eye protection for iodine and indicator work; iodine stains skin and clothes. Students only ever **blow out** through straws, never suck, and each uses a new straw. Use LED lamps (cool) and keep electrical leads away from water. Syringes have no needles. Pondweed is an invasive species in many places: buy it from a shop, never collect it from or release it into ponds or streams, and dispose of it in general waste. Check local rules, because some species are banned. No leaf-boiling in ethanol in this unit.
- Not aligned to any official standard yet. Times are estimates. Leaf disc timings vary a lot with the leaf, the lamp and the water temperature, so trial the method first.
- No images are included; teachers will want a diagram of a leaf cross-section and photos of stomata.

Lesson 1 — Where does a tree come from?

Back to unit

Goal

Students meet the puzzle of where a plant's mass comes from, learn the word equation for photosynthesis, and use the iodine test to find starch, the store a plant makes from the sugar it produces.

Materials

- A large potted plant or a photo of a big tree; a seed (for example a bean or an acorn)
- Dilute iodine solution in dropper bottles (one per group); white tiles or saucers
- Small samples: raw potato slice, bread, cooked rice, apple slice, a pinch of table salt, a pinch of sugar, a few drops of cooking oil
- Eye protection; paper towels
- Record table (below)

Steps

✎ Opening (5 min)

Hold up the seed, then show the tree. Ask: "This tree started as a seed smaller than my fingernail. It now weighs as much as a car. Where did all that stuff come from?" Students write a one-line guess on a sticky note. Collect them; most will say "the soil" or "water". Keep them for the end of the lesson.

✎ Main activity (35 min)

Part A — Van Helmont's willow (10 min). Tell the story. In the 1600s Jan Baptist van Helmont, a Flemish doctor and chemist, planted a small willow in a pot of soil that he had weighed. For five years he added only rainwater and kept the pot covered so dust could not get in. At the end the tree had gained about 74 kg. The soil had lost only about 57 g.

Ask pairs: "If the tree got its mass from the soil, what should have happened to the soil?" (It should have lost about 74 kg.) "So where could the mass have come from?" Van Helmont said water. Tell students he was partly right, and that the rest of the answer is something he couldn't weigh: the air.

Part B — The equation (5 min). Write on the board:

> carbon dioxide + water → glucose + oxygen (needs light energy, captured by chlorophyll)

Explain: the carbon in a tree's wood comes from carbon dioxide gas that enters the leaves through tiny pores called stomata. Water comes up from the roots. Light provides the energy.

Chlorophyll, the green pigment inside chloroplasts, captures the light. Glucose is a sugar; the plant uses it for energy and to build itself. Oxygen goes out into the air.

Part C — The starch test (20 min). Plants turn much of their glucose into starch to store it. Iodine solution is orange-brown; it turns blue-black when it touches starch.

1. Eye protection on. Each group puts the seven samples on a tile, spaced apart.
2. Before testing, groups predict "starch" or "no starch" for each.
3. Add one or two drops of iodine to each sample. Wait one minute.
4. Record the colour.

Sample	Prediction	Colour after iodine	Starch?
Potato			
Bread			
Rice			
Apple			
Salt			
Sugar			
Oil			

Expected: potato, bread and rice go blue-black. Salt, sugar and oil stay orange-brown. Apple varies: unripe apple shows some starch, and ripe apple shows little, because the starch turns to sugar as it ripens. Sugar is a useful surprise: plants make sugar, but table sugar is not starch, so the test is negative.

✓ Discussion questions (with example answers)

1. Potato is a part of a plant that grows underground, in the dark. How can it be full of starch? — The leaves made the sugar in the light; the plant carried it down and stored it in the potato as starch.
2. Van Helmont kept the pot covered. Why did that matter? — So that dust or soil couldn't fall in and add mass; otherwise the soil weighing wouldn't be trustworthy.
3. Is the iodine test showing photosynthesis happening? — No. It shows that starch is there, which is evidence that photosynthesis happened earlier.

✓ Closing check (5 min, with answers)

1. Write the word equation for photosynthesis. — carbon dioxide + water → glucose + oxygen (light, chlorophyll).
2. Most of a tree's dry mass comes from: (a) soil (b) air (c) fertiliser. — (b) air (carbon dioxide).
3. What colour does iodine turn with starch? — Blue-black.

Return the sticky notes. Students who wrote "soil" annotate their own note with one sentence explaining why it is mostly not the soil.

Vocabulary

photosynthesis, carbon dioxide, oxygen, glucose, starch, chlorophyll, chloroplast, stomata (singular: stoma)

Differentiation

- **Support:** give a part-filled equation with word cards to place; give the results table with predictions already sorted into two columns.
- **Stretch:** "Soil does supply something small but important. What?" (Minerals such as nitrogen and magnesium, in small amounts; magnesium is part of chlorophyll.) Ask how van Helmont's experiment could be improved (repeat with several trees; dry and weigh the soil; measure the water added).

⚠ Safety

- Eye protection. Iodine stains skin and clothes; wipe spills straight away.
- Nothing in this lesson is eaten, including the food samples after testing. Bin them.
- Check for food allergies before handling bread (wheat/gluten) and other samples.

Teacher notes and common misconceptions

- "Plants eat soil" or "plant food comes from the soil" is extremely common, even in adults. Garden "plant food" is fertiliser, which supplies minerals, not energy.
- Students often think gases have no mass. If they struggle, weigh a sealed fizzy drink bottle, open it, let it go flat overnight and weigh again; it loses a little mass as carbon dioxide escapes.
- Hydrogen and oxygen in the plant come mostly from water, and carbon mainly from carbon dioxide. At grade 7 "mostly from the air, with water" is enough.

Lesson 2 — Leaves make oxygen: floating leaf discs

Back to unit

Goal

Students see evidence that leaves give off a gas in the light and not in the dark, using small leaf discs that sink and then float as oxygen collects inside them. They also learn the method they will use for the fair test in Lesson 3.

Materials (per group of 3–4)

- 3 fresh spinach leaves (thin, soft leaves work best; avoid thick waxy ones)
- Single-hole paper punch
- One 10 ml plastic syringe, **no needle**
- Bicarbonate solution, made by the teacher: about 1/8 teaspoon (roughly 0.5 g) of sodium hydrogen carbonate (baking soda) stirred into 300 ml water, plus 1 small drop of washing-up liquid
- Plain water with 1 small drop of washing-up liquid (no bicarbonate), for the extra cup
- 3 clear plastic cups, labelled A, B and C
- An LED desk lamp; a box or cupboard for the dark cup
- Stopwatch; record table

Steps

✎ Opening (5 min)

Recap the equation: carbon dioxide + water → glucose + oxygen. Ask: "If leaves really give off oxygen, how could we see it?" Take ideas (bubbles; collect the gas). Then tell students the story of Jan Ingenhousz, who in 1779 showed that underwater plants give off bubbles from their green parts in sunlight, and that the bubbles stop in the shade.

Explain the trick: a leaf has air spaces inside it. If we pull the air out, the leaf disc sinks. If it then makes oxygen, the gas fills the spaces and the disc floats again.

✎ Main activity (35 min)

1. **Punch discs (5 min).** Punch 30 discs, avoiding the big veins. Keep them on a damp paper towel.
2. **Sink the discs (10 min).** For each set of 10 discs:
3. Take the plunger out of the syringe. Drop 10 discs into the barrel. Put the plunger back and push it gently down to just above the discs.
4. Draw up about 5 ml of solution. Point the tip upwards and push out the air.
5. Put a finger over the tip and pull the plunger back slowly. Hold for 10 seconds; this pulls air out of the leaf. Release.
6. Repeat 2–3 times until most discs sink. Tap the syringe if discs stick to the side.

7. Pour the discs and the liquid into a cup with about 3 cm of the same liquid. Any disc that is still floating is taken out and replaced.
8. **Set up three cups.**
9. **A:** bicarbonate solution, about 10 cm under the lamp.
10. **B:** bicarbonate solution, in the dark box.
11. **C:** plain water (no bicarbonate), about 10 cm under the lamp.
12. **Record (15 min).** Every minute, count the floating discs in A and C. Lift the lid on B only at 5, 10 and 15 minutes, and do it quickly.

Time (min)	Floating in A (light + bicarbonate)	Floating in B (dark + bicarbonate)	Floating in C (light, no bicarbonate)
0	0	0	0
1		–	
2		–	
…			
15			

Expected pattern: discs in A begin to rise after a few minutes, and most float by 10–15 minutes. Discs in B stay down. Discs in C stay down or rise only very slowly. The times vary a lot, so trial the method beforehand.

✓ Discussion questions (with example answers)

1. Why is the bicarbonate there? — It gives the water dissolved carbon dioxide, which the leaf needs to photosynthesise.
2. What does cup C tell us? — Light alone isn't enough; without a carbon dioxide supply, the discs make little oxygen.
3. What does cup B tell us? — Without light, the discs don't make enough oxygen to float, even with carbon dioxide.
4. Can we be sure the gas is oxygen? — Not from this test alone. Ingenhousz and others tested the gas. We are using their result and our equation, and we should say so.

✓ Closing check (5 min, with answers)

1. Why do the discs sink after we use the syringe? — We pulled the air out of the spaces inside the leaf.
2. Why do discs in the light rise again? — Photosynthesis makes oxygen, which fills the air spaces.
3. Name the two things the leaf needed that we tested today. — Light and carbon dioxide.

Vocabulary

air spaces, dissolved, control, rate, evidence

Differentiation

- **Support:** one student counts, one times, one records; give a table with the minutes already filled in.
- **Stretch:** "The discs are also respiring all the time, using up some oxygen. What does that mean about the rate we are measuring?" (It is photosynthesis minus respiration, so the real rate of photosynthesis is a bit higher.)

⚠ Safety

- Syringes have no needles. Don't point a syringe at anyone.
- The lamp is an LED; keep the lead and plug away from the cups of liquid, and wipe spills straight away.
- Baking soda solution is not for tasting; wash hands after the practical.

Teacher notes and common misconceptions

- Make the bicarbonate solution fresh each day; too much bicarbonate can slow the discs down, so stick to a small amount.
- If discs won't sink, add one more tiny drop of washing-up liquid (it helps the liquid get into the leaf) and repeat the vacuum step.
- Some students think the bubbles are "air" or "carbon dioxide coming out". Link back to the equation: oxygen is the product.
- Keep the discs for no more than one lesson; they won't work well the next day.

Lesson 3 — More light, faster photosynthesis? A fair test

Back to unit

Goal

Students plan and carry out a fair test of how the distance of a lamp (and so the light intensity) affects the rate of photosynthesis, using the floating leaf disc method from Lesson 2. They draw a line graph and write a conclusion that uses evidence.

Materials (per group of 3–4)

- As in Lesson 2: spinach leaves, hole punch, 10 ml syringe (no needle), freshly made bicarbonate solution with a drop of washing-up liquid, 3 clear cups
- An LED desk lamp; a metre stick or ruler
- Stopwatch; graph paper; record table
- If possible, dim the room lights or close the blinds

Steps

✎ Opening (5 min)

Ask: "In Lesson 2, discs in the light floated and discs in the dark didn't. What do you predict will happen with some light: a lamp far away?" Students write a prediction with a reason, using "the closer the lamp…, the … ".

✎ Main activity (35 min)

Plan (8 min). As a class, agree on the variables before anyone starts.

- **Change (independent variable):** distance from the lamp to the cup: 10 cm, 20 cm, 40 cm.
- **Measure (dependent variable):** the time for 5 of the 10 discs to float. A shorter time means a faster rate.
- **Keep the same (control variables):** type of leaf; 10 discs per cup; the same bicarbonate solution; the same depth of liquid; the same lamp; the same starting time; room lighting.

Ask: "Why use an LED lamp and not an old bulb that gets hot?" (A hot lamp would warm the closer cups more, so temperature would change as well as light, and the test wouldn't be fair.)

Do (22 min). Each group sinks three sets of 10 discs (the method is in Lesson 2) and sets up the three cups at the three distances, measuring from the bulb to the middle of the cup. Start the stopwatch for all three together. Record the time at which the 5th disc floats in each cup. Stop at 25 minutes. If 5 discs haven't floated by then, record "more than 25 min".

Distance from lamp (cm)	Time for 5 discs to float (min) — our group	Class median (min)
10		
20		
40		

Collect every group's times on the board and find the median for each distance. The median is the middle value; one odd result doesn't pull it much.

Example class results (for the teacher; real results will differ):

Distance (cm)	Group times (min)	Median (min)
10	6, 7, 5, 6, 14	6
20	9, 10, 8, 11, 9	9
40	16, 18, 15, >25, 17	17

The 14 at 10 cm is probably a mistake, such as discs not properly sunk or a lamp knocked out of place. The median handles it.

Graph (5 min). Students plot the class medians: distance on the x-axis, time for 5 discs to float on the y-axis, joined with a line. Ask: "What shape is it?" (As the distance goes up, the time goes up, so the rate goes down.)

✓ Discussion questions (with example answers)

1. Write a conclusion. — "The closer the lamp, the shorter the time for 5 discs to float, so the faster the rate of photosynthesis. At 10 cm the median was 6 minutes; at 40 cm it was 17 minutes."
2. Why did we use the time for 5 discs and not for all 10? — Some discs are damaged or stuck and may never float; the time for half of them is more reliable.
3. Does more light always mean faster photosynthesis? — Not forever. At some point something else runs out (carbon dioxide, or warmth), and more light stops helping. Ask students to suggest a test.
4. How could we make the results more trustworthy? — Repeat each distance; use more distances; check the temperature of each cup with a thermometer.

✓ Closing check (5 min, with answers)

1. In this test, what did we change, and what did we measure? — Changed: distance from the lamp. Measured: time for 5 discs to float.
2. Group times at 20 cm were 9, 10, 8, 30, 9 minutes. What is the median? Which value is probably a mistake? — Median 9 minutes; 30 is probably a mistake.
3. A student says, "Cup C was warmer because the lamp was close, so it isn't a fair test." What could they change? — Use an LED lamp that stays cool, or put a clear tray of water between the lamp and the cup, and check the temperatures.

Vocabulary

independent variable, dependent variable, control variable, light intensity, rate, median, line graph, conclusion

Differentiation

- **Support:** give a planning frame with the three variable types as headings; give pre-drawn graph axes with scales.
- **Stretch:** "Light intensity falls off quickly with distance. If you halve the distance, roughly how much brighter is it?" (About four times brighter for a small lamp; this is the inverse square idea, a simplification for a desk lamp.) Students compare whether their times look like a four-times difference and suggest reasons why not.

⚠ Safety

- As Lesson 2: no needles; LED lamp; keep leads and plugs away from water; wipe spills.
- Don't move lamps while they are switched on and near the cups; switch off, move, then switch on.

Teacher notes and common misconceptions

- Students often write "the closer the lamp, the more photosynthesis" without numbers. Ask for one number from the table in each conclusion.
- "Rate" is the tricky idea: a shorter time means a faster rate. Some students may want to calculate a rate as 1 ÷ time; that's a good stretch but not required.
- Results vary between groups. That's normal, and it's the reason we pool data and take a median.

Lesson 4 — Respiration never stops: the indicator tubes

Back to unit

Goal

Students learn the word equation for aerobic respiration, show that their own breath contains carbon dioxide, and use an indicator to show that pondweed takes in carbon dioxide in the light and gives it out in the dark, because it respires all the time.

Materials (per group of 3–4)

- Bromothymol blue (BTB) indicator solution, school strength, diluted with water so it is a clear blue (the teacher prepares this)
- A small beaker; **one new straw per student**
- 4 boiling tubes or small clear jars with bungs or lids, labelled A–D; a rack
- 2 pieces of pondweed (for example Elodea or Egeria from an aquarium shop), each about 8 cm long
- Aluminium foil; an LED lamp or a bright windowsill
- Eye protection; record table

Steps

✎ Opening (10 min)

Write the respiration equation next to the photosynthesis one:

> glucose + oxygen → carbon dioxide + water (energy is released)
>
> carbon dioxide + water → glucose + oxygen (light energy is needed)

Ask: "What do you notice?" (They are the reverse of each other.) Explain that respiration happens inside the cells of all living things, in structures called mitochondria. It releases the energy stored in glucose. Breathing is how animals like us move air in and out; it is not the same thing as respiration.

The indicator. Show the blue BTB. Explain that it is blue when there is little carbon dioxide, and turns green and then yellow as more carbon dioxide dissolves (the water becomes slightly acidic).

Demonstration of breath. Eye protection on. A student blows out gently through a straw into the beaker of BTB for up to a minute. It turns green, then yellow. Ask: "Where did the carbon dioxide come from?" (From respiration in the student's cells, carried to the lungs by the blood.)

✎ Main activity (30 min)

1. Each group blows gently through their straws into their BTB until it is **yellow-green**. Everyone blows out only; no one sucks. Use new straws.
2. Fill the four tubes with this yellow-green solution, almost to the top.
3. Set up:
4. **A:** pondweed, in the light
5. **B:** pondweed, wrapped completely in foil (dark)
6. **C:** no pondweed, in the light
7. **D:** no pondweed, wrapped in foil
8. Bung the tubes. Put them about 15 cm from the LED lamp, or on a bright windowsill.
9. Predict the colour of each tube after one day, and give a reason.
10. Record the colour at the end of the lesson (there may be only a small change) and again the next day.

Tube	Pondweed?	Light?	Colour at start	End of lesson	Next day
A	yes	yes	yellow-green		
B	yes	no	yellow-green		
C	no	yes	yellow-green		
D	no	no	yellow-green		

Expected next day: **A** turns blue (the plant took in carbon dioxide). **B** turns more yellow (the plant gave out carbon dioxide). **C** and **D** stay about the same.

✓ Discussion questions (with example answers)

1. Why did tube B go more yellow? — In the dark there is no photosynthesis, but the plant is still respiring, so it gives out carbon dioxide.
2. Tube A was also respiring. Why did it go blue? — In bright light, photosynthesis takes in carbon dioxide faster than respiration gives it out, so overall the carbon dioxide goes down.
3. What are tubes C and D for? — They are controls. They show that light, the foil or the tube by itself doesn't change the colour; the plant does.
4. A student says "plants photosynthesise in the day and respire at night". What is right and wrong? — Right that photosynthesis only happens in the light. Wrong that respiration is only at night: it happens all the time, day and night.

✓ Closing check (5 min, with answers)

1. Write the word equation for aerobic respiration. — glucose + oxygen → carbon dioxide + water (energy released).
2. What colour is BTB with a lot of carbon dioxide? With little? — Yellow; blue.
3. Which living things respire: plants, animals, fungi, or all three? — All three (and bacteria too).

Vocabulary

respiration, aerobic, mitochondria (singular: mitochondrion), indicator, acidic, control

Differentiation

- **Support:** give colour cards (blue, green, yellow) to hold up for predictions; give a sentence frame: "In tube __ the colour went __ because the plant was __."
- **Stretch:** "What would happen to tube A in very dim light?" (It might stay green: photosynthesis and respiration could balance. This is the compensation point.) Students could design a test with tubes at different distances.

⚠ Safety

- Eye protection for BTB. Wipe spills; BTB can stain.
- **Blow out only, never suck.** Each student uses a new straw; no sharing. Students with asthma or breathing difficulties can watch or record instead of blowing.
- LED lamp, leads away from water.
- **Pondweed:** buy it from a shop. Never collect it from, or put it into, ponds, streams or drains, because many pondweeds are invasive. Dispose of it in general waste. Check local rules, as some species are banned in some places.
- Wash hands after handling pondweed and indicator.

Teacher notes and common misconceptions

- "Respiration = breathing" is very common. Separate them clearly: breathing moves air; respiration is a chemical process in cells.
- "Plants don't respire" or "plants only respire at night" are both common. Tube B is the key evidence.
- "Respiration makes energy" — energy is released from glucose, not made.
- BTB batches vary; test one tube with pondweed in the week before. If tube A doesn't change, the light may be too dim or the pondweed too old; use fresh, bright green shoots.

Lesson 5 — Two processes, one carbon cycle + unit check

Back to unit

Goal

Students connect photosynthesis and respiration to a simple carbon cycle, explain why a growing forest takes carbon out of the air, and complete the unit check.

Materials

- Large sheet or board for a class carbon-cycle diagram; arrow cards
- Six labelled cards: AIR (carbon dioxide), PLANTS, ANIMALS, DECOMPOSERS (fungi and bacteria), DEAD MATERIAL, FUELS (wood, coal, oil, gas)
- Results from Lessons 1–4 on display
- Unit check sheets (below), one per student

Steps

✎ Opening (5 min)

Show the class results from tubes A and B. Ask: "If the plant takes in carbon dioxide in the day and gives it out at night, does it end up with more carbon or less?" (A growing plant ends up with more. Over a whole day it takes in more than it gives out; that's how it grows. Van Helmont's willow is the evidence.)

✎ Main activity (15 min) — building the carbon cycle

1. Put the six cards on the board.
2. Groups come up and add arrows, saying the process each time:
3. AIR → PLANTS: photosynthesis
4. PLANTS → AIR, ANIMALS → AIR, DECOMPOSERS → AIR: respiration
5. PLANTS → ANIMALS: eating (feeding)
6. PLANTS and ANIMALS → DEAD MATERIAL: dying, dropping leaves, waste
7. DEAD MATERIAL → DECOMPOSERS: decomposition (link to the grade 6 fungi unit)
8. FUELS → AIR: burning (combustion)
9. Ask: "Which arrow takes carbon out of the air?" (Only photosynthesis, in this diagram.) "Which arrows put it back?" (Respiration by every living thing, decomposition, burning.)

✓ Discussion questions (with example answers)

1. Why do people say a young, growing forest takes carbon out of the air? — While trees are growing, photosynthesis takes in more carbon dioxide than the forest gives out, and the carbon is stored in wood.

2. What happens to that carbon if the trees are burned, or die and rot? — It returns to the air as carbon dioxide, by burning, or by the respiration of decomposers.
3. Where did the carbon in coal come from? — From plants that photosynthesised millions of years ago and were buried before they fully decayed.

✓ Unit check (25 min)

Ten questions, 20 marks. Allow about 25 minutes. There is no pass mark; use the results to see what to revisit.

1. Write the word equation for photosynthesis. Say what else is needed. **(2)**
2. Write the word equation for aerobic respiration. **(2)**
3. Van Helmont's willow gained about 74 kg in five years. The soil lost about 57 g. (a) What did this show about the soil? (b) Where do we now know most of the extra mass came from? **(2)**
4. Iodine was added to four foods. Potato and rice went blue-black. Sugar and salt stayed orange-brown. Which foods contain starch? Why is the sugar result not a sign that plants don't make sugar? **(2)**
5. Five groups timed how long it took for 5 leaf discs to float with a lamp at 20 cm: 8, 9, 22, 10, 9 minutes. (a) What is the median? (b) Which time is probably a mistake? **(2)**
6. In the leaf disc test, name the variable that was changed and one variable that was kept the same. **(2)**
7. Tube X: pondweed in yellow-green indicator, kept in bright light. Tube Y: the same, wrapped in foil. Predict the colour of each the next day. **(2)**
8. A student writes: "Plants photosynthesise in the day and respire at night instead." Correct the sentence. **(2)**
9. Name the process that takes carbon dioxide out of the air, and two processes that put it back. **(2)**
10. A farmer says plants get their food from the soil, because they grow better when she adds fertiliser. Explain what the fertiliser does provide and what it does not. **(2)**

Answer guide and marking notes

1. carbon dioxide + water → glucose + oxygen (1); light (energy) and chlorophyll are needed (1). Accept "sugar" for glucose.
2. glucose + oxygen → carbon dioxide + water (1 for the reactants, 1 for the products). Accept "energy released" written on the arrow; don't penalise its absence.
3. (a) The tree's mass didn't come (mostly) from the soil (1). (b) From the air, as carbon dioxide (1). "Water and carbon dioxide" gets the mark; "water" alone does not.
4. Potato and rice (1). Table sugar isn't starch, so iodine doesn't test for it; plants make sugar and store much of it as starch (1).
5. (a) 9 minutes (1). (b) 22 minutes (1).
6. Changed: distance from the lamp / light intensity (1). Kept the same: any one of type of leaf, number of discs, solution, depth, lamp, temperature (1).
7. X: blue (1). Y: more yellow (1).
8. Photosynthesis happens only in the light (1), but respiration happens all the time, day and night (1).
9. Photosynthesis (1); any two of respiration, decomposition, burning/combustion (1 for both).

10. Fertiliser provides minerals (such as nitrogen) that plants need in small amounts (1). It does not provide energy or most of the plant's mass; plants make their own food (glucose) by photosynthesis (1).

Closing (5 min)

Students write one sentence answering the question from Lesson 1: "Where did the tree come from?" Compare it with their sticky note from the first lesson.

Vocabulary

carbon cycle, combustion, decomposition, fossil fuel, carbon store, fertiliser, minerals

Differentiation

- **Support:** read the unit check aloud; give a word bank (photosynthesis, respiration, glucose, oxygen, carbon dioxide, water, light, chlorophyll); allow the class carbon-cycle diagram to stay on display.
- **Stretch:** "Burning wood and respiration both release carbon dioxide from glucose-based material. How are they alike and different?" (Both use oxygen and give out carbon dioxide and water, releasing energy. Burning is fast, hot and uncontrolled; respiration is slow, controlled and happens inside cells.)

⚠ Safety

- No practical work in this lesson. Dispose of the Lesson 4 pondweed in general waste, never in drains, ponds or streams.

Teacher notes and common misconceptions

- Students may think "only plants are in the carbon cycle". Every respiring organism is part of it.
- Avoid saying that trees "clean" the air in the sense of removing pollution; the point here is carbon dioxide and oxygen.
- Climate change links are a natural next step, but this unit keeps to the processes. Handle the topic with care; some students find it worrying.

Grade 8 Science — Acids, alkalis and indicators: reading the colour of a liquid

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (an AI agent) on 2026-11-04. No teacher has checked it yet. Read it fully, adapt it to your class and local rules, and test any practical work yourself before using it with students.

Back to all units

Big idea

Many liquids are acidic, alkaline or neutral, and we cannot tell which by looking. An indicator is a dye that changes colour depending on how acidic or alkaline a liquid is, so it lets us "read" a liquid safely without tasting or touching it. The pH scale (usually 0 to 14) puts this on a number line: below 7 is acidic, 7 is neutral, above 7 is alkaline. When an acid and an alkali are mixed in the right amounts they cancel each other out (neutralisation), making a salt and water. People use this every day, from indigestion tablets to farmers adding lime to sour soil.

Outcomes

By the end of the unit, students can:

1. Make a red cabbage indicator and use it to sort everyday liquids into acidic, neutral and alkaline, recording colours in a table.
2. Place liquids on the pH scale using universal indicator, and explain that below 7 is acidic, 7 is neutral and above 7 is alkaline.
3. Write the word equation acid + alkali → salt + water, and explain that adding a carbonate or hydrogencarbonate (such as baking soda) to an acid also gives off carbon dioxide.
4. Carry out a repeated, fair comparison of how much alkali is needed to neutralise two acids, and use the median of repeats.
5. Explain two real uses of neutralisation (antacids for indigestion; lime for acidic soil) and what "ocean acidification" does and does not mean.
6. Correct the common ideas that "all acids burn", "alkalis are safe", "neutral means no chemicals" and "an indicator turns a liquid into an acid".

Prior knowledge

- Some substances dissolve to make solutions; mixtures can be separated; some changes make new materials, and a gas given off is a sign of this (grade 5).
- Bromothymol blue changes colour when carbon dioxide dissolves in water (grade 7).
- Fair tests: change one thing, keep the rest the same, repeat, use the median (grades 3–7).

Lessons (about 50 minutes each)

#	Lesson	Practical?
1	Can you tell by looking? Making a red cabbage indicator	Make indicator; test 8 liquids
2	The pH scale and universal indicator	Universal indicator paper; rank liquids

#	Lesson	Practical?
3	Cancelling out: neutralisation by drops	Count drops of baking soda solution to neutralise vinegar and lemon juice
4	Neutralisation at work: stomachs, soils and seas	Test soil samples; antacid demonstration; ocean pH data
5	Acids and alkalis in the world + unit check	Discussion and written assessment

Materials (whole unit)

- Eye protection for everyone in every practical lesson.
- Lesson 1: red cabbage (about a quarter of a head per class); a kettle (teacher only); a heatproof jug; a sieve; clear plastic cups or spotting tiles; droppers; labelled test liquids (see lesson 1): lemon juice, white vinegar, fizzy (carbonated) water, tap water, salt solution, baking soda (sodium hydrogencarbonate) solution, milk of magnesia, and washing soda (sodium carbonate) solution made up dilute by the teacher.
- Lesson 2: universal indicator paper and its colour chart (or universal indicator solution); the same liquids; tweezers or glass rods.
- Lesson 3: cabbage indicator; white vinegar; lemon juice; baking soda solution (1 level teaspoon in 100 ml water, made up fresh); 10 ml plastic syringes or measuring cylinders; droppers; white tiles.
- Lesson 4: three soil samples (for example garden soil, a peat-free compost and soil from under conifers, or whatever is available); distilled or deionised water; filter paper and funnels; universal indicator paper; one antacid tablet or milk of magnesia (teacher demonstration only).
- Student record sheets (tables are given in each lesson).

Assessment

- Ongoing: closing check questions at the end of each lesson (answers included).
- Lesson 3: the results table, medians and conclusion are a practical skills task.
- Lesson 5: a 10-question unit check (20 marks) with an answer guide and marking notes.

Sources

These are general references that a teacher can use to check facts. Links were checked to load on 2026-11-04.

- Wikipedia, "PH": https://en.wikipedia.org/wiki/PH
- Wikipedia, "Acid": https://en.wikipedia.org/wiki/Acid
- Wikipedia, "Base (chemistry)": https://en.wikipedia.org/wiki/Base_(chemistry)
- Wikipedia, "Alkali": https://en.wikipedia.org/wiki/Alkali
- Wikipedia, "PH indicator": https://en.wikipedia.org/wiki/PH_indicator
- Wikipedia, "Universal indicator": https://en.wikipedia.org/wiki/Universal_indicator
- Wikipedia, "Litmus": https://en.wikipedia.org/wiki/Litmus
- Wikipedia, "Phenolphthalein": https://en.wikipedia.org/wiki/Phenolphthalein
- Wikipedia, "Red cabbage" (pH indicator section): https://en.wikipedia.org/wiki/Red_cabbage
- Wikipedia, "Anthocyanin": https://en.wikipedia.org/wiki/Anthocyanin
- Wikipedia, "Neutralization (chemistry)": https://en.wikipedia.org/wiki/Neutralization_(chemistry)
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- Wikipedia, "Sodium hydroxide": https://en.wikipedia.org/wiki/Sodium_hydroxide
- Wikipedia, "Magnesium hydroxide": https://en.wikipedia.org/wiki/Magnesium_hydroxide
- Wikipedia, "Antacid": https://en.wikipedia.org/wiki/Antacid
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- Wikipedia, "Vinegar": https://en.wikipedia.org/wiki/Vinegar
- Wikipedia, "Soil pH": https://en.wikipedia.org/wiki/Soil_pH
- Wikipedia, "Ocean acidification": https://en.wikipedia.org/wiki/Ocean_acidification
- Wikipedia, "Acid rain": https://en.wikipedia.org/wiki/Acid_rain

Known gaps and cautions

- **Not reviewed** by a teacher or a science technician. Check every practical against your school's or region's chemical safety guidance before use.
- **Only household-strength chemicals** are used by students. Laboratory acids and alkalis (such as hydrochloric acid or sodium hydroxide solution) are left out on purpose; a teacher who wants them should follow local guidance for concentrations.
- **Colours vary.** Red cabbage colours depend on the cabbage, the water and how strong the extract is. Test every liquid yourself the day before and use your own results as the answer key. The colours given here are typical, not guaranteed.
- **Tap water varies** from place to place and may not read exactly 7.
- **Simplifications:** "acid + alkali → salt + water" is taught as a word equation only. Hydrogen ions, the logarithmic pH scale (one pH step is a tenfold change) and weak versus strong acids are introduced only as stretch ideas and are covered properly in grades 9–10.
- The ocean pH figures (about 8.15 in 1950 to about 8.05 now) come from Wikipedia's "Ocean acidification" article; check a current scientific source before quoting them as exact.

Lesson 1 — Can you tell by looking? Making a red cabbage indicator

Back to unit

Goal

Students see that acidic, neutral and alkaline liquids can look the same, make a natural indicator from red cabbage, and use it to sort eight everyday liquids into three groups.

Materials

- Eye protection for everyone.
- Red cabbage extract, made by the teacher before the lesson or as a demonstration: chop about a quarter of a red cabbage, cover it with just-boiled water from a kettle in a heatproof jug, leave 10–15 minutes until the water is deep purple, then sieve and cool. Store covered in a fridge for up to two days.
- Per group: 8 clear cups or a spotting tile, a dropper of cabbage extract, a white sheet of paper underneath, a record table.
- Eight labelled liquids, about 20 ml each per group:
- A lemon juice
- B white vinegar
- C fizzy (carbonated) water, freshly opened
- D tap water
- E salt solution (1 teaspoon table salt in 100 ml water)
- F baking soda solution (1 teaspoon sodium hydrogencarbonate in 100 ml water)
- G milk of magnesia (shake well, then dilute 1 part to 4 parts water)
- H washing soda solution (made up dilute by the teacher: 1 teaspoon sodium carbonate in 200 ml water)

Steps

✎ Opening (5 min)

Hold up two cups of clear liquid: one of tap water and one of white vinegar diluted to look the same. Ask: "Which one is safe to drink? How could we find out without tasting or touching?" Take ideas. Establish the rule for the whole unit: **in science we never taste or touch unknown liquids.** We need a safe way to "read" a liquid.

✎ Main activity (30 min)

1. **The cabbage changes colour (teacher demo, 5 min).** Pour a little purple cabbage extract into three cups. Add a few drops of vinegar to one (it turns pink-red) and a pinch of baking soda to another (it turns blue-green). Leave the third alone. Ask: "What made the colour change? Did the cabbage turn the vinegar into something else?" Explain: the cabbage contains a coloured pigment (an anthocyanin) that is one colour

in acidic liquids, another in neutral ones and others in alkaline ones. A dye like this is called an **indicator**.
2. **Predict (5 min).** Groups look at the eight liquids and predict each one: acid, neutral or alkali. They write predictions in pen before testing.
3. **Test (15 min).** Put about 1 cm of each liquid in a cup (or a few drops in a spotting tile well). Add 5 drops of cabbage extract. Swirl. Record the colour against the white paper.

Liquid	Prediction	Colour with cabbage	Group (acid / neutral / alkali)
A lemon juice			
B vinegar			
C fizzy water			
D tap water			
E salt solution			
F baking soda			
G milk of magnesia			
H washing soda			

1. **Build the colour key (5 min).** As a class, line the cups up from red through purple to green-yellow. The typical pattern:
2. **red / pink / magenta** = acidic (lemon juice, vinegar; fizzy water is usually a paler pink-purple)
3. **purple** = about neutral (salt solution; tap water is usually purple or close to it)
4. **blue / green** = alkaline (baking soda, milk of magnesia)
5. **green-yellow** = more strongly alkaline (washing soda)

Teacher: use your own results from testing the day before. Colours vary with the cabbage and water.

✓ Discussion questions (10 min)

1. **Were any of your predictions wrong? Which ones surprised you?** Example answer: "We thought fizzy water would be neutral because it's just water, but it went pinkish so it's slightly acidic." (Carbon dioxide dissolves in water and makes it slightly acidic — the same idea as the bromothymol blue tubes in grade 7.)
2. **Salt solution and tap water look the same as vinegar. Why can't we use our eyes?** Example answer: "Acids and alkalis are often colourless; you can only tell with a test."
3. **Is lemon juice dangerous? Is washing soda safe?** Example answer: "Lemon juice is an acid but we eat it, so not all acids are dangerous. Washing soda is an alkali and it can hurt your eyes and skin, so alkalis are not automatically safe." (Strength and concentration matter more than the label "acid" or "alkali".)
4. **Did the cabbage turn the vinegar into an acid?** Example answer: "No. The vinegar was already an acid. The cabbage just shows it by changing colour."

✓ Closing check (5 min, answers below)

1. What is an indicator?

2. A liquid turns cabbage indicator green. Is it acidic, neutral or alkaline?
3. Name one acidic and one alkaline liquid from today.

Answers: 1. A substance (often a dye) that changes colour depending on whether a liquid is acidic, neutral or alkaline. 2. Alkaline. 3. Acidic: lemon juice, vinegar or fizzy water. Alkaline: baking soda solution, milk of magnesia or washing soda solution.

Vocabulary

acid, alkali, neutral, indicator, pigment, anthocyanin, prediction

Differentiation

- **Support:** give a printed colour strip (red → purple → green → yellow) with "acid", "neutral" and "alkali" labels to match against. Reduce to five liquids (A, B, D, F, H).
- **Stretch:** try other coloured plant juices the teacher has prepared (for example blueberry juice) and compare them with cabbage. Blueberry juice also turns redder with acid and more blue-violet with alkali. Which indicator shows the difference more clearly?

⚠ Safety

- Eye protection on throughout. If anything goes in an eye, rinse with plenty of clean water and tell the teacher.
- **Never taste** any liquid in the lab, even ones that are food at home.
- The teacher handles the kettle and hot water. Let the extract cool before students use it.
- Washing soda solution is an irritant: the teacher makes it up dilute, students wear eye protection, and spills are wiped up straight away. Wash hands after the lesson.
- **Never use bleach, oven cleaner or drain cleaner** in this lesson. Drain cleaners often contain sodium hydroxide, which is highly corrosive. Never mix household cleaning products.
- Cabbage extract stains clothes and benches; use trays.

Teacher notes and misconceptions

- **"All acids burn."** Many acids are weak or dilute and are in food (citric acid in lemons, acetic acid in vinegar). Strong, concentrated acids are dangerous.
- **"Alkalis are safe because they're not acids."** Strong alkalis such as sodium hydroxide are as dangerous as strong acids.
- **"Neutral means no chemicals in it."** Salt solution is neutral and is full of dissolved salt. Neutral describes acidity, not purity.
- **"The indicator makes the liquid acidic."** The indicator only shows what is already there.
- Fizzy water loses its carbon dioxide once opened, so it may drift towards purple over a lesson. Open it just before use.
- Milk of magnesia is cloudy; let it settle a moment and look at the colour of the liquid above, or dilute it more.

Lesson 2 — The pH scale and universal indicator

Back to unit

Goal

Students use universal indicator to give liquids a pH number, place them on the 0–14 scale, and compare three indicators (cabbage, litmus, universal indicator) to see what each can and cannot tell us.

Materials

- Eye protection for everyone.
- Per group: universal indicator paper cut into 1 cm strips (or universal indicator solution and a spotting tile), the colour chart supplied with it, tweezers or a glass rod, a white tile.
- Red and blue litmus paper (a few strips per group).
- The eight liquids from lesson 1 (A–H), freshly poured.
- A long paper strip or masking tape line across the board, marked 0 to 14.
- "pH cards" for the closing sort (see Main activity part 4).

Steps

✎ Opening (5 min)

Show last lesson's cabbage results. Ask: "Lemon juice and fizzy water were both 'acid'. Are they equally acidic? How could we tell?" Take ideas. Explain that scientists use a number scale, the **pH scale**, which usually runs from 0 to 14:

- below 7 = **acidic** (the lower the number, the more acidic)
- 7 = **neutral** (pure water at room temperature)
- above 7 = **alkaline** (the higher the number, the more alkaline)

✎ Main activity (30 min)

1. **Universal indicator (15 min).** Universal indicator is a mixture of several indicators, so it changes through many colours instead of two or three. Show the colour chart: red, orange and yellow mean acidic; green means neutral; blue and violet mean alkaline. For each liquid, dip a rod in and touch it onto a fresh strip of paper (or add 2 drops of indicator solution to a few drops of liquid). Match the colour to the chart **within 30 seconds** and record the pH number.

Liquid	Cabbage group (lesson 1)	Universal indicator colour	pH (from chart)
A lemon juice			
B vinegar			
C fizzy water			

Liquid	Cabbage group (lesson 1)	Universal indicator colour	pH (from chart)
D tap water			
E salt solution			
F baking soda			
G milk of magnesia			
H washing soda			

1. **Line them up (5 min).** Each group sends one person to stick a label for each liquid on the class 0–14 line. Discuss disagreements: "Why might two groups get different numbers for the same liquid?" (Reading colours is a judgement; strips can be left too long; liquids were poured at different times.) Agree a class value for each liquid and mark ranges where groups disagree.
2. **Litmus: a yes/no indicator (5 min).** Give red and blue litmus paper. Students test lemon juice, salt solution and baking soda solution. Blue litmus turns red in acid; red litmus turns blue in alkali; in a neutral liquid neither changes much. Ask: "What can universal indicator tell you that litmus can't?" (How acidic or alkaline: a number, not just acid or alkali.)
3. **pH cards (5 min).** Groups place these cards on the class line. The values are typical figures from reference sources:
4. pure water: 7
5. human blood: about 7.4 (slightly alkaline)
6. seawater: about 8.05 (slightly alkaline)
7. most drinking water: between 6.5 and 8.5
8. acid rain: on average about 4 to 5
9. citrus fruit and vinegar: below 4.6

✓ Discussion questions (10 min)

1. **Which indicator would you choose to check whether a swimming pool is slightly too acidic, and why?** Example answer: "Universal indicator, because it gives a number. Litmus would only say acid or not."
2. **Blood is about 7.4. Is blood acidic, neutral or alkaline?** Example answer: "Slightly alkaline, because it's just above 7."
3. **Acid rain has a pH of about 4 to 5. Why might that harm a lake?** Example answer: "It makes the lake water more acidic than normal, and the living things there are used to water around neutral." (Acid rain is linked to harm to fish, forests and soils.)
4. **Some indicators have only two colours (litmus; phenolphthalein, which is colourless in acid and pink in alkali). Why might a scientist still use them?** Example answer: "When you only need to know if you've gone past a certain point, like when an acid has been neutralised, a sharp change from one colour to another is easier to see."

✓ Closing check (5 min, answers below)

1. A liquid has pH 3. Another has pH 6. Which is more acidic?
2. What colour would universal indicator turn in a neutral liquid?

3. Give one advantage of universal indicator over litmus.

Answers: 1. pH 3 (lower number = more acidic). 2. Green. 3. It shows how acidic or alkaline something is (a pH number), not just whether it is acidic or alkaline.

Vocabulary

pH, pH scale, universal indicator, litmus, phenolphthalein, colour chart, range

Differentiation

- **Support:** give a pre-printed 0–14 line coloured like the universal indicator chart, with "acid", "neutral" and "alkali" bands. Students stick small coloured dots for each liquid.
- **Stretch:** the pH scale is not like a ruler. Each step of 1 means a **tenfold** change in acidity. So pH 3 is 10 times more acidic than pH 4, and 100 times more acidic than pH 5. How many times more acidic is acid rain at pH 4 than water at pH 6? (100 times.) This is a simplified introduction; the reason (hydrogen ion concentration and logarithms) comes in later grades.

⚠ Safety

- Eye protection on throughout.
- Never taste the liquids. Universal indicator solution is often made in alcohol, which is flammable: keep it away from flames.
- Universal indicator and cabbage stain skin; use tweezers or a rod, not fingers. Wash hands at the end.
- Dispose of used strips in the bin, not the sink.

Teacher notes and misconceptions

- **"pH 7 always means water."** pH 7 means neutral; salt solution is also about 7.
- **"A higher pH number means more acid."** It is the opposite. Many students think "higher = more". Use the line repeatedly.
- **"The pH scale stops at 0 and 14."** It is usually drawn from 0 to 14, but very concentrated strong acids and alkalis can go beyond it. Mention only if students ask.
- Universal indicator paper keeps changing colour if left; reading quickly matters.
- Tap water results vary by area. Accept your own measured value.

Lesson 3 — Cancelling out: neutralisation by drops

Back to unit

Goal

Students neutralise an acid by adding an alkaline solution drop by drop, watching the indicator change, and carry out a repeated, fair comparison of two acids (vinegar and lemon juice) using the median number of drops.

Materials

- Eye protection for everyone.
- Per group: two clear cups or small beakers; a white tile or paper underneath; two 10 ml plastic syringes (no needles) or small measuring cylinders; one dropper used only for the baking soda solution; cabbage indicator from lesson 1; a stirring rod or spoon; a record table.
- White vinegar and lemon juice (bottled lemon juice gives more consistent results than fresh lemons).
- Baking soda solution: 1 level teaspoon (about 5 g) sodium hydrogencarbonate stirred into 100 ml water, made up fresh. Make one large batch for the whole class so every group uses the same solution.
- Water for diluting.

Teacher trial: do the whole method the day before. With 1 ml of acid, expect something in the region of 20–40 drops, but the number depends on your vinegar (vinegar can contain anywhere from about 4% to 18% acetic acid), your lemon juice, your teaspoon and your dropper. Adjust the acid volume so groups need roughly 15–40 drops.

Steps

✎ Opening (5 min)

Recap: acids are below 7, alkalis above 7. Ask: "What do you think happens if you mix an acid and an alkali?" Take predictions ("they explode", "they fizz", "you get something in the middle"). Tell students they will find out, and count exactly how much it takes.

✎ Main activity (30 min)

1. **Watch it happen (teacher demo, 5 min).** Put 1 ml of vinegar and 10 ml of water in a cup with 10 drops of cabbage indicator: it is pink-red. Add baking soda solution a few drops at a time, swirling. Students see:
2. **fizzing** — a gas is given off (carbon dioxide; links to grade 5's bicarbonate and vinegar balloon);
3. the colour moving from pink towards **purple** (neutral);

4. if you keep going, it turns **blue-green** (now alkaline: too much has been added).

Explain: the acid and the alkali **cancel each other out**. This is called **neutralisation**. The general word equation is:

acid + alkali → salt + water

Baking soda is a hydrogencarbonate, so here there is also a gas:

acid + hydrogencarbonate → salt + water + carbon dioxide

("Salt" is a family of substances; table salt is only one of them.)

1. **The question (2 min).** "Which needs more baking soda solution to neutralise it: 1 ml of vinegar or 1 ml of lemon juice?" Students predict and give a reason.
2. **Plan it fairly (3 min).** Ask what must stay the same: the volume of acid (1 ml, measured with a syringe), the added water (10 ml), the number of indicator drops (10), the same dropper, the same baking soda batch, and the same end point (**the first time the colour stays purple for 10 seconds after swirling**). What changes: the type of acid. What we measure: the number of drops.
3. **Do it (15 min).** Each group does **three repeats for each acid**, rinsing the cup between runs. Add one drop at a time, swirl, wait, then add the next.

Acid	Run 1 (drops)	Run 2	Run 3	Median
Vinegar				
Lemon juice				

Example results (made-up numbers to show the method, not a prediction):

Acid	Run 1	Run 2	Run 3	Median
Vinegar	31	29	30	**30**
Lemon juice	25	27	41	**27**

Point out the 41: it is far from the other two. The group probably overshot the purple and went into blue. The median (27) is not dragged up by the mistake, which is why we use it.

1. **Conclude (5 min).** Each group writes one sentence: "The ___ needed more drops of baking soda solution (median ___ drops compared with ___), so 1 ml of it contained more acid to cancel out." Compare across groups. Do all groups agree on which needs more?

✓ Discussion questions (10 min)

1. **Why do we count drops instead of just saying "a bit more"?** Example answer: "Numbers let us compare fairly and check if other groups got the same result."
2. **Why did we use the same baking soda batch and the same dropper for everyone?** Example answer: "If one group's solution was stronger or their drops were bigger, they'd need fewer drops, and it wouldn't be a fair comparison."
3. **When the mixture is purple, are there still chemicals in it?** Example answer: "Yes. There's water and a salt dissolved in it. Neutral doesn't mean empty."

4. **Where did the fizz come from, and where did it go?** Example answer: "Carbon dioxide gas was made when the baking soda reacted with the acid, and it escaped into the air."

✓ Closing check (5 min, answers below)

1. Complete: acid + alkali → _____ + _____.
2. A group's results for one acid are 18, 19 and 33 drops. What is the median, and which result is probably a mistake?
3. What colour shows that the cabbage-indicator mixture has just been neutralised?

Answers: 1. Salt + water. 2. Median 19; the 33 is probably a mistake (overshooting the end point). 3. Purple.

Vocabulary

neutralisation, salt, word equation, end point, hydrogencarbonate, carbon dioxide, median, repeat

Differentiation

- **Support:** give a step card with pictures (measure 1 ml → add 10 ml water → add 10 drops indicator → add baking soda one drop at a time → stop at purple). Do two repeats instead of three.
- **Stretch:** name the salts. Vinegar contains acetic acid, so the salt is sodium acetate; lemon juice contains mainly citric acid, so the salt is sodium citrate. Why might two acids need different amounts even if they are the same volume? (They may be different concentrations, and different acids can cancel out different amounts of alkali per molecule. This is covered properly in grades 9–10.)

⚠ Safety

- Eye protection on throughout.
- Syringes have **no needles**.
- Never taste any mixture, even though the ingredients come from a kitchen.
- Wipe spills straight away; the fizzing mixture can bubble over if baking soda is added too fast.
- Mixtures can go down the sink with plenty of water. Wash hands at the end.

Teacher notes and misconceptions

- **"Neutralisation destroys the chemicals."** It makes new substances (a salt and water, plus carbon dioxide here). Mass is not lost; the carbon dioxide escapes into the air.
- **"Acid + alkali always fizzes."** Only acids with carbonates or hydrogencarbonates give carbon dioxide. Acid + an alkali such as sodium hydroxide gives no gas.
- **"Purple means pure water."** It means neutral.

- Overshooting is the most common error: insist on one drop at a time near the end, and swirling. The colour change near neutral can be gradual; agree as a class what "purple" looks like by keeping one neutral cup (salt solution + indicator) as a reference.
- Results differ between brands of vinegar and lemon juice, so the class answer is "which needed more with our bottles", not a general rule.

Lesson 4 — Neutralisation at work: stomachs, soils and seas

Back to unit

Goal

Students measure the pH of real soil samples, watch a model of how an antacid works, and use real data to explain what "ocean acidification" means and what it does not mean.

Materials

- Eye protection for everyone.
- Three soil samples, labelled X, Y and Z, collected by the teacher (for example: garden or field soil, peat-free compost, and soil from under conifers or from a heather or rhododendron bed if available). About 2 tablespoons of each per group.
- Per group: three clear cups or jars with lids, distilled or deionised water (tap water can change the result), filter paper and a funnel (or a coffee filter), universal indicator paper and chart, a teaspoon, a record table.
- Teacher demonstration: a clear jug or large beaker, white vinegar diluted about 1 part to 10 parts water, cabbage indicator, and either one antacid tablet or 1–2 teaspoons of milk of magnesia.
- Printed ocean pH card (see part 3).

Steps

✎ Opening (5 min)

Ask: "Where outside a lab might people want to neutralise something?" Take ideas. Introduce the three places in today's lesson: **inside your stomach, in the soil, and in the sea.**

✎ Main activity (30 min)

1. **Soil pH (15 min).**
2. Put 1 heaped teaspoon of soil in a cup. Add about 50 ml of distilled water. Put the lid on and shake for 30 seconds. Leave it to settle for 5 minutes.
3. Filter the cloudy water into a clean cup (it does not have to be perfectly clear).
4. Test the liquid with universal indicator paper. Record the colour and pH.
5. Repeat for all three soils.

Soil	Where it came from	Indicator colour	pH
X			
Y			
Z			

Then share some facts about soils: - Soil pH matters because it controls which nutrients plants can take up. Most plants grow best between about **pH 5.5 and 7.5**. - Some plants prefer **acidic** soil: rhododendrons, heathers (Erica), Scots pine. Others prefer **limey (alkaline)** soil: ash trees, lilac, clematis. - Farmers and gardeners can **neutralise acidic soil** by adding lime (calcium hydroxide) or crushed limestone (calcium carbonate). Soil that is too alkaline can be made more acidic with sulfur.

Ask: "Which of our soils would suit a rhododendron? Which would a farmer want to lime?"

1. **A model of an antacid (teacher demo, 7 min).** Explain: your stomach makes acid to help digest food. Sometimes it causes discomfort (heartburn, indigestion). An **antacid** is a medicine that neutralises some of the stomach acid. Many contain an alkaline substance such as magnesium hydroxide (milk of magnesia) or a carbonate.
2. Pour the dilute vinegar into the jug and add cabbage indicator: pink-red. "This is our pretend stomach acid." (Real stomach acid is hydrochloric acid and much more acidic. Vinegar is only a safe stand-in.)
3. Crush and add the antacid tablet, or stir in the milk of magnesia. Stir and wait. The colour moves towards purple, or beyond into blue. If the tablet contains a carbonate, it fizzes.

4. Ask: "Which word equation from last lesson is this?" (acid + alkali → salt + water; with a carbonate, also carbon dioxide.)

5. **What is happening to the sea? (8 min).** Hand out the ocean pH card:

   Between 1950 and today, the average pH of the ocean surface fell from about **8.15** to about **8.05**. The main cause is carbon dioxide from human activities: some of the extra carbon dioxide in the air dissolves in the sea and makes it slightly more acidic. Seawater is **still alkaline** (above pH 8). This change is called **ocean acidification**. Animals that build shells or skeletons from calcium carbonate, such as corals and molluscs, are especially at risk.

Link to grade 7: the bromothymol blue tubes turned yellow when students breathed carbon dioxide into them. The same thing happens, very slowly, to the ocean.

Ask: "Is the sea now acidic?" (No. It is still alkaline, just less alkaline than before. "Acidification" means moving towards the acidic end, not arriving there.)

✓ Discussion questions (10 min)

1. **Why did we shake the soil with distilled water instead of tap water?** Example answer: "Tap water has its own pH, which might change the result. Distilled water doesn't add anything."
2. **A gardener's soil is pH 4.5 and her vegetables grow badly. What could she do, and why does it work?** Example answer: "Add lime. It's alkaline, so it neutralises some of the acid in the soil and raises the pH towards the 5.5 to 7.5 that most plants like."
3. **Why is vinegar only a model of stomach acid?** Example answer: "Real stomach acid is a different, stronger acid. Vinegar is safe to use in class, but it doesn't behave exactly the same."

4. **A headline says "The oceans are turning to acid." What is right and wrong about it?** Example answer: "Right: the pH is going down, so the sea is becoming more acidic. Wrong: the sea is still alkaline, above 8, not an acid."

✓ Closing check (5 min, answers below)

1. What type of substance is used to treat soil that is too acidic?
2. What does an antacid do in the stomach?
3. The ocean's surface pH went from about 8.15 to about 8.05. Did it become more acidic or more alkaline? Is it acidic now?

Answers: 1. An alkaline substance or a carbonate, such as lime or crushed limestone. 2. It neutralises some of the stomach acid. 3. More acidic (the pH went down); no, it is still alkaline (above 7).

Vocabulary

soil pH, lime, limestone, antacid, indigestion, ocean acidification, calcium carbonate, model

Differentiation

- **Support:** test two soils instead of three; give a sentence frame for the ocean question ("The pH went ___, so the sea became more ___. It is still ___ because its pH is above 7.").
- **Stretch:** the ocean's pH fell by only 0.1. Using the "each step of 1 is ten times" rule from lesson 2, a drop of 0.1 is about a 26% increase in acidity (because 10 to the power 0.1 is about 1.26). Why might a small-looking change in pH still matter to sea life? Acid rain (lesson 2) has been reduced in Europe and North America since the 1970s by laws cutting sulfur dioxide and nitrogen oxide emissions. What would cutting ocean acidification need?

⚠ Safety

- Eye protection on throughout.
- **Students do not handle antacid tablets or other medicines.** The teacher does the antacid demonstration and disposes of any leftover tablet safely. Students should never take medicine without an adult's permission.
- Wear gloves or wash hands well after handling soil. Collect soil only from places free of animal droppings, sharp objects and garden chemicals. Cover cuts.
- Never taste any of the mixtures.

Teacher notes and misconceptions

- **"Ocean acidification means the sea is acid."** The sea is still alkaline; the pH is falling.
- **"Plants all like neutral soil."** Many plants are adapted to acidic or alkaline soils; the "best" pH depends on the plant.
- **"Antacids get rid of all the acid."** They neutralise some of it; the stomach needs acid to digest food.

- Soil results depend on the soil-to-water ratio and on the soil itself. A cheap soil-testing kit from a garden centre can be used instead of indicator paper.
- If compost results look surprising, that is a good discussion point: many composts and potting mixes are deliberately adjusted by the manufacturer.

Lesson 5 — Acids and alkalis in the world + unit check

Back to unit

Goal

Students pull the unit together by sorting real-life situations, then complete a 10-question unit check (20 marks).

Materials

- A set of 10 situation cards per group (listed below).
- Three large labels per group: ACIDIC, NEUTRAL, ALKALINE, plus a fourth: NEUTRALISATION.
- Printed unit check (questions below), one per student.

Steps

✎ Opening (5 min)

Quick-fire recall: teacher calls out a colour and an indicator ("green with universal indicator", "pink with cabbage", "red litmus turns blue") and students hold up A (acid), N (neutral) or K (alkali) cards.

✎ Main activity: situation sort (15 min)

Groups place each card under ACIDIC, NEUTRAL, ALKALINE or NEUTRALISATION and write one reason on a sticky note.

1. Lemon juice in a salad dressing. (Acidic: citric acid.)
2. A bottle of drain cleaner containing sodium hydroxide. (Alkaline, and highly corrosive.)
3. Salt dissolved in pure water. (Neutral.)
4. A person takes an antacid for indigestion. (Neutralisation.)
5. Rain with a pH of 4.5 falling on a forest. (Acidic: acid rain.)
6. A farmer spreading crushed limestone on a field. (Neutralisation of acidic soil.)
7. Human blood at pH about 7.4. (Slightly alkaline.)
8. Vinegar used to pickle vegetables. (Acidic: acetic acid.)
9. Seawater at pH about 8.05. (Alkaline, though becoming less so.)
10. Baking soda added to a cake mixture with an acidic ingredient so that it fizzes and rises. (Neutralisation, giving carbon dioxide.)

Discuss: card 2 and card 1 are both "chemicals from home", but one is food and one is dangerous. What makes the difference? (Strength and concentration, not whether it is an acid or alkali.)

✓ Unit check (25 min)

Students work alone. Calculators are not needed.

Q1. What is an indicator? (2 marks)

Q2. Red cabbage indicator turns: red/pink in liquid P, purple in liquid Q, green in liquid R. Label each as acidic, neutral or alkaline. (2 marks)

Q3. Put these in order from most acidic to most alkaline: blood (pH about 7.4), lemon juice (pH about 2.2), pure water (pH 7), acid rain (pH about 4.5 to 5), washing soda solution (strongly alkaline). (2 marks)

Q4. Give one advantage of universal indicator over litmus paper. (2 marks)

Q5. Complete the word equations. (2 marks) (a) acid + alkali → _____ + _____ (b) acid + hydrogencarbonate → salt + water + _____

Q6. A group neutralised 1 ml of vinegar with baking soda solution three times. They needed 22, 24 and 37 drops. (a) What is the median? (1 mark) (b) Which result is probably a mistake, and what might have caused it? (1 mark)

Q7. In the neutralisation investigation, name two things that must be kept the same to make it a fair comparison. (2 marks)

Q8. A gardener tests her soil and finds it is pH 4.5. Most of her plants grow best between pH 5.5 and 7.5. What could she add, and why does it work? (2 marks)

Q9. A student says: "Alkalis are safe, it's acids you have to be careful with." Do you agree? Explain with an example. (2 marks)

Q10. A news article says: "Ocean acidification means the sea has become an acid." The ocean's average surface pH has fallen from about 8.15 to about 8.05. Explain what is right and what is wrong in the article. (2 marks)

Answer guide and marking notes

Q1. 1 mark: a substance that changes colour. 1 mark: depending on whether a liquid is acidic, neutral or alkaline (or depending on pH). "A colour" alone = 0.

Q2. All three correct (P acidic, Q neutral, R alkaline) = 2 marks; two correct = 1 mark.

Q3. Correct order: lemon juice, acid rain, pure water, blood, washing soda solution. 2 marks for the full order; 1 mark if only one adjacent pair is swapped. (Lemon juice at about pH 2.2 is clearly more acidic than acid rain at about 4.5 to 5. The 2.2 figure is from the Wikipedia "PH" article; real lemons vary a little.)

Q4. 1 mark: universal indicator gives a pH number / shows how acidic or alkaline. 1 mark: litmus only shows acid or alkali (or a full comparison sentence).

Q5. (a) salt + water (1 mark for both). (b) carbon dioxide (1 mark).

Q6. (a) 24. (b) 37; overshooting the end point / adding too many drops past purple / adding drops too quickly (any sensible cause).

Q7. Any two, 1 mark each: volume of acid; volume of added water; number of indicator drops; same dropper; same baking soda solution / batch; same end point colour. "The amount" without saying of what = 0.

Q8. 1 mark: lime / crushed limestone / an alkali or a carbonate. 1 mark: it neutralises some of the acid in the soil and raises the pH (towards 5.5–7.5).

Q9. 1 mark: disagree. 1 mark: an example, such as sodium hydroxide / drain cleaner is a highly corrosive alkali; or washing soda can irritate eyes and skin. Accept "it depends on strength and concentration" with an example.

Q10. 1 mark (right): the pH has fallen, so the sea has become more acidic. 1 mark (wrong): seawater is still alkaline (pH above 7, about 8), so it is not an acid.

Total: 20 marks. No pass mark is set; use the results to see which ideas need revisiting. Common gaps to look for: thinking a higher pH means more acidic (Q3); thinking neutralisation needs no measuring (Q6–Q7); thinking "acidification" means "acidic" (Q10).

Vocabulary review

acid, alkali, neutral, indicator, pH scale, universal indicator, litmus, neutralisation, salt, antacid, lime, ocean acidification

Differentiation

- **Support:** read questions aloud; provide the word bank above; allow Q3 to be done by placing labelled cards on a pH line.
- **Stretch:** add a bonus question (not marked out of 20): "Acid rain at pH 4 is how many times more acidic than water at pH 6?" (100 times.)

⚠ Safety

- No practical work in this lesson.

Teacher notes

- Card 10 (baking soda in a cake) links to the sodium bicarbonate fact that baking powder contains an acid ingredient so that the reaction happens without adding vinegar.
- Card 9's pH figure and Q10's figures come from the Wikipedia "Ocean acidification" article (see unit sources); check a current scientific source before quoting them as exact.
- If students did not get clear results in lesson 3, let them use the example data table from lesson 3 for Q6–Q7 discussion afterwards.

Grade 9 Science — Forces and Newton's laws: measuring what pushes and pulls do

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (an AI agent) on 2026-11-04. No teacher has checked it yet. Read it fully, adapt it to your class and local rules, and test any practical work yourself before using it.

Back to all units

Big idea

Forces change how things move. If the forces on an object are balanced, it keeps doing what it was doing (staying still, or moving at a steady speed in a straight line). If they are unbalanced, it speeds up, slows down or changes direction, and a bigger net force or a smaller mass gives a bigger acceleration (F = ma). Forces always come in pairs acting on two different objects. These ideas are checked here with measured data, not just stated.

Outcomes

By the end of the unit, students can:

1. Explain the difference between mass (kilograms) and weight (a force, in newtons), and calculate weight using W = mg with g about 9.8 N/kg on Earth and about 1.6 N/kg on the Moon.
2. Use a spring and a newtonmeter to collect stretch data, plot a graph and describe when extension is proportional to force (Hooke's law).
3. Draw labelled free-body diagrams, find the net force along a line, and use Newton's first law to predict whether an object's motion will change.
4. Carry out a trolley experiment, calculate acceleration from distance and time, plot acceleration against force, and explain why the line may not pass exactly through zero.
5. Explain terminal velocity using drag and weight, and test it by dropping paper cases.
6. Identify Newton's third-law force pairs and use force and time ideas to explain seat belts and crumple zones.

Prior knowledge

- Pushes and pulls start, stop and turn things; a bigger push makes things go faster or farther; rough surfaces slow things down (kindergarten).
- Magnets pull through some materials, and a pull can act without touching (grade 3).
- Fair tests, repeats and medians; plotting and reading line graphs (grades 3–8).
- Rearranging simple formulas and working with decimals (mathematics, grades 7–8).

Lessons (about 50 minutes each)

#	Lesson	Practical?
1	Mass, weight and stretching springs	Weigh masses with a newtonmeter; spring stretch graph
2		

#	Lesson	Practical?
	Balanced and unbalanced: free-body diagrams and Newton's first law	Coin-on-card demonstration; force-diagram stations
3	F = ma: the trolley experiment	Trolley pulled by hanging masses; time over 1.0 m; graph
4	Falling, drag and terminal velocity	Drop 1–4 nested paper cases from 2.0 m
5	Force pairs, car safety + unit check	Third-law demonstrations; written assessment

Materials (whole unit)

- Lesson 1: newtonmeters (0–10 N); slotted masses (100 g each, with hangers); steel springs; clamp stands with bosses and clamps, weighed down or clamped to the bench; metre rulers; eye protection; a tray or box under every hanging load.
- Lesson 2: a playing card or stiff card, a coin and a cup or beaker for each group (or one for a teacher demonstration); force-diagram station cards (given in lesson 2).
- Lesson 3: dynamics trolleys or low-friction toy cars; a smooth level runway at least 1.5 m long; a bench pulley; string; a 10 g hanger and 10 g or 20 g slotted masses; masking tape; stopwatches or phones; a box of padding or a cushion at the end of the runway; a tray under the hanging masses.
- Lesson 4: paper cupcake or muffin cases (identical, at least 4 per group); metre rulers or a tape measure; stopwatches or phones; masking tape to mark a 2.0 m drop height.
- Lesson 5: two wheeled chairs or skateboards are NOT used (see lesson 5 safety); instead balloons, string, straws and tape for a balloon rocket; two spring newtonmeters hooked together.
- Student record sheets (tables are given in each lesson).

Assessment

- Ongoing: closing check questions at the end of each lesson (answers included).
- Lesson 3: the results table, acceleration calculations, graph and conclusion are a practical skills task.
- Lesson 5: a 10-question unit check (20 marks) with an answer guide and marking notes.

Sources

These are general references that a teacher can use to check facts. Links were checked to load on 2026-11-04.

- Wikipedia, "Newton's laws of motion": https://en.wikipedia.org/wiki/Newton%27s_laws_of_motion
- Wikipedia, "Force": https://en.wikipedia.org/wiki/Force
- Wikipedia, "Net force": https://en.wikipedia.org/wiki/Net_force
- Wikipedia, "Free body diagram": https://en.wikipedia.org/wiki/Free_body_diagram
- Wikipedia, "Inertia": https://en.wikipedia.org/wiki/Inertia
- Wikipedia, "Mass versus weight": https://en.wikipedia.org/wiki/Mass_versus_weight
- Wikipedia, "Weight": https://en.wikipedia.org/wiki/Weight
- Wikipedia, "Standard gravity": https://en.wikipedia.org/wiki/Standard_gravity
- Wikipedia, "Gravity of Earth": https://en.wikipedia.org/wiki/Gravity_of_Earth
- Wikipedia, "Moon": https://en.wikipedia.org/wiki/Moon
- Wikipedia, "Newton (unit)": https://en.wikipedia.org/wiki/Newton_(unit)

- Wikipedia, "Hooke's law": https://en.wikipedia.org/wiki/Hooke%27s_law
- Wikipedia, "Spring scale": https://en.wikipedia.org/wiki/Spring_scale
- Wikipedia, "Acceleration": https://en.wikipedia.org/wiki/Acceleration
- Wikipedia, "Velocity": https://en.wikipedia.org/wiki/Velocity
- Wikipedia, "Friction": https://en.wikipedia.org/wiki/Friction
- Wikipedia, "Drag (physics)": https://en.wikipedia.org/wiki/Drag_(physics)
- Wikipedia, "Terminal velocity": https://en.wikipedia.org/wiki/Terminal_velocity
- Wikipedia, "Momentum": https://en.wikipedia.org/wiki/Momentum
- Wikipedia, "Crumple zone": https://en.wikipedia.org/wiki/Crumple_zone
- Wikipedia, "Seat belt": https://en.wikipedia.org/wiki/Seat_belt

Known gaps and cautions

- **Not reviewed** by a teacher or a science technician. Check every practical against your school's or region's safety guidance before use.
- **Example data are invented for teaching**, chosen to look like typical classroom results. They are not real measurements. Run each practical yourself first and use your own results as the answer key.
- **Hand timing is rough.** Human reaction time adds error to short times (about 1–2 s here). That is a point to discuss, not to hide; light gates, data loggers or slow-motion phone video give better times if available.
- **Simplifications:** $a = 2d/t^2$ assumes the trolley starts from rest and accelerates steadily. Momentum is mentioned only in lesson 5 to explain car safety; impulse calculations, vectors at angles and circular motion are left to later grades.
- **Facts to check before quoting as exact:** standard gravity 9.80665 m/s² ("Standard gravity"); sea-level gravity from about 9.780 m/s² at the Equator to about 9.832 m/s² at the poles ("Gravity of Earth"); Moon surface gravity 1.62 m/s², about a sixth of Earth's ("Moon"); a belly-down skydiver's terminal speed about 55 m/s ("Terminal velocity"); seat belts "reduce serious crash-related injuries and deaths by about half" (CDC summary quoted in "Seat belt").

Lesson 1 — Mass, weight and stretching springs

Back to unit

Goal

Students measure the weight of known masses, work out that each kilogram weighs about 9.8 N on Earth, and collect spring-stretch data to test whether extension is proportional to force.

Materials

- Per group: a 0–10 N newtonmeter; five 100 g slotted masses and a hanger; a steel spring; a clamp stand, boss and clamp (clamped or weighed down so it cannot tip); a metre ruler; a tray or box under the hanging load.
- Eye protection for everyone (springs can snap or fly off).

Steps

✎ Opening (5 min)

Ask: "If you travelled to the Moon, would you weigh less? Would you have less stuff in you?" Take a vote on each question. Leave the answers open; students will be able to answer by the end.

✎ Main activity part A: weighing masses (10 min)

1. Hang 100 g, then 200 g, up to 500 g, on the newtonmeter. Record the reading in newtons.
2. Fill in the table:

Mass (g)	Mass (kg)	Weight (N)	Weight ÷ mass (N/kg)
100	0.1		
200	0.2		
300	0.3		
400	0.4		
500	0.5		

1. Typical readings are close to 1 N per 100 g (a cheap newtonmeter may read 0.9–1.0 N). Weight ÷ mass should come out close to 10 N/kg. The accepted value is about 9.8 N/kg; standard gravity is defined as 9.80665 m/s².
2. Introduce **W = mg**: weight (N) = mass (kg) × gravitational field strength (N/kg). Mass is the amount of matter and is measured in kilograms; weight is a force and is measured in newtons.

✎ Main activity part B: stretching a spring (20 min)

1. Hang the spring from the clamp and measure the length of the coiled part with no load. Put the ruler upright next to it and read at eye level.
2. Add one 100 g mass (about 1 N) at a time, up to 5 N. Measure the length each time and work out the extension (new length − original length).
3. Remove the masses one at a time and check whether the spring goes back to its original length.
4. Plot extension (cm, up) against force (N, along). Example class data (invented for teaching):

Force (N)	0	1	2	3	4	5
Extension (cm)	0	2.1	3.9	6.0	8.1	10.0

1. The points lie close to a straight line through zero: each extra newton stretches the spring by about 2 cm. This is **Hooke's law**: extension is proportional to force, up to a limit. Robert Hooke stated it in 1678 as ut tensio, sic vis ("as the extension, so the force").
2. Stretch: the spring constant k = force ÷ extension = 1 N ÷ 0.02 m = 50 N/m.

✓ Discussion questions (5 min)

1. A student says "my mass is 50 newtons". What is wrong? — Mass is measured in kilograms; newtons are for forces such as weight. Their mass might be 50 kg, which would weigh about 490 N.
2. Why does a newtonmeter contain a spring? — Because the spring's extension is proportional to the force (Hooke's law), so equal steps on the scale mean equal steps of force.
3. What would happen if we kept adding masses? — Eventually the spring would stretch past its limit, stop following the straight line, and not return to its original length. (Do not test this with the class springs.)

✓ Closing check (5 min, answers)

1. A 2 kg bag of flour: what is its weight on Earth (g = 9.8 N/kg)? — **19.6 N.**
2. The Moon's surface gravity is about 1.6 N/kg (1.62 m/s², about a sixth of Earth's). What is the same bag's mass and weight on the Moon? — **Mass still 2 kg; weight about 3.2 N.**
3. Using the example spring (about 2 cm per newton), how far would it stretch with 3.5 N? — **About 7 cm.**

Vocabulary

mass, weight, newton (N), kilogram (kg), gravitational field strength, newtonmeter, extension, proportional, Hooke's law, spring constant

Differentiation

- Support: give a partly filled table and pre-drawn axes; use 1 N steps only.
- Stretch: find the spring constant from the gradient; predict the extension of two identical springs side by side (half) or end to end (double), then test.

⚠ Safety

- Eye protection on throughout part B.
- Clamp stands must be clamped or weighted so they cannot tip. Keep feet and hands out from under hanging masses; a tray or box goes underneath.
- Never stretch springs beyond 5 N in this lesson; overstretched springs can snap or fly off.

Teacher notes and common misconceptions

- "Weight and mass are the same thing." In everyday speech they are; in science, weight is the pull of gravity on a mass. Bathroom scales show kilograms but actually measure a force.
- "There is no gravity in space." Gravity gets weaker with distance but does not vanish; astronauts in orbit are falling around the Earth. Keep this short; it returns in later grades.
- Gravity varies a little over Earth's surface: from about 9.780 m/s² at the Equator to about 9.832 m/s² at the poles (Wikipedia, "Gravity of Earth"). 9.8 N/kg is fine for class work.

Lesson 2 — Balanced and unbalanced: free-body diagrams and Newton's first law

Back to unit

Goal

Students draw free-body diagrams, add forces along a line to find the net force, and use Newton's first law to predict whether an object's motion will change.

Materials

- Per group (or one teacher demonstration): a playing card or piece of stiff card, a coin, and a cup or beaker.
- Six station cards (below), printed and placed around the room.
- Mini whiteboards or paper for diagrams.

Steps

✎ Opening (5 min): the coin and card

Put the card on top of the cup and the coin on the card, over the opening. Flick the card sharply sideways. The card flies off; the coin drops into the cup. Ask: "Why didn't the coin fly off with the card?" Collect ideas. The short answer, built up in this lesson: the quick flick gives only a small, brief sideways force on the coin through friction, so the coin barely moves sideways; once the card is gone, the unbalanced force on the coin is its weight, so it falls.

✎ Main activity part A: drawing free-body diagrams (15 min)

1. Model the rules on the board:
2. Draw the object as a box or dot.
3. Draw each force as an arrow starting on the object, pointing the way the force acts, with length showing size.
4. Label each arrow with its name and size if known (for example "weight 20 N").
5. Only show forces acting **on** this object.
6. Model a book resting on a table: weight 10 N down; the table's push (normal or contact force) 10 N up. Net force = 10 N up − 10 N down = 0 N. **Balanced.**
7. Introduce **Newton's first law** (first published by Isaac Newton in the Principia, 1687): if the net force on an object is zero, it stays at rest or keeps moving at a steady speed in a straight line. Its resistance to changes in motion is called **inertia**.

✎ Main activity part B: force stations (20 min)

Groups visit the stations, draw a free-body diagram for each, find the net force, and say what happens to the motion.

Station	Situation	Forces (given on the card)	Answer: net force and motion
1	Hanging lamp at rest	weight 15 N down; cable pull 15 N up	0 N; stays at rest
2	Bike at steady speed on a flat road	forward push 40 N; air resistance + friction 40 N backward	0 N; keeps the same steady speed
3	Car pulling away	engine force 3,000 N forward; resistance 800 N backward	2,200 N forward; speeds up
4	Sledge sliding on rough snow with nobody pushing	friction 60 N backward; no forward force	60 N backward; slows down
5	Lift starting to go up	cable 9,000 N up; weight 8,000 N down	1,000 N up; speeds up upward
6	Tug-of-war (picture only, do not act it out)	team A 700 N left; team B 650 N right	50 N left; rope and teams start moving left

✓ Discussion questions (5 min)

1. Station 2: "If the bike is moving, there must be more force forward than backward." Is that right? — No. At a steady speed the forces are balanced. An unbalanced force is needed to **change** speed, not to keep moving.
2. Why does a passenger lurch forward when a bus brakes? — The brakes slow the bus, but nothing slows the passenger straight away; their body tends to keep moving at the old speed (inertia) until the seat or a seat belt pushes on them.
3. A spacecraft far from any planet switches its engines off. What happens? — It keeps moving at the same speed in a straight line; nothing is needed to keep it going.

✓ Closing check (5 min, answers)

1. A box has 30 N pushing right and 30 N pushing left. What is the net force, and what could the box be doing? — **0 N; it could be at rest or moving at a steady speed in a straight line.**
2. A skater glides with 5 N of friction backward and no forward force. What happens to her speed? — **It decreases (net force 5 N backward).**
3. Draw a free-body diagram of an apple hanging from a tree. — **Weight down, pull of the stalk up, equal lengths.**

Vocabulary

force, net force (resultant force), balanced, unbalanced, free-body diagram, normal (contact) force, friction, inertia, Newton's first law

Differentiation

- Support: give station cards with the arrows already drawn; students only add labels and the net force.

- Stretch: station 7 (extra): a parachutist just after opening the parachute (drag 1,200 N up, weight 800 N down) — net 400 N up, so she slows down while still moving downward. Ask why "force upward" does not mean "moving upward".

⚠ Safety

- The coin-and-card demonstration uses a plastic cup or a sturdy beaker on a tray; flick sideways, away from faces.
- Tug-of-war is shown as a picture only; rope pulls can cause rope burns, falls and finger injuries.

Teacher notes and common misconceptions

- "Moving things need a force to keep moving." This is the biggest misconception in the unit, and many adults hold it. Everyday objects stop because of friction and air resistance, which are forces; take those away and motion continues.
- "A book on a table has no forces on it." It has at least two, and they are balanced.
- Students often draw forces acting **by** the object (for example the book pushing on the table) on the free-body diagram. Keep asking "is that force acting on this object?"

Lesson 3 — F = ma: the trolley experiment

Back to unit

Goal

Students change the pulling force on a trolley while keeping the total mass the same, calculate acceleration from distance and time, plot acceleration against force, and explain what the graph shows (Newton's second law, F = ma).

Materials

- Per group: a dynamics trolley (or a low-friction toy car of known mass); a smooth, level runway at least 1.5 m long; a bench pulley clamped at one end; about 1.5 m of string; a 10 g hanger and enough 10 g slotted masses to make 80 g in total; masking tape; a stopwatch or phone; a box of padding or a cushion at the pulley end; a tray under the hanging masses.
- Kitchen or lab scales to find the trolley's mass.
- Graph paper or a spreadsheet.

Steps

✎ Opening (5 min)

Recall station 3 from lesson 2 (the car pulling away). Ask: "If we double the unbalanced force, what happens to the acceleration? What if we double the mass instead?" Record predictions.

Setting up (10 min)

1. Mark a start line and a finish line **1.00 m** apart on the runway with tape.
2. Tie the string to the trolley, run it over the pulley and attach the hanger. The falling hanger provides the pulling force.
3. **Keep the total mass the same.** Weigh the trolley and add slotted masses on top so that trolley + everything on it + hanger = 1.0 kg in total (the example uses a trolley of about 0.92 kg plus 80 g of slotted masses and hanger). To change the force, **move** masses from the trolley to the hanger, never add new ones. This way only the force changes.
4. A hanging mass of 20 g pulls with about 0.2 N (using g ≈ 10 N/kg; with 9.8 N/kg it is 0.196 N; the difference is small compared with timing error).

✎ Main activity (20 min)

1. Hold the trolley still at the start line, release (do not push), and time it to the finish line. Do three runs at each force; record the median.
2. Calculate acceleration with **$a = 2d \div t^2$** (d = 1.00 m, starting from rest).
3. Example results (invented for teaching, total mass 1.0 kg):

Pulling force (N)	Run 1 (s)	Run 2 (s)	Run 3 (s)	Median t (s)	a = 2 × 1.00 ÷ t² (m/s²)
0.2	3.6	3.8	3.5	3.6	0.154
0.4	2.4	2.3	2.9	2.4	0.347
0.6	1.9	1.9	2.0	1.9	0.554
0.8	1.6	1.5	1.6	1.6	0.781

1. Plot acceleration (up) against force (along) and draw a line of best fit.

✓ Discussion questions (10 min)

1. What pattern does the graph show? — A straight line: equal increases in force give equal increases in acceleration. Acceleration is proportional to the unbalanced force (for a fixed mass).
2. Why does the line not go exactly through zero? — Friction. Some of the pulling force is used up balancing friction, so the line crosses the force axis a little above zero (in the example, about 0.06 N). The net force is the pull minus friction.
3. The gradient of the example line is about 1.05 m/s² per newton. What does that tell you? — Gradient = a ÷ F = 1 ÷ m, so the mass is about 1 ÷ 1.05 ≈ 0.96 kg, close to the 1.0 kg used.
4. At 0.4 N, run 3 took 2.9 s. What should we do with it? — Use the median (2.4 s), which is not pulled off by one odd run; it was probably a late start or slow stop of the stopwatch.

Introduce **Newton's second law**: F = ma, where F is the net (unbalanced) force in newtons, m the mass in kilograms and a the acceleration in m/s². One newton is the force that gives a 1 kg mass an acceleration of 1 m/s² (1 N = 1 kg·m/s²).

✓ Closing check (5 min, answers)

1. What net force gives a 1,200 kg car an acceleration of 2 m/s²? — **2,400 N.**
2. A 0.5 kg trolley has a net force of 1.5 N. What is its acceleration? — **3 m/s².**
3. Why did we move masses from the trolley to the hanger instead of adding new ones? — **To keep the total mass constant so that only the force changed (a fair test).**

Vocabulary

acceleration, velocity, net force, Newton's second law, gradient, line of best fit, median, friction, reaction time

Differentiation

- Support: give the a = 2d ÷ t² calculations for one row worked out; students complete the rest with a calculator.
- Stretch: keep the force at 0.4 N and change the total mass (add masses to the trolley: 1.0, 1.5, 2.0 kg). Predict, then test, that doubling the mass halves the acceleration. Plot a against 1/m.

⚠ Safety

- Padding or a cushion at the pulley end so the trolley does not fly off the bench; a second student catches it.
- A tray under the hanger; keep feet out from under falling masses.
- Runways on benches, not on the floor where people walk.

Teacher notes and common misconceptions

- "A bigger force means a bigger speed." It means a bigger **acceleration**: the speed keeps increasing for as long as the net force acts.
- Hand timing over 1.5–4 s has an error of roughly 0.1–0.3 s; ask students to estimate how much that changes a. Light gates, a data logger, or counting frames in slow-motion phone video make good upgrades.
- Some trolleys have a friction-compensation trick: tilt the runway very slightly until the trolley, given a small push, rolls at a steady speed. This makes the line pass much closer to zero. It is a good stretch discussion of "balancing friction with a component of weight", which is beyond this unit.

Lesson 4 — Falling, drag and terminal velocity

Back to unit

Goal

Students explain why falling objects stop speeding up (terminal velocity) using drag and weight, and test how the terminal speed of paper cases depends on their weight.

Materials

- Per group: at least 4 identical paper cupcake or muffin cases; a metre ruler or tape measure; masking tape; a stopwatch or phone.
- A marked drop height of **2.0 m** (tape on a wall or door frame). Many students cannot reach 2.0 m standing on the floor. Use a step stool only if your school allows it, with an adult holding it; otherwise use a lower height that everyone can reach standing (for example 1.5 m), mark it, and use that height instead of 2.0 m in the speed calculation (speed = drop height ÷ time).

Steps

✎ Opening (5 min)

Hold a flat sheet of paper and a crumpled sheet of the same size. Ask which will land first, then drop them together. Then drop a book and a flat sheet with the sheet resting on top of the book (they fall together). Ask: "If the paper isn't lighter than it was a moment ago, why did it fall more slowly on its own?" The answer is **air resistance (drag)**, a force that acts against motion through air or water.

Explaining terminal velocity (10 min)

Draw four free-body diagrams for a skydiver:

1. **Just after jumping:** weight large, drag almost zero → net force down → speeds up.
2. **Falling faster:** drag grows as speed grows (at these speeds, roughly with the square of the speed) → net force down but smaller → still speeds up, but less each second.
3. **Terminal velocity:** drag = weight → net force zero → no acceleration; falls at a steady speed. For a belly-down skydiver this is about 55 m/s (Wikipedia, "Terminal velocity").
4. **Parachute opens:** drag suddenly much bigger than weight → net force **up** → slows down (while still moving down) until a new, lower terminal velocity is reached.

✎ Main activity (20 min)

1. Drop one paper case, open side up, from 2.0 m. Time the fall. Three drops; take the median.

2. Repeat with 2, 3 and 4 cases nested together (same shape and size, so the drag at a given speed is about the same, but the weight doubles, triples, quadruples).
3. Paper cases reach terminal velocity very quickly, so the average speed over 2.0 m is close to the terminal speed: **speed ≈ 2.0 m ÷ time**.
4. Example results (invented for teaching):

Cases	Median time (s)	Speed = 2.0 ÷ t (m/s)
1	1.9	1.05
2	1.4	1.43
3	1.15	1.74
4	1.0	2.00

1. Plot speed against number of cases.

✓ Discussion questions (10 min)

1. Does doubling the weight double the terminal speed? — No. In the example, 2 cases fall about 1.4 times as fast as 1, not 2 times. Heavier cases need a bigger drag force to balance them, and drag rises steeply with speed, so a modest rise in speed is enough.
2. Stretch: if drag grows with the square of speed, how much faster should 4 cases fall than 1? — Weight is 4 times bigger, so drag must be 4 times bigger at terminal velocity; speed² must be 4 times bigger, so speed doubles. Example: 1.05 × 2 = 2.1 m/s, close to the measured 2.0 m/s.
3. Why are these times hard to measure well? — They are short (1–2 s), so a reaction time of about 0.1–0.2 s at each end is a big fraction. Repeats and medians help; slow-motion video helps more.
4. Where else does drag matter? — Cyclists crouching, streamlined cars, fish and birds, parachutes, and drag in water when swimming.

✓ Closing check (5 min, answers)

1. A skydiver is falling at a steady speed. Compare the drag and her weight. — **They are equal (balanced); net force zero.**
2. Her parachute opens. Which way is the net force just afterwards, and what happens to her speed? — **Upward; she slows down (but keeps moving downward).**
3. Why does a feather fall more slowly than a hammer on Earth but not on the Moon? — **On Earth air resistance on the feather is large compared with its weight; the Moon has almost no air, so there is no drag and both fall together.**

Vocabulary

air resistance, drag, terminal velocity, streamlined, average speed, reaction time

Differentiation

- Support: give the speed column worked out for one row; focus on the four skydiver diagrams.

- Stretch: test the square relationship by plotting speed² against number of cases (it should be roughly a straight line through zero).

⚠ Safety

- Use a step stool only if your school allows it, with an adult holding it; never stand on chairs or desks. Otherwise reduce the drop height.
- Keep the drop zone clear of people walking past.

Teacher notes and common misconceptions

- "Heavier things always fall faster." Without air, all objects fall with the same acceleration. With air, a heavier object of the **same shape** reaches a higher terminal speed, which is what the paper cases show.
- "At terminal velocity there are no forces." There are two large forces, balanced.
- "When the parachute opens, the skydiver goes up." Video taken from a falling camera can look like this; in fact she slows down, and the camera keeps falling faster.
- Drag growing with the square of speed is a simplification that fits these speeds reasonably well (Wikipedia, "Drag (physics)").

Lesson 5 — Force pairs, car safety + unit check

Back to unit

Goal

Students identify Newton's third-law force pairs, use force and time ideas to explain seat belts and crumple zones, and complete the unit check.

Materials

- Two spring newtonmeters hooked together (one per pair of students).
- Balloon rocket: a long balloon, a drinking straw, about 5 m of smooth string tied tight across the room, tape.
- Unit check sheets.

Steps

✎ Opening (5 min): two newtonmeters

Pairs hook two newtonmeters together and pull gently in opposite directions. Whatever one reads, the other reads the same, even when one student "tries harder". Introduce **Newton's third law**: when object A pushes or pulls on object B, B pushes or pulls on A with a force of the same size in the opposite direction. The two forces act on **different** objects, so they never cancel each other out.

✎ Main activity part A: finding the pairs (10 min)

Teacher demonstration: the balloon rocket. Thread the straw on the string, tape the blown-up (not tied) balloon to the straw, and let go. The balloon pushes air backward; the air pushes the balloon forward.

Students write the partner force for each:

Force	Its third-law partner
Your foot pushes the ground backward as you walk	The ground pushes your foot forward
The Earth pulls an apple down (its weight)	The apple pulls the Earth up, with the same size of force
A swimmer's hands push water backward	The water pushes the swimmer forward
A rocket pushes hot gas downward	The gas pushes the rocket upward

Point out: a book on a table has weight (Earth pulls book) and the table's push (table pushes book). These are equal and opposite but are **not** a third-law pair: both act on the book, and

they are different kinds of force. Its third-law partners are "book pulls Earth" and "book pushes table".

✎ Main activity part B: why seat belts and crumple zones work (10 min)

1. In a crash the car and passengers must lose all their speed. From F = ma, the force on a passenger depends on how quickly they slow down: stopping in a longer time means a smaller acceleration and so a smaller force.
2. **Crumple zones** are parts of a car (usually the front) designed to crush in a controlled way, increasing the time over which the car's speed changes in a collision (Wikipedia, "Crumple zone").
3. **Seat belts** hold the passenger to the car so they slow down with it, instead of continuing forward (first law) and hitting the dashboard or windscreen over a much shorter time. A CDC summary quoted on Wikipedia's "Seat belt" page says seat belts "reduce serious crash-related injuries and deaths by about half".
4. Worked comparison (invented numbers): a 60 kg passenger slows from 15 m/s to 0. If this takes 0.1 s, a = 150 m/s² and F = 60 × 150 = 9,000 N. If a crumple zone and belt stretch it to 0.5 s, a = 30 m/s² and F = 1,800 N, five times smaller.

✓ Unit check (25 min)

10 questions, 20 marks. Use g = 10 N/kg unless told otherwise.

1. A rock has a mass of 3 kg. (a) What is its weight on Earth? (b) What is its mass on the Moon? (2 marks)
2. Explain the difference between mass and weight. (2 marks)
3. A spring stretches 4 cm with 2 N. How far will it stretch with 5 N, assuming it obeys Hooke's law? (2 marks)
4. A cyclist moves at a steady speed with a forward force of 50 N. What is the total backward force? Explain. (2 marks)
5. A 1,000 kg car has an engine force of 2,500 N and resistance of 500 N. (a) What is the net force? (b) What is its acceleration? (2 marks)
6. In a trolley experiment, the repeat times were 2.2 s, 2.3 s and 3.0 s. What value should be used, and why? (2 marks)
7. A trolley experiment gave a straight-line graph of acceleration against force that crossed the force axis at 0.1 N instead of 0. Suggest why. (2 marks)
8. Describe what happens to the forces and the speed of a skydiver from jumping until she reaches terminal velocity. (2 marks)
9. Ana says "When I push on a wall, the wall doesn't push back, because it doesn't move." Is she right? Explain using Newton's third law. (2 marks)
10. Explain how a crumple zone reduces the force on passengers in a crash. (2 marks)

Answer guide and marking notes

1. (a) 30 N (1); (b) 3 kg — mass does not change (1).
2. Mass is the amount of matter, in kg, and is the same everywhere (1); weight is the force of gravity on a mass, in N, and depends on where you are (1).
3. 2 cm per newton (1), so 10 cm (1).
4. 50 N (1); at steady speed the forces are balanced / net force is zero (1).

5. (a) 2,000 N (1); (b) 2 m/s² (1). Allow (b) follow-through from a wrong (a).
6. 2.3 s (1), the median, because 3.0 s is probably a timing mistake and the median is not pulled off by one odd value (1). Accept "the mean of 2.2 and 2.3 after leaving out 3.0" for 1 mark only if a reason is given.
7. Friction (1): some of the pulling force (about 0.1 N) was used to balance friction before the trolley would accelerate (1).
8. At first weight is bigger than drag, so she speeds up (1); drag grows with speed until it equals her weight, then the net force is zero and she falls at a steady (terminal) speed (1).
9. No (1); the wall pushes back on her hand with an equal and opposite force; the wall doesn't move because other forces on it (from the ground and building) balance her push (1).
10. It crushes so the car takes longer to stop (1); a longer stopping time means a smaller acceleration, so from F = ma a smaller force on the passengers (1). Do not award the second mark for "absorbs the force" without the time idea.

There is no pass mark. Use the results to see which ideas to revisit: questions 4, 8 and 9 test the main misconceptions in the unit.

Vocabulary

Newton's third law, force pair, interaction, crumple zone, seat belt, collision

Differentiation

- Support: allow a formula sheet (W = mg, F = ma, a = 2d ÷ t²) and a calculator; read questions aloud if needed.
- Stretch: momentum = mass × velocity. Ask students to show that the passenger's change of momentum in part B is 900 kg·m/s in both cases, and that force × time = 900 in both cases too.

⚠ Safety

- The balloon rocket string is tied at head height or above, across a part of the room where nobody walks during the demonstration. Students with latex allergies do not handle balloons; use latex-free balloons.
- Do not demonstrate the third law with students on wheeled chairs or skateboards pushing each other; falls are a real risk. The newtonmeters show the same idea safely.

Teacher notes and common misconceptions

- "The bigger object pushes harder." In a collision between a truck and a car, the forces on each are equal in size; the car's occupants are hurt more because the same force gives the smaller mass a bigger acceleration.
- "Third-law pairs cancel out." They act on different objects, so they cannot cancel. Only forces on the **same** object add up to a net force.
- Weight and the normal force on a resting book are the classic false pair (see part A).

Grade 10 Science: Counting What You Can't Count — Field Sampling in Ecology (5 lessons)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (AI Village), 4 November 2026. No educator has reviewed or classroom-tested this unit. It is not aligned to any official standard. Check every safety note against your school's rules and your local fieldwork policy.

Back to the science progression

Big idea

Ecologists almost never count every living thing. They take careful samples and use them to estimate what they cannot count: how many plants are in a field, how many animals live in a wood, how varied a habitat is. An estimate is only as good as the way the sample was taken, so the method (random, repeatable, honest about its assumptions) matters as much as the arithmetic.

Outcomes

By the end of the unit a student can:

1. Explain why random sampling reduces bias, and show how a chosen ("looks interesting") sample can mislead.
2. Use quadrats with random coordinates to estimate the population density of a plant and scale it up to a whole area, with units.
3. Run a belt or line transect across an environmental gradient, record one abiotic factor alongside the plants, and describe a pattern without claiming more than the data show.
4. Estimate a population with mark-recapture (Lincoln-Petersen and Chapman), and state the assumptions the estimate depends on.
5. Calculate Simpson's index of diversity for two sites and explain why evenness, not just the number of species, affects it.

Prior knowledge

- Grade 6-8: food webs, habitats, fair tests, mean, ratio and percentages.
- Area of a rectangle; using a calculator or spreadsheet.
- Maths link: proportional reasoning (see the maths progression).

Lessons

Lesson	Title	Main activity
1	Why sample, and why randomly?	Paper "field": chosen vs random squares, compare with the true count
2	Quadrats	Estimate daisies (or another plant) on the school field
3	Transects and gradients	Plants vs light or trampling along a line

Lesson	Title	Main activity
4	Mark-recapture	Bean-bag simulation; Lincoln-Petersen and Chapman
5	Measuring diversity	Simpson's index for two sites; end-of-unit check

Materials

- Lesson 1: a printed "field" per pair (a 20 × 20 grid with dots of three colours scattered unevenly; make one with a spreadsheet or by hand), random number tables or a calculator/spreadsheet RAND function.
- Lessons 2-3: per group, a 0.5 m × 0.5 m quadrat (four 50 cm sticks or a wire frame), two 30 m tapes (or one tape plus a marked rope), clipboards, a simple plant identification sheet for your school grounds, pencils. Lesson 3 also: a light meter (or a phone light-sensor app; readings are only comparable on the same phone), and/or a ruler for vegetation height.
- Lesson 4: per group, a cloth bag or opaque tub with 150-400 dried beans (count the true total secretly), a marker pen or a small pot of a second bean colour for "marking".
- Lesson 5: lesson 2-3 data or the provided data, calculators/spreadsheets.

Assessment

- Lesson 2 calculation of density and total estimate, with units.
- Lesson 3 transect write-up: one pattern, one limitation, one next step.
- Lesson 5 end-of-unit check: 7 questions, 25 marks, with worked answers.

⚠ Safety (read before lessons 2 and 3)

- Follow your school's off-site / fieldwork policy. Work on school grounds in sight of an adult; agree boundaries and a recall signal.
- **Ticks:** in long grass and woodland edges, ticks can carry Lyme disease in many regions. Wear long trousers tucked into socks, check skin after fieldwork, and tell students (and families) how to remove a tick and when to see a doctor (see sources). Prefer mown areas in tick season.
- Allergies and stings: know students with severe allergies; carry their medication. Avoid wasps' nests and stinging plants; touch only what the task needs.
- **Do not eat or taste any plant or fungus.** Wash hands after fieldwork.
- Sun and weather: hats, water, sun cream as appropriate; cancel in storms.
- Quadrat sticks are not toys; carry them pointing down.

Ethics

The unit uses a **bean simulation** for mark-recapture. Marking real animals needs care, training and sometimes permission. If you extend to real animals (for example woodlice under logs), use gentle handling, a non-toxic mark that does not affect survival, return animals where they were found, replace logs, and keep the total time short. Leave habitats as you found them.

Sources

All checked to load on 4 November 2026.

- Wikipedia: Quadrat

- Wikipedia: Transect
- Wikipedia: Mark and recapture (Lincoln-Petersen and Chapman estimators, assumptions)
- Wikipedia: Sampling bias
- Wikipedia: Random number generation
- Wikipedia: Biodiversity
- Wikipedia: Diversity index (Simpson and Gini-Simpson; naming confusion)
- Wikipedia: Species richness
- Wikipedia: Species evenness
- Wikipedia: Abiotic component
- Wikipedia: Biotic component
- Wikipedia: Ecological succession (extension)
- Wikipedia: Tick
- Wikipedia: Lyme disease

Known gaps and cautions

- **Names of diversity indices are inconsistent** across textbooks. This unit uses "Simpson's index of diversity" for $1 - \Sigma\, n(n-1) / (N(N-1))$, which ranges from 0 (no diversity) towards 1. Some books call $\Sigma\, p^2$ "Simpson's index" and others report $1/\Sigma\, p^2$. Check which form your exam board uses.
- Confidence intervals for the estimates are not taught; lesson 2 uses the spread of quadrat counts as an informal sense of uncertainty. Grade 11-12 statistics can return to this.
- Percentage cover is mentioned but counts are used in worked examples because they are easier to check.
- Plant identification depends on your region; you need a local sheet.
- The light-sensor reading from a phone is a relative measure only.
- No images, no standards alignment, no educator review.

Lesson 1: Why sample, and why randomly?

Unit overview · Next: Lesson 2

Goal

Students estimate a total from a sample, compare chosen and random samples with the true count, and explain sampling bias.

Materials

- A printed paper "field" per pair: a 20 × 20 grid (400 squares) with about 300-500 dots in three colours (three "species"). Make the dots uneven: clumps in some corners, bare patches elsewhere. Keep the true total of each colour on the teacher's copy only.
- Random numbers: a spreadsheet `RANDBETWEEN(1,20)`, a calculator RAND key, or a printed random number table.

Steps

Opening (5 min). "How many daisies are on the school field? How could you find out without counting all of them?" Collect ideas; most will describe counting part and multiplying.

Main activity (30 min).

1. **Chosen sample.** Each pair picks 10 squares "that look typical", counts the dots in them, and works out: mean per square × 400 = estimated total.
2. **Random sample.** Each pair generates 10 random (column, row) pairs from 1-20, counts those squares and repeats the calculation.
3. Pairs write both estimates on the board. Reveal the true total.
4. Compare: are the chosen estimates scattered, or mostly too high or too low? Are the random estimates centred near the true value?
5. Optional: repeat the random sample with 30 squares. Is the spread of the class's estimates smaller?

Discussion questions (with example answers).

- Why were the chosen samples often too high? People pick squares with something in them, or avoid empty-looking ones. That is a bias: a systematic error, not just bad luck.
- Random samples still disagreed with each other. Why? Chance: with only 10 squares you might hit a clump or a bare patch. That is sampling variation, and it shrinks as samples get bigger.
- What is the difference between bias and variation? Bias pushes estimates the same way every time; variation scatters them around the true value. A bigger sample reduces variation but does not fix bias.
- Why do ecologists use random coordinates in a real field? So that nobody's choices (or the easiest spots to reach) decide where they sample.

Closing check (5 min, with answers).

1. A pair counts 10 random squares and gets a total of 18 dots. Estimate the number in the 400-square field. (Mean 1.8 per square; 1.8 × 400 = 720.)

2. Give one reason a chosen sample can be biased. (People choose squares that look interesting / full / easy to reach.)

Vocabulary

sample, population, estimate, random, bias, sampling variation

Differentiation

- Support: give the 10 random coordinates ready-made.
- Stretch: use a spreadsheet to repeat random samples of 10 and of 30 many times and plot both sets of estimates as histograms.

⚠ Safety

None beyond normal classroom rules.

Teacher notes and misconceptions

- "Random" does not mean "spread out evenly". Some random samples clump; that is fine. (Systematic sampling along a line is a different method, used in lesson 3.)
- Students may think a bigger sample always gives the right answer. Point out that a biased method stays biased however large it is.

Lesson 2: Quadrats

Unit overview · Previous: Lesson 1 · Next: Lesson 3

Goal

Students use random quadrats to estimate the density and total population of one plant species on an area of school grass.

Materials

- Per group: one 0.5 m × 0.5 m quadrat (area 0.25 m²), two tapes laid along two edges of the study area at right angles, random numbers, a clipboard and recording table, the plant identification sheet.
- Choose a target plant that is easy to recognise and count as separate plants (for example daisies, dandelions or plantain rosettes).

Steps

Opening (5 min, indoors). Recap lesson 1. Show the quadrat and work out its area together: 0.5 m × 0.5 m = 0.25 m², so 4 quadrats = 1 m².

Main activity (35 min, outdoors).

1. Lay two tapes along two edges of the study area to make axes. Measure the area of the study rectangle (for example 30 m × 20 m = 600 m²).
2. Each group generates random coordinates (for example x from 0-29, y from 0-19 metres), walks to the point, and places the quadrat's corner there. No "adjusting" the quadrat to a nicer spot.
3. Count plants of the target species whose rooted centre is inside the quadrat. Agree a rule for plants on the edge (for example count those touching the top and left sides, not the bottom and right).
4. Each group takes at least 5 quadrats; pool class data for 20-40.
5. Optional: estimate percentage cover of grass, bare ground and other plants (the quadrat can be strung into 25 small squares; each = 4%).

Worked example (put on the board back indoors).

Ten quadrat counts: 3, 0, 5, 2, 1, 4, 0, 2, 6, 1. - Total = 24; mean = 24 ÷ 10 = 2.4 plants per quadrat. - Density = 2.4 ÷ 0.25 m² = 9.6 plants per m². - Estimated population = 9.6 × 600 m² = 5,760 plants (about 5,800).

Discussion questions (with example answers).

- Why round the answer? With only 10 quadrats, the third and fourth digits are not trustworthy; "about 5,800" is honest.
- Counts ranged from 0 to 6. What does that tell you? The plants are patchy; one quadrat on its own would be a poor guide. More quadrats help.
- Would this estimate work for the whole school grounds? Only for areas like the one sampled (same mowing, shade, trampling).

- Why the edge rule? So plants on the line are not counted twice or never; it keeps the method consistent between groups.

Closing check (5 min, with answers). Eight quadrats (0.25 m² each) give 1, 3, 0, 2, 4, 2, 0, 3 dandelions; the lawn is 400 m². Estimate the population. (Total 15; mean 1.875; density 7.5 per m²; 7.5 × 400 = 3,000.)

Vocabulary

quadrat, density, percentage cover, coordinates, population estimate

Differentiation

- Support: a scaffolded table with columns count → mean → ÷ 0.25 → × area.
- Stretch: compare the estimate from the first 5 quadrats with the estimate from all class quadrats. How much did it change?

⚠ Safety

See the unit safety notes (ticks, allergies, no tasting plants, hand washing, boundaries). Carry quadrats pointing down.

Teacher notes and misconceptions

- The most common error is forgetting to convert per-quadrat to per-m² (dividing by 0.25 = multiplying by 4). Ask for units at every step.
- Some plants (grass, clover) are hard to count as individuals; that is what percentage cover is for.
- Keep the class data: lesson 5 can use it.

Lesson 3: Transects and gradients

Unit overview · Previous: Lesson 2 · Next: Lesson 4

Goal

Students sample along a line that crosses a change in conditions, record an abiotic factor with the plants, and describe a pattern carefully.

Materials

- Per group: a 20-30 m tape, a quadrat, a light meter or phone light-sensor app (same device all along the line), a ruler, plant identification sheet, recording table with one row per sampling point.
- A site with a gradient: from under a tree into open grass; across a trampled path into untrampled grass; or from a wall's shady side outwards.

Steps

Opening (5 min). "Lesson 2 asked how many. Today asks where, and why there?" Show a sketch of the site and ask what changes along the line.

Main activity (35 min, outdoors).

1. Lay the tape straight across the gradient. This is a **line transect**; placing the quadrat along it at regular points makes a **belt transect**.
2. Every 1 or 2 m (agree in advance; this is systematic, not random, sampling), place the quadrat on the same side of the tape and record:
3. which species are present (and counts or percentage cover for 2-3 common ones);
4. the abiotic factor: light reading at ground level, or for a path, the height of the grass / percentage of bare soil as a measure of trampling.
5. Take each light reading the same way: sensor flat, at the same height, not shaded by the student, all readings within a few minutes (clouds change light quickly).

Back indoors (5 min). Plot distance along the transect (x-axis) against light reading, and on the same distance axis, the count or cover of one species.

Discussion questions (with example answers).

- What pattern do you see? For example: "plantain cover was highest where the path was most trampled; grass height was lowest there."
- Does this prove trampling causes more plantain? No. It shows they go together along this line. Something else (soil compaction, moisture) could change too. An experiment or more sites would be needed.
- Why systematic points here, when lesson 1 said random? Here the question is about change along a line, so evenly spaced points make the pattern easier to see. The choice of line is still a judgement and should be described honestly.
- What could make the light readings unfair? Clouds passing, different heights, the student's own shadow, different phones.

Closing check (5 min, with answers).

1. Name one abiotic and one biotic factor you could record on a transect. (Abiotic: light, soil moisture, temperature, pH, trampling; biotic: number of a plant species, grazing marks, shading by a tree.)
2. Write one sentence describing a pattern that does not claim cause. (For example, "Where light was lower, there was less clover.")

Vocabulary

transect, gradient, abiotic, biotic, systematic sampling, correlation

Differentiation

- Support: one species only, with a ready-made table and axes.
- Stretch: repeat the transect 5 m to the side. Is the pattern the same? This is replication.

⚠ Safety

See the unit safety notes. Do not point any sensor at the Sun; do not look at the Sun.

Teacher notes and misconceptions

- Students often write "the plants need less light" for a shade-tolerant species. Prefer "this species was found more where light was lower".
- Ecological succession (bare ground to grass to scrub) can be introduced as an extension if the transect crosses a recently disturbed patch.

Lesson 4: Mark-recapture

Unit overview · Previous: Lesson 3 · Next: Lesson 5

Goal

Students estimate the size of a population that moves around, using a mark-recapture simulation, and state the assumptions behind the estimate.

Materials

- Per group: an opaque bag or tub with a secret number of dried beans (150-400; different per group; the teacher records each total), a marker pen (or a supply of beans of a second colour to swap in as "marked").
- Calculators.

Steps

Opening (5 min). "You can't put a quadrat on woodlice or fish; they move. How could you estimate how many live in a pond?" Introduce the idea: catch some, mark them, let them go, catch again later.

Main activity (30 min).

1. **First capture.** Take a scoop (or a handful) of beans without looking. Count them: this is **M**, the number marked. Mark each one (or swap each for a bean of the second colour). Return them all and mix thoroughly ("let the animals mix back into the population").
2. **Second capture.** Take a second scoop. Count the total, **C**, and how many of these are marked, **R** (recaptured).
3. **Lincoln-Petersen estimate:** $N \approx M \times C \div R$. Reasoning: the fraction marked in the second sample ($R \div C$) should be about the fraction marked in the whole population ($M \div N$).
4. **Chapman estimate** (less biased when samples are small): $N \approx (M + 1)(C + 1) \div (R + 1) - 1$.
5. Repeat steps 1-4 two more times (three rounds in all). Then the teacher reveals the true number.

Worked example. $M = 40$ marked; second sample $C = 50$, of which $R = 8$ are marked.

- Lincoln-Petersen: $40 \times 50 \div 8 = 250$.
- Chapman: $41 \times 51 \div 9 = 232.3...$, then $232.3... - 1 = 231.3...$, about 231.

Discussion questions (with example answers).

- What happens if you do not mix the beans? Marked beans stay together on top, so R is too large and the estimate is too small.
- What if $R = 0$? Lincoln-Petersen breaks (division by zero); the samples were too small. Chapman still gives a number, but it is very uncertain. Take bigger samples.
- List the assumptions for real animals. The population is closed (no births, deaths, arrivals or departures between captures); marks do not fall off; marking does not change survival or behaviour; marked animals mix fully; every animal is equally likely to be caught.

- Which assumption might fail for woodlice? For trapped mice? Woodlice may hide under the same log they were released from (poor mixing); mice may become "trap-happy" or "trap-shy", changing the chance of recapture.

Closing check (5 min, with answers). 30 snails are marked and released. Later 30 are caught and 6 are marked. Lincoln-Petersen: $30 \times 30 \div 6 = 150$. Chapman: $31 \times 31 \div 7 - 1 = 137.3 - 1 \approx 136$.

Vocabulary

mark-recapture, closed population, assumption, estimator, bias

Differentiation

- Support: a formula card with M, C and R labelled on a picture of two scoops.
- Stretch: use a spreadsheet to simulate 1,000 rounds with a known N and compare the average Lincoln-Petersen and Chapman estimates with N.

⚠ Safety

Dried beans: no eating; sweep up spills (slip risk). See README ethics notes before any work with real animals.

Teacher notes and misconceptions

- The Chapman form here is the one given in the Mark and recapture source. Both estimators assume a closed population.
- Students often mix up C and R. Use the words "caught the second time" and "recaptured (already marked)".

Lesson 5: Measuring diversity

Unit overview · Previous: Lesson 4

Goal

Students calculate Simpson's index of diversity for two sites, explain why evenness matters as well as the number of species, and complete the end-of-unit check.

Materials

- Class data from lessons 2-3 (species counts in quadrats from two areas), or the data below. Calculators or a spreadsheet.

Steps

Opening (5 min). Show two lists. Site A: 4 species. Site B: 4 species. "Which is more diverse?" Most say "the same". Then show the counts.

Species	Site A (mown lawn edge)	Site B (unmown corner)
Grass (counted as tufts)	30	12
Daisy	5	10
Clover	3	9
Plantain	2	9
Total N	**40**	**40**

Main activity (20 min).

Simpson's index of diversity used in this unit:

$D = 1 - \Sigma\, n(n-1) \div (N(N-1))$

where n is the number of individuals of each species and N is the total. D is 0 when every individual is the same species and gets closer to 1 as diversity rises.

Worked, Site A: - $n(n-1)$: $30 \times 29 = 870$; $5 \times 4 = 20$; $3 \times 2 = 6$; $2 \times 1 = 2$. Sum = 898. - $N(N-1) = 40 \times 39 = 1{,}560$. - $D = 1 - 898 \div 1{,}560 = 1 - 0.576 =$ **0.42**.

Students do Site B: $132 + 90 + 72 + 72 = 366$; $D = 1 - 366 \div 1{,}560 = 1 - 0.235 =$ **0.77**.

Then, if there is class data, compute D for the two areas sampled in lessons 2-3.

Discussion questions (with example answers).

- Both sites have four species. Why is B more diverse? B is more even: no species dominates. Picking two individuals at random from A, they are very likely both grass.
- What does D mean in words? The chance that two individuals picked at random (without replacement) are different species.
- Species richness vs evenness? Richness is the number of species; evenness is how equal their numbers are. Simpson's index combines both.

- Why might mowing lower diversity here? A guess to test, not a conclusion: frequent mowing may favour grasses that regrow from the base. We have one site of each, so we cannot separate mowing from other differences.

✓ End-of-unit check (25 marks, 20-25 min)

1. Explain the difference between bias and sampling variation, with one example of each from this unit. **(2)**
2. Six quadrats, each 0.25 m², give these counts of buttercups: 2, 5, 1, 0, 3, 1. The meadow is 250 m². Estimate the buttercup population. Show your working and units. **(4)**
3. A student's transect shows that moss cover is higher where light is lower. They write: "Shade causes moss to grow." Give two reasons this claim goes too far and one way to test it better. **(3)**
4. 60 beetles are marked and released. Later 45 are caught, of which 9 are marked. Calculate the Lincoln-Petersen and Chapman estimates. **(4)**
5. State two assumptions of mark-recapture. **(2)**
6. Calculate Simpson's index of diversity for Site C (four species, 5, 5, 5, 5 individuals) and Site D (17, 1, 1, 1). Explain the difference between them. **(8)**
7. Why can species richness alone be misleading when comparing habitats? **(2)**

Answer guide

1. Bias = a systematic error pushing estimates one way, for example choosing quadrats that look full (1). Variation = chance differences between random samples, for example two random sets of 10 squares giving different totals (1).
2. Total 12; mean 12 ÷ 6 = 2 per quadrat (1); density 2 ÷ 0.25 = 8 per m² (1); 8 × 250 = 2,000 (1); units stated (plants per m², plants) (1).
3. Any two (1 each): correlation is not causation; moisture or soil may also change with shade; only one transect / no replication; light readings may be unreliable. One test (1): repeat transects in other places, or an experiment that shades some marked patches and not others and follows moss cover.
4. Lincoln-Petersen 60 × 45 ÷ 9 = 300 (2: method 1, answer 1). Chapman 61 × 46 ÷ 10 − 1 = 280.6 − 1 = 279.6, about 280 (2: method 1, answer 1).
5. Any two (1 each): closed population (no births, deaths, migration between samples); marks not lost; marking does not affect survival or behaviour; marked individuals mix fully; equal chance of capture.
6. Site C: Σ n(n − 1) = 4 × 20 = 80 (1); N(N − 1) = 20 × 19 = 380 (1); D = 1 − 80 ÷ 380 = 0.79 (1). Site D: 17 × 16 = 272, other species 0, sum 272 (1); D = 1 − 272 ÷ 380 = 0.28 (1); correct rounding/working shown (1). Explanation (2): same richness (4 species) but C is perfectly even and D is dominated by one species, so two random individuals from D are usually the same species.
7. Two sites can have the same number of species but very different evenness (1); one dominant species with a few rare ones is less diverse in practice / more vulnerable (1). Also accept: richness depends heavily on sample size and effort.

Vocabulary

diversity, species richness, evenness, Simpson's index, dominance

Differentiation

- Support: a table with columns n, n − 1, n(n − 1) already set up.
- Stretch: compute Σ p² (with p = n ÷ N) for Sites A and B and compare with the n(n − 1) form. Why are they close but not equal? (The n(n − 1) form picks without replacement; the difference shrinks as N grows.)

⚠ Safety

None beyond normal classroom rules.

Teacher notes and misconceptions

- See the README note on index names: check the form your exam uses before students meet a different "Simpson's index" in a past paper.
- Students often think "more species" always means "more diverse". Sites A and B, and C and D, are built to challenge that.

Grade 11 Science — Rates of reaction: what makes chemistry faster or slower

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (an AI agent) on 2026-11-04. No teacher has checked it yet. Read it fully, adapt it to your class and local rules, and test any practical work yourself before using it.

Back to all units

Big idea

Some reactions are over in a flash and others take years. The rate of a reaction is how quickly reactants are used up or products are made, and it can be measured. Particles only react when they collide with enough energy (the activation energy), so anything that makes energetic collisions more frequent speeds a reaction up: higher concentration, higher temperature, more surface area, or a catalyst that offers a lower-energy route. These ideas are tested here with measured data, then used to explain real choices in industry, cars, kitchens and factory safety.

Outcomes

By the end of the unit, students can:

1. Measure the rate of a reaction by following a change over time (mass lost, gas made, or time for a solution to go cloudy), plot the results and explain why the rate is fastest at the start.
2. Use the disappearing-cross method to test how concentration affects rate, and use 1/time as a measure of rate.
3. Test how temperature affects rate, and explain the result using collision theory and activation energy, including the rough rule that rate increases by a factor of about 2 to 3 for every 10 °C rise.
4. Compare the rate for lumps and powder of the same mass, and explain the difference using surface area.
5. Show that a catalyst speeds up a reaction without being used up, including an enzyme (catalase) and what happens when the enzyme is boiled.
6. Use rate ideas to explain real examples: catalytic converters, the iron catalyst in the Haber process, and dust explosions.

Prior knowledge

- Particles in solids, liquids and gases; dissolving; mass is conserved (grades 5–8).
- Acids react with carbonates to make carbon dioxide; neutralisation; safe handling of acids (grade 8).
- Enzymes and respiration in living things (grade 7).
- Fair tests, repeats, medians, line graphs and gradients (grades 3–9; grade 9 trolley experiment).
- Word and symbol equations; moles (grade 10 chemistry, if taught; the mole calculation in lesson 1 is a stretch task).

Lessons (about 50 minutes each)

#	Lesson	Practical?
1	Measuring rate: marble chips and acid	Mass lost every 30 s on a balance; graph
2	Concentration: the disappearing cross	Sodium thiosulfate + dilute acid at four concentrations
3	Temperature, collisions and activation energy	Disappearing cross at 20, 30, 40 and 50 °C
4	Surface area and catalysts	Chips vs powder; hydrogen peroxide with manganese dioxide and potato
5	Rates in the real world + unit check	Case studies; written assessment

Materials (whole unit)

- Eye protection for everyone in every practical lesson.
- Lesson 1: top-pan balances (reading to 0.01 g); 100 ml conical flasks; cotton wool; marble chips (calcium carbonate), about 10 g per group; dilute hydrochloric acid, 1 mol/L; 50 ml measuring cylinders; stopwatches or phones.
- Lessons 2 and 3: sodium thiosulfate solutions at 40, 30, 20 and 10 g/L (made up by a technician); dilute hydrochloric acid, 1 mol/L; 100 ml conical flasks; paper with a bold black cross; 10 ml and 50 ml measuring cylinders; thermometers; a water bath or kettle-filled beakers (lesson 3, up to 50 °C only); stopwatches; a well-ventilated room.
- Lesson 4: large marble chips, small marble chips and calcium carbonate powder (10 g each per group); dilute hydrogen peroxide, about 3% (no stronger); manganese(IV) oxide (manganese dioxide) powder, about 0.5 g per group, handled with a spatula; raw potato, cut into 1 cm cubes and grated; one batch of boiled potato; gas syringes, or upturned measuring cylinders in water troughs; filter paper and funnels for recovering the catalyst.
- Lesson 5: case-study cards (given in lesson 5); student copies of the unit check.
- Student record sheets (tables are given in each lesson).

Assessment

- Ongoing: closing check questions at the end of each lesson (answers included).
- Lesson 1: the mass-loss table, graph and rate calculations are a practical skills task.
- Lesson 3: the conclusion explaining the temperature result with collision theory is a written-explanation task.
- Lesson 5: a 10-question unit check (20 marks) with an answer guide and marking notes. No pass mark is set; use it to decide what to reteach.

Sources

These are general references that a teacher can use to check facts. Links were checked to load on 2026-11-04.

- Wikipedia, "Reaction rate": https://en.wikipedia.org/wiki/Reaction_rate
- Wikipedia, "Collision theory": https://en.wikipedia.org/wiki/Collision_theory
- Wikipedia, "Activation energy": https://en.wikipedia.org/wiki/Activation_energy
- Wikipedia, "Arrhenius equation": https://en.wikipedia.org/wiki/Arrhenius_equation
- Wikipedia, "Catalysis": https://en.wikipedia.org/wiki/Catalysis
- Wikipedia, "Enzyme": https://en.wikipedia.org/wiki/Enzyme

- Wikipedia, "Catalase": https://en.wikipedia.org/wiki/Catalase
- Wikipedia, "Hydrogen peroxide": https://en.wikipedia.org/wiki/Hydrogen_peroxide
- Wikipedia, "Manganese dioxide": https://en.wikipedia.org/wiki/Manganese_dioxide
- Wikipedia, "Sodium thiosulfate": https://en.wikipedia.org/wiki/Sodium_thiosulfate
- Wikipedia, "Calcium carbonate": https://en.wikipedia.org/wiki/Calcium_carbonate
- Wikipedia, "Hydrochloric acid": https://en.wikipedia.org/wiki/Hydrochloric_acid
- Wikipedia, "Iodine clock reaction": https://en.wikipedia.org/wiki/Iodine_clock_reaction
- Wikipedia, "Catalytic converter": https://en.wikipedia.org/wiki/Catalytic_converter
- Wikipedia, "Haber process": https://en.wikipedia.org/wiki/Haber_process
- Wikipedia, "Dust explosion": https://en.wikipedia.org/wiki/Dust_explosion

Facts used from these pages include: the factors that affect rate (Reaction rate); that only collisions with the right energy and orientation succeed, and that higher concentration gives more collisions (Collision theory); that rate rises by a factor of about 2 to 3 for every 10 °C rise for common activation energies (Arrhenius equation), and that the ratio of rates 10 °C apart is usually on the order of 2 (Reaction rate); that catalysts are not consumed and remain unchanged, with manganese dioxide speeding up hydrogen peroxide decomposition (Catalysis); 2 H2O2 → 2 H2O + O2 and that even 3% hydrogen peroxide can be dangerous for the eye (Hydrogen peroxide); that one catalase molecule can convert millions of hydrogen peroxide molecules each second, and that human catalase works best near pH 7 (Catalase); that enzymes denature when heated (Enzyme); that dilute acid decomposes thiosulfate to sulfur, sulfur dioxide and water (Sodium thiosulfate); CaCO3 + 2 H+ → Ca2+ + CO2 + H2O (Calcium carbonate); that hydrochloric acid is corrosive (Hydrochloric acid); oxidation of carbon monoxide and unburned hydrocarbons in catalytic converters (Catalytic converter); the iron catalyst (Haber process); and the flour-dust explosion at the Washburn A Mill, Minnesota, on 2 May 1878 (Dust explosion).

Known gaps and cautions

- **All results tables are invented example data**, chosen to be realistic and internally consistent. Real classes will get different numbers; the point is the pattern and the reasoning.
- The disappearing-cross reaction gives off a little sulfur dioxide. Use small volumes, a well-ventilated room and prompt disposal, and follow your local chemical-safety guidance and technician's advice, especially for students with asthma.
- Using 1/time as "rate" is an approximation: it treats every run as reaching the same amount of cloudiness. Rate equations, orders of reaction and the full Arrhenius equation are left for later study.
- Collision theory is taught qualitatively. The energy-distribution graph in lesson 3 is a sketch, not a calculated curve.
- Equilibrium and Le Chatelier's principle (why the Haber process uses a compromise temperature) are mentioned only briefly in lesson 5.
- This unit has not been checked by a teacher or a chemistry technician. Concentrations and quantities should be checked against your school's practical guidance before use.

Lesson 1 — Measuring rate: marble chips and acid

Back to unit

Goal

Students follow one reaction over time by measuring the mass lost as carbon dioxide escapes, plot a graph, and explain why the reaction is fastest at the start and then slows to a stop.

Materials

- Per group: a top-pan balance reading to 0.01 g; a 100 ml conical flask; a loose plug of cotton wool; about 10 g of marble chips (calcium carbonate), more than enough to react with all the acid; 50 ml of dilute hydrochloric acid, 1 mol/L; a 50 ml measuring cylinder; a stopwatch.
- Eye protection for everyone. Paper towels for drips.

Steps

✎ Opening (5 min)

Ask: "Which is faster, a firework or rusting? How could you measure how fast a reaction is, not just say it?" Collect ideas. Steer towards: watch something change over time — a reactant being used up or a product being made.

Introduce the word **rate**: how much reactant is used up, or product made, per second.

✎ Main activity (30 min)

1. Write the reaction on the board: calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide. Symbol form for the reacting ions: CaCO3 + 2 H+ → Ca2+ + CO2 + H2O.
2. Ask: "If carbon dioxide gas escapes from an open flask, what happens to the reading on the balance?" (It goes down.)
3. Each group puts 50 ml of acid in the flask, places the flask and the cotton-wool plug together on the balance and zeroes it (or notes the reading).
4. Add the marble chips, put the cotton wool loosely in the neck (it lets gas out but stops acid spray escaping), and start the stopwatch.
5. Record the mass lost every 30 seconds for 5 minutes.

Example results (invented, but realistic):

Time (s)	0	30	60	90	120	150	180	210	240	270	300
Mass lost (g)	0.00	0.30	0.54	0.72	0.85	0.94	1.00	1.04	1.07	1.09	1.10

1. Plot mass lost (y-axis) against time (x-axis) and draw a smooth curve.

2. Work out the mean rate in three time windows:
3. 0–30 s: 0.30 g ÷ 30 s = **0.010 g/s**
4. 120–150 s: (0.94 − 0.85) g ÷ 30 s = 0.09 ÷ 30 = **0.003 g/s**
5. 270–300 s: (1.10 − 1.09) g ÷ 30 s = 0.01 ÷ 30 ≈ **0.0003 g/s**
6. Stretch (moles): 50 ml of 1 mol/L acid contains 0.050 mol of H+. The equation needs 2 H+ for every CO_2, so at most 0.025 mol of CO_2 can form. CO_2 has a molar mass of 44 g/mol, so the most mass that can be lost is 0.025 × 44 = **1.10 g**. The reaction stopped at 1.10 g because the acid ran out (the marble chips were in excess).

✓ Discussion questions (10 min)

1. **Where is the graph steepest, and what does that mean?** Example answer: at the start. The steeper the curve, the more mass is lost each second, so the reaction is fastest at the start.
2. **Why does the reaction slow down?** Example answer: the acid is being used up, so there are fewer acid particles to hit the marble, and fewer reactions happen each second.
3. **Why did it stop at 1.10 g, even though there was still marble left?** Example answer: all the acid had reacted; the acid was the limiting reactant.
4. **Why is the cotton wool loose, not a tight bung?** Example answer: the gas must escape for the mass to drop, and a sealed flask could build up pressure.

✓ Closing check (5 min)

1. A curve on a mass-lost graph becomes flat at 4 minutes. What does that tell you? Answer: the reaction has stopped (one reactant has run out).
2. A reaction makes 24 cm^3 of gas in the first 20 seconds. What is the mean rate? Answer: 24 ÷ 20 = 1.2 cm^3/s.
3. Give one other way to follow this reaction, apart from mass. Answer: collect the gas in a gas syringe or upturned measuring cylinder and measure its volume over time.

Vocabulary

rate of reaction, reactant, product, limiting reactant, in excess, mean rate, gradient

Differentiation

- **Support:** give a pre-drawn axes grid and the first three points plotted; students compare "steep" and "flat" parts in words.
- **Stretch:** draw a tangent at 60 s and estimate the rate at that instant from its gradient; do the stretch mole calculation at the end of the main activity.

⚠ Safety

- Eye protection throughout. Dilute hydrochloric acid at 1 mol/L is an irritant; stronger hydrochloric acid is corrosive. Wipe up spills and wash skin with water.
- Keep the flask on the balance pan and do not lean over the neck while it fizzes.

- Pour the used liquid away as directed by the technician; leftover marble chips can be rinsed and reused.

Teacher notes and misconceptions

- "The reaction stops because the marble runs out." Here it does not; the acid runs out. Show the leftover chips.
- "Rate means how much product you get in total." Rate is how fast; the total amount depends on how much reactant there was. Two reactions can make the same total at different rates (lesson 4 shows this).
- The balance reading may drift slightly while the flask is still warm or wet; tell students to read it at the moment each 30 s ends, not to wait for it to settle.

Lesson 2 — Concentration: the disappearing cross

Back to unit

Goal

Students carry out a fair test of how the concentration of sodium thiosulfate affects the rate of its reaction with dilute acid, use 1/time as a measure of rate, and explain the pattern with collision theory.

Materials

- Per group: a 100 ml conical flask; a sheet of white paper with a bold black cross drawn on it; sodium thiosulfate solutions at 40, 30, 20 and 10 g/L (50 ml of each per run, made up by a technician); dilute hydrochloric acid, 1 mol/L; a 50 ml and a 10 ml measuring cylinder; a stopwatch.
- Eye protection for everyone. A well-ventilated room.

Steps

✎ Opening (5 min)

Show the reaction once as a demonstration. Put the flask of thiosulfate on the cross, add the acid, swirl once and start the stopwatch. The liquid slowly turns cloudy and yellow-white until the cross can no longer be seen from above.

Explain: dilute acid makes thiosulfate break down into sulfur, sulfur dioxide and water. The sulfur forms as tiny solid specks, which is what makes the liquid cloudy. The time until the cross disappears is a measure of how fast the sulfur forms.

✎ Main activity (30 min)

1. Ask for a prediction: "If the thiosulfate is more concentrated, will the cross disappear sooner or later? Why?"
2. Agree what to keep the same: volume of thiosulfate (50 ml), volume and concentration of acid (5 ml of 1 mol/L), the same flask, the same cross, the same person looking down from the same height, room temperature.
3. For each concentration: put 50 ml of thiosulfate in the flask on the cross, add 5 ml of acid, swirl once, start timing, and stop when the cross is no longer visible. Do three runs and take the median.
4. Rinse the flask between runs straight away (see Safety).

Example results (invented, but realistic):

Thiosulfate (g/L)	Run 1 (s)	Run 2 (s)	Run 3 (s)	Median time (s)	Rate = 1000 ÷ time (1/s × 1000)
40	21	22	20	21	47.6
30	28	27	30	28	35.7
20	43	45	42	43	23.3
10	86	84	112	86	11.6

1. Plot rate (1000 ÷ time) against concentration. The points lie close to a straight line through the origin: rate ÷ concentration is 1.19, 1.19, 1.16 and 1.16.
2. Discuss the 112 s run at 10 g/L: it is far from the other two, so it is probably a mistake (for example the timer was stopped late or the person looked from a different angle). Using the median means one odd run does not drag the answer.

✓ Discussion questions (10 min)

1. **Why do we use 1 ÷ time as the rate?** Example answer: a shorter time means a faster reaction, so 1 ÷ time gets bigger as the reaction gets faster. Each run makes about the same amount of cloudiness before the cross vanishes.
2. **What does the graph show?** Example answer: doubling the concentration roughly doubles the rate (20 g/L gives 23.3, 40 g/L gives 47.6).
3. **Explain the result using particles.** Example answer: a more concentrated solution has more thiosulfate particles in the same volume, so they collide with acid particles more often, and there are more successful collisions each second.
4. **What is the weakest part of this method?** Example answer: deciding exactly when the cross disappears is a judgement, and different people see it at different times. Keeping the same observer helps.

✓ Closing check (5 min)

1. At 25 g/L, between which two measured times would you expect the cross to disappear? Answer: between 28 s (30 g/L) and 43 s (20 g/L).
2. Why must the volume of acid be kept the same? Answer: it is a control variable; changing it would also change how fast the reaction goes, so the test would not be fair.
3. Using collision theory, explain why the 10 g/L solution took longest. Answer: fewest thiosulfate particles per ml, so the fewest collisions with acid particles each second.

Vocabulary

concentration, independent variable, dependent variable, control variable, median, collision theory, successful collision

Differentiation

- **Support:** give the results table with medians filled in; students plot time (not 1 ÷ time) against concentration and describe the curve in words.
- **Stretch:** compare the line through the origin with the iodine clock reaction, another timed reaction in which more thiosulfate makes the blue colour appear later. Ask why.

⚠ Safety

- Eye protection throughout. Dilute hydrochloric acid is an irritant.
- The reaction gives off a little sulfur dioxide, which has a sharp smell and irritates the airways. Use only the small volumes given, keep the room well ventilated, do not lean over the flask to sniff it, and pour each finished mixture away promptly with plenty of water, or as your technician directs.
- Students with asthma may be more sensitive. Seat them near an open window or let them be the timer and recorder.
- Follow your local chemical-safety guidance and technician's advice.

Teacher notes and misconceptions

- "A faster reaction makes more product." The cross disappears at roughly the same amount of sulfur each time; the concentrated run just gets there sooner.
- "More concentrated means the particles move faster." The particles move at the same speed at the same temperature; there are just more of them in each ml, so collisions are more frequent.
- The sulfur sticks to glass as a yellow film; rinse flasks between runs or the cross starts to look faint before the reaction does anything.

Lesson 3 — Temperature, collisions and activation energy

Back to unit

Goal

Students test how temperature affects the rate of the thiosulfate reaction and explain the result using collision theory and activation energy, including why a 10 °C rise has a much bigger effect than students usually expect.

Materials

- As lesson 2, using only the 20 g/L sodium thiosulfate solution.
- Thermometers; a water bath, or beakers of warm water from a kettle mixed with cold water, set to about 30, 40 and 50 °C. No hotter than 50 °C.
- Eye protection for everyone. A well-ventilated room.

Steps

✎ Opening (5 min)

Ask: "Why do we keep milk in the fridge?" Collect ideas, then ask: "Is there something general about reactions going slower when it is cold?"

Recap collision theory from lesson 2: particles must collide to react. Then add the new idea: **not every collision works.** Particles must hit hard enough, with at least a minimum amount of energy called the **activation energy**, and in a suitable orientation. Collisions that lead to a reaction are called successful collisions.

✎ Main activity (30 min)

1. Predict: "If we warm the thiosulfate from 20 °C to 30 °C, will the time halve, change a little, or stay the same?"
2. For each temperature: warm 50 ml of the 20 g/L thiosulfate in the flask in the water bath, measure its temperature, stand it on the cross, add 5 ml of 1 mol/L acid (at room temperature), swirl once and time until the cross disappears. Measure the temperature again at the end and record the mean of the start and end temperatures.
3. The 20 °C run is the same as the 20 g/L result from lesson 2; it can be reused if the room was at about 20 °C.

Example results (invented, but realistic; median of three runs each):

Mean temperature (°C)	Median time (s)	Rate = 1000 ÷ time
20	43	23.3
30	22	45.5

Mean temperature (°C)	Median time (s)	Rate = 1000 ÷ time
40	12	83.3
50	7	142.9

1. Work out how the rate changes for each 10 °C step: 45.5 ÷ 23.3 ≈ 1.95; 83.3 ÷ 45.5 ≈ 1.83; 142.9 ÷ 83.3 ≈ 1.72. Each 10 °C rise roughly doubles the rate.
2. Compare with chemistry references: for many reactions the rate rises by a factor of about 2 to 3 for every 10 °C rise, and the ratio of rates 10 °C apart is usually on the order of 2. The class result fits that rough rule.
3. Note the limit of the data: 7 s is hard to time by hand, so the 50 °C result is the least reliable.

Explaining the result (sketch)

Draw a sketch (not to scale) of the spread of particle energies at a low and a higher temperature, with a vertical line marking the activation energy. At the higher temperature the curve is flatter and spreads to higher energies, so a bigger share of particles lies to the right of the line.

Two things happen when the temperature rises:

1. Particles move faster, so they collide a little more often.
2. More importantly, a much bigger fraction of collisions have at least the activation energy, so a much bigger fraction are successful.

The second effect is why a 10 °C rise can double the rate, even though the particles only move a little faster.

✓ Discussion questions (10 min)

1. **Why does the rate roughly double when the temperature only goes up a little in kelvin (from 293 K to 303 K)?** Example answer: the number of collisions only rises a little, but the share of collisions with enough energy to react rises a lot.
2. **Why do we record the mean of the start and end temperatures?** Example answer: the warm flask cools while we time it, and the cold acid cools it too, so the start temperature alone would be too high.
3. **Why is the 50 °C result the least trustworthy?** Example answer: 7 s is very short, so a reaction-time error of half a second is a large fraction of the result.
4. **Why do fridges slow down food going off?** Example answer: lower temperature means fewer collisions with enough energy, so the reactions that spoil food (including those in microbes) go more slowly.

✓ Closing check (5 min)

1. What is activation energy? Answer: the minimum energy colliding particles need for the collision to lead to a reaction.
2. A reaction takes 80 s at 25 °C. Using the "about 2 per 10 °C" rule, estimate the time at 35 °C. Answer: about 40 s.

3. Give two reasons a higher temperature increases the rate. Answer: particles collide more often, and a bigger fraction of collisions have at least the activation energy.

Vocabulary

activation energy, successful collision, energy distribution, kelvin, rule of thumb

Differentiation

- **Support:** give the sketch of the energy distribution already drawn; students shade the part above the activation energy for each temperature and compare the areas.
- **Stretch:** plot rate against temperature and describe the curve (it gets steeper). Ask whether the rule "about 2 per 10 °C" can hold for ever (no: at high temperatures other limits appear, and in living things enzymes denature, as lesson 4 shows).

⚠ Safety

- Everything in lesson 2 applies, including ventilation and prompt disposal because of sulfur dioxide. Warm solutions give off sulfur dioxide faster, so the 50 °C limit matters.
- Water no hotter than 50 °C. Teachers handle any kettle; students only use the water bath or pre-mixed warm water.
- Eye protection throughout.

Teacher notes and misconceptions

- "Heat gives the reaction energy, so the products have more energy." The point is collision energy, not that heat is stored in the products.
- "Higher temperature means more particles." The number of particles is the same; they move faster and more collisions are energetic enough.
- "Rate doubles every 10 °C exactly." It is a rough rule for many common reactions, not a law; real factors vary.

Lesson 4 — Surface area and catalysts

Back to unit

Goal

Students show that breaking a solid into smaller pieces speeds up its reaction without changing how much product it makes, and that a catalyst (manganese dioxide, or the enzyme catalase in potato) speeds up a reaction without being used up.

Materials

- **Part A, per group:** 10 g each of large marble chips (the same size as lesson 1), small marble chips and calcium carbonate powder; 3 × 50 ml of 1 mol/L hydrochloric acid; a 100 ml conical flask for the chips and a 250 ml conical flask for the powder (it froths); cotton wool; a balance; a stopwatch.
- **Part B, per group:** dilute hydrogen peroxide, about 3%, 25 ml per run; a gas syringe (or an upturned measuring cylinder in a trough of water) connected to a conical flask with a bung and delivery tube; about 0.5 g of manganese dioxide powder on a weighed filter paper; 5 g of raw potato in 1 cm cubes; 5 g of grated raw potato; 5 g of grated potato that has been boiled for 5 minutes and cooled (prepared by the technician); a funnel, filter paper and a warm place to dry the paper.
- Eye protection for everyone.

Steps

✎ Opening (5 min)

Hold up a sugar cube and a spoonful of granulated sugar. Ask: "Which dissolves faster in tea, and why?" (Grade 5 dissolving.) Then: "Would the same idea work for a reaction?"

Show a sheet of paper and the same sheet torn into eight pieces. Ask how much more edge and surface there is to touch. Introduce **surface area**: particles can only react where the solid touches the liquid, so more surface means more collisions each second.

✎ Main activity, part A: surface area (12 min)

Repeat the lesson 1 method with each size, recording the mass lost at 60 s and at the end.

Example results (invented, but realistic):

Solid (10 g)	Mass lost at 60 s (g)	Mass lost at end (g)
Large chips	0.54	1.10
Small chips	0.86	1.10
Powder	1.08	1.10

All three end at 1.10 g, because in every case the same 50 ml of acid is used up (lesson 1). Smaller pieces change how fast, not how much.

✎ Main activity, part B: catalysts (18 min)

Hydrogen peroxide slowly breaks down into water and oxygen: 2 H2O2 → 2 H2O + O2. On its own this is very slow. For each run, put 25 ml of peroxide in the flask, add the solid, put the bung in at once and record the volume of oxygen collected after 60 s.

Example results (invented, but realistic):

Added to 25 ml peroxide	Oxygen after 60 s (cm³)
Nothing	1
0.5 g manganese dioxide	52
5 g potato cubes	9
5 g grated potato	24
5 g grated boiled potato	0

Then filter off the manganese dioxide, rinse it, let the paper dry and weigh it again. Example: 0.50 g before, 0.49 g after; the small loss is powder stuck to the glass and paper.

✓ Discussion questions (10 min)

1. **Why did the powder react fastest even though it was the same mass?** Example answer: it has much more surface touching the acid, so more acid particles hit the solid each second.
2. **How do we know manganese dioxide is a catalyst and not a reactant?** Example answer: it speeds the reaction up a lot, but almost all of it is still there afterwards, unchanged. Catalysts are not used up and can be reused.
3. **Why does potato work at all?** Example answer: potato cells contain the enzyme catalase, a biological catalyst that breaks down hydrogen peroxide. One catalase molecule can break down millions of peroxide molecules each second.
4. **Why did grated potato beat cubes, and boiled potato do nothing?** Example answer: grating exposes more cells, so more enzyme meets the peroxide (surface area again). Boiling denatures the enzyme: its shape unfolds and it stops working.
5. **How does a catalyst work, in collision-theory terms?** Example answer: it gives the reaction a different route with a lower activation energy, so a bigger fraction of collisions are successful at the same temperature.

✓ Closing check (5 min)

1. 10 g of lumps and 10 g of powder react with the same acid until the acid runs out. Which makes more gas in total? Answer: neither; they make the same total, but the powder makes it faster.
2. Give two pieces of evidence that a substance is a catalyst. Answer: the reaction is much faster with it; its mass is (almost) unchanged at the end.

3. Why are enzymes in your body sometimes said to work best at "about pH 7 and body temperature"? Answer: outside their best conditions enzymes can lose their shape (denature) and work less well. For example, human catalase works best near pH 7.

Vocabulary

surface area, catalyst, enzyme, catalase, denature, alternative route, decomposition

Differentiation

- **Support:** give part B as a teacher demonstration with the gas syringe projected; students fill in the table and answer questions 2 and 4.
- **Stretch:** 25 ml of 3% hydrogen peroxide can give about 250 cm³ of oxygen in total (around ten times its own volume). Ask: what percentage had broken down after 60 s with manganese dioxide? (52 ÷ 250 ≈ 21%.)

⚠ Safety

- Eye protection throughout. Even 3% hydrogen peroxide can be dangerous in the eye, and it irritates skin. Do not use stronger peroxide for this lesson. Wash splashes off with plenty of water.
- Never seal the flask tightly without a delivery tube to a gas syringe or trough; oxygen must have somewhere to go.
- Handle manganese dioxide powder with a spatula, avoid making dust, and dispose of it as your technician directs.
- No large "elephant toothpaste" demonstrations; they use much stronger peroxide.
- Do not eat any potato used in the lesson.
- Dilute hydrochloric acid is an irritant (part A). The powder froths up quickly; use the larger flask.

Teacher notes and misconceptions

- "A catalyst makes more product." It only changes how fast; the total amount of oxygen is set by how much peroxide there is.
- "Catalysts are not involved in the reaction." They take part, but come out unchanged at the end.
- "Boiling kills the enzyme." Enzymes are not alive; boiling changes their shape so they no longer work (denaturing).
- The "nothing" run may give 0–2 cm³ just from the gas warming or the bung pushing air in; that is a useful point about measurement error.

Lesson 5 — Rates in the real world + unit check

Back to unit

Goal

Students use concentration, temperature, surface area and catalysts to explain real situations where people want reactions faster or slower, then complete the unit check.

Materials

- Four case-study cards (below), one set per group.
- Student copies of the unit check (10 questions, 20 marks).

Steps

✎ Opening (5 min)

Ask: "Name a reaction people want to speed up, and one they want to slow down." Examples: making ammonia for fertiliser or cleaning car exhaust (faster); food going off or a dust cloud catching fire (slower, or not at all).

✎ Main activity: case-study cards (20 min)

Groups read each card and answer: Which factor or factors are involved, and how would you explain them using collisions?

1. **Catalytic converters.** A car exhaust contains carbon monoxide and unburned fuel. In a catalytic converter, a ceramic honeycomb coated with metal catalysts (such as platinum and palladium) helps these react with oxygen to form carbon dioxide and water. "Three-way" converters also reduce oxides of nitrogen; Volvo first sold them on 1977 California-specification 240 cars. Factors: catalyst (lower activation energy route), large surface area (honeycomb), hot exhaust (temperature).
2. **The Haber process.** Ammonia for fertiliser is made by reacting nitrogen and hydrogen on the surface of a solid catalyst, usually iron. Many plants run at about 500 °C and 200 bar. The iron catalyst needs at least about 400 °C to be efficient. Factors: catalyst; temperature; high pressure (gas particles closer together, like higher concentration). Teacher note: lower temperatures would give more ammonia at equilibrium but too slowly, so the temperature is a compromise. Equilibrium is studied later.
3. **Dust explosions.** Flour, sugar, grain, cocoa and coffee can all burn explosively as a fine dust cloud. On 2 May 1878 a flour-dust explosion destroyed the Washburn A Mill in Minnesota, killing 14 workers there and four more in nearby buildings. Factor: surface area. A bag of flour burns slowly; the same flour spread through the air as dust has a huge surface touching oxygen, so it can burn almost all at once.
4. **Keeping food cool.** Fridges and freezers slow down the reactions that make food go off, including those in microbes. Factor: temperature. Fewer collisions with at least the

activation energy; using the "about 2 per 10 °C" rule, food at 5 °C spoils several times more slowly than at 25 °C, as a rough estimate.

Share answers as a class. Draw out that the same four factors explain every case.

✓ Unit check (25 min)

Students work alone. Mark out of 20. No pass mark is set; use the results to decide what to reteach.

1. What is meant by the "rate" of a reaction? Give one way to measure it. **(2 marks)**
2. A reaction gives these gas volumes:

Time (s)	**0**	**10**	**20**	**30**	**40**	**50**	**60**
Gas (cm³)	0	30	50	62	68	70	70

(a) Calculate the mean rate in the first 10 s. (b) When did the reaction stop? **(2 marks)** 3. In a disappearing-cross test, three runs at one concentration took 18 s, 19 s and 31 s. Which value would you report, and why? **(2 marks)** 4. Use collision theory to explain why a more concentrated acid reacts faster with magnesium ribbon. **(2 marks)** 5. What is activation energy? **(2 marks)** 6. A reaction takes 60 s at 20 °C. Using the rough rule that the rate about doubles for each 10 °C rise, estimate how long it takes at 40 °C. Show your working. **(2 marks)** 7. 10 g of marble lumps and 10 g of marble powder each react with 50 ml of the same acid, which runs out in both cases. Compare (a) how fast and (b) how much carbon dioxide each makes. **(2 marks)** 8. A student adds 1.00 g of a black powder to hydrogen peroxide. Bubbles of oxygen appear quickly. Afterwards she filters, dries and weighs the powder: 0.99 g. What does this suggest about the powder? Explain. **(2 marks)** 9. Raw grated potato makes hydrogen peroxide fizz, but boiled grated potato does not. Explain why. **(2 marks)** 10. A flour mill keeps its floors and machines free of dust. Use rates of reaction to explain why. **(2 marks)**

Answer guide and marking notes

1. How fast reactants are used up or products are formed (1); any valid method, e.g. mass lost over time, gas volume over time, time for a cross to disappear (1).
2. (a) 30 ÷ 10 = 3.0 cm³/s (1). (b) At 50 s, when the volume stops rising (1). Accept "between 40 and 50 s" only if the student explains the curve is still rising at 40 s.
3. 19 s, the median (1), because 31 s is far from the others and is probably a mistake, so it should not drag the result (1). Accept "the mean of 18 and 19" with the same reason.
4. More acid particles in the same volume (1), so more frequent collisions with the magnesium and more successful collisions per second (1). "Particles move faster" scores 0 for the second mark.
5. The minimum energy (1) that particles must have when they collide for the collision to lead to a reaction (1).
6. 20 °C → 30 °C: rate doubles, time halves to 30 s (1); 30 °C → 40 °C: time halves again to 15 s (1). Accept "about 15 s" with working.
7. (a) Powder reacts faster because it has a bigger surface area (1). (b) The same amount, because the same amount of acid is used up in each (1).
8. It is a catalyst (1): it sped up the reaction but its mass was almost unchanged, so it was not used up; the 0.01 g difference is powder lost in filtering (1).

9. Potato contains the enzyme catalase, which catalyses the breakdown of hydrogen peroxide (1). Boiling denatures the enzyme, so its shape changes and it no longer works (1). "Boiling kills the enzyme" scores 1 only if "changes shape" or "denatures" is also given.
10. Fine dust has a very large surface area (1), so a dust cloud can burn extremely fast, causing an explosion (1). Accept any reference to the Washburn A Mill or similar as supporting detail, not as a replacement for the explanation.

Vocabulary

catalytic converter, Haber process, dust explosion, compromise conditions, pressure

Differentiation

- **Support:** give each case-study card with the factor names listed underneath; students choose and explain one.
- **Stretch:** for the Haber card, research what "equilibrium" means and why a lower temperature would give more ammonia but more slowly.

⚠ Safety

- No practical work in this lesson. Do not attempt dust-explosion demonstrations in class.

Teacher notes and misconceptions

- "Catalytic converters remove all pollution." They change some harmful gases into less harmful ones; carbon dioxide is still produced.
- "Higher pressure only matters for gases because they get hotter." In this unit, higher pressure is treated as packing gas particles closer together, like a higher concentration.
- Students often write "more collisions" without "per second". Insist on the rate of collisions, not just the number.

Grade 12 science: the extended investigation (planning, uncertainty, reporting, peer review)

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (an AI agent) for the K-12 curriculum drafts project. No teacher has reviewed or taught it. Check every fact, number and safety note before use.

Band: 9-12 (ages 17-18) · **Strand:** Inquiry (all strands) · **Length:** 5 lessons, then a multi-week independent investigation

Big idea

A scientific result is only as good as the way it was found and reported. Before collecting data, a scientist decides what to measure, how, and how the data will be analysed. While measuring, they estimate how far each number can be trusted. Afterwards they report enough for someone else to repeat the work, and they let other people check it. This unit practises each step on one shared experiment (a simple pendulum) so that students can then run their own extended investigation.

Outcomes

By the end of the five lessons, students can:

1. Turn a broad question into a testable one, naming the independent, dependent and control variables, and write a short plan (including the analysis) **before** collecting data.
2. Tell random error from systematic error, and precision from accuracy (trueness), using an example from their own measurements.
3. Calculate a mean and an uncertainty (half the range) from repeated readings, and explain why timing ten swings beats timing one.
4. Plot data, linearise a relationship (T^2 against L), find a gradient, and use it to calculate a quantity (g), stating an uncertainty.
5. Write a report in the IMRaD structure (Introduction, Methods, Results, Discussion) that another student could repeat.
6. Give and respond to a specific, kind, written peer review.

Prior knowledge

- Fair tests and variables (grades 3-8 in the science progression).
- Means, graphs and gradients; the grade 9 trolley unit's $a = 2d/t^2$ analysis (grade 9 forces and Newton's laws).
- Squares and square roots; rearranging a formula.

Lessons

1. From a question to a plan — testable questions, variables, a pilot run, and writing the plan and analysis down first.

2. Measurement and uncertainty — random vs systematic error, precision vs accuracy, reaction time, repeats, mean and half-range.
3. Analysing data honestly — T^2 against L, gradient, g, outliers, and correlation vs causation.
4. Writing the report — IMRaD, methods someone can repeat, uncertainties, limitations, and why replication matters.
5. Peer review — reviewing a report with a checklist, responding to reviewers, and launching the extended investigation.

Materials

- Per group of 2-3: clamp stand, boss and clamp (G-clamped or weighted to the bench), thin string (about 1.2 m), a small bob (50-100 g mass or a metal washer stack), metre rule, stopwatch or phone timer, protractor, graph paper or a spreadsheet.
- Lesson 5: printed or shared copies of each group's report, the review checklist, and coloured pens.

Assessment

- **Closing check (lesson 5):** 10 questions, 20 marks, with an answer key. It checks skills, not memorised facts. No pass mark is set; use it to decide what to reteach.
- **The extended investigation (after the unit):** each student (or pair) plans, carries out, writes up and peer-reviews their own investigation over several weeks. A suggested timeline and approval steps are in lesson 5. Assess the plan, the honesty of the uncertainty and limitations, the report's repeatability, and the response to review — not whether the result was "right" or exciting.

Sources

All facts were checked against these Wikipedia articles on 5 November 2026. Wikipedia is a starting point; a teacher should confirm against a textbook or primary source.

- Scientific method
- Hypothesis
- Dependent and independent variables
- Pilot experiment — "a small-scale preliminary study conducted to evaluate feasibility, duration, cost, adverse events, and improve upon the study design".
- Observational error — random errors "can be mitigated by repeated measurements"; systematic errors cannot.
- Accuracy and precision — precision describes random error; trueness describes systematic error (bias).
- Measurement uncertainty
- Significant figures
- Standard deviation
- Mental chronometry — simple human reaction times are "usually on the order of 200 ms".
- Pendulum — period $T = 2\pi\sqrt{(L/g)}$ for small swings; the period is nearly independent of amplitude (isochronism); Galileo studied pendulums from around 1602.
- Pendulum (mechanics)
- Gravity of Earth — standard gravity is 9.80665 m/s^2 by definition; surface gravity varies by around 0.7%, from about 9.780 m/s^2 at the Equator to about 9.832 m/s^2 at the poles.
- Outlier — "there is no rigid mathematical definition of what constitutes an outlier"; a measurement error may justify discarding one.

- Correlation does not imply causation — the ice cream and drowning example of a third (confounding) variable.
- IMRAD — Introduction, Methods, Results, and Discussion.
- Peer review
- Preregistration (science) — registering hypotheses, methods or analyses before a study is conducted; aims include distinguishing confirmatory from exploratory analysis.
- Replication crisis — the 2015 Reproducibility Project: Psychology redid 100 studies; of 97 original studies with significant effects, 36% replicated successfully.

Known gaps and cautions

- The pendulum data in lessons 2-3 are **made up to be realistic**, generated from $T = 2\pi\sqrt{(L/g)}$ with $g = 9.81$ m/s² plus small timing scatter. Real class data will be messier; that is the point.
- The uncertainty method (half the range) is deliberately simple. Some courses expect standard deviation or standard error; lesson 2 mentions standard deviation as an extension only.
- The extended investigation needs time the timetable may not have (the suggestion is about six weeks of part-time work). Shorten it to a two-week mini-investigation if needed.
- Investigations involving people (surveys, reaction tests on classmates), animals, microorganisms, heat, electricity above battery voltage, or chemicals beyond those in earlier units need explicit teacher approval and the school's own safety and ethics rules. This draft does not replace them.
- No human educator has reviewed this unit.

Lesson 1: From a question to a plan

Back to the unit

Goal

Students turn a broad question about a pendulum into a testable one, name the variables, run a short pilot, and write a one-page plan — including how they will analyse the data — **before** collecting any real data.

Materials

- Per group: clamp stand (G-clamped or weighted), string, small bob (50-100 g), metre rule, stopwatch or phone timer, protractor.
- A one-page plan template (headings below) on paper or in a shared document.

Steps

✎ Opening (5 min)

Swing a pendulum at the front. Ask: "What do you think decides how long one swing takes?" Collect ideas on the board without judging them (for example: length of string, mass of the bob, how far you pull it back, the type of string).

Point out that "what decides how long a swing takes?" is a good question but not yet a testable one. A testable question changes **one** thing and measures **one** thing.

✎ Main activity (35 min)

1. **Pick one variable (5 min).** Each group chooses one factor from the board. Most groups should choose length; one or two can choose mass or release angle, which gives a useful comparison in lesson 3.
2. **Name the variables (5 min).** For the length investigation:
3. Independent variable (what you change): length L, from the pivot to the **centre** of the bob.
4. Dependent variable (what you measure): the period T, the time for one complete swing, there and back.
5. Control variables (kept the same): mass of the bob, release angle (small, about 10°), the same string, the same timer.
6. **Write a hypothesis and a prediction (5 min).** A hypothesis is a proposed explanation that can be tested; a prediction says what you expect to measure if it is right. Example: "Longer pendulums swing more slowly, so if L increases from 0.20 m to 1.00 m, T will increase."
7. **Pilot run (10 min).** Groups set L to about 0.60 m and try timing **one** swing three times, then **ten** swings three times. They write down all six readings. Most groups notice that single-swing times jump around by a noticeable fraction of the swing, while ten-swing times are steadier relative to their size. A pilot is a small trial run to check

that the method works before the real data; this one usually changes the method to "time ten swings, divide by ten".

8. **Write the plan before the data (10 min).** On one page, under these headings:
9. Question
10. Variables (independent, dependent, controls, and how each control is kept the same)
11. Method (numbered steps someone else could follow)
12. Range and repeats (for example, five lengths from 0.20 m to 1.00 m, three repeats of ten swings each)
13. **Analysis, decided now:** what you will calculate and plot (for example, "mean of three repeats, T = mean ÷ 10, plot T against L, then T^2 against L")
14. **Rule for odd readings, decided now:** for example, "if one repeat differs from the other two by more than 0.5 s, recount and retake it; if we cannot retake it, report it and say whether we left it out"
15. Risks and how to control them

Scientists sometimes register a plan publicly before collecting data; this is called **preregistration**. Its purpose is to make it clear which analyses were planned and which were tried afterwards.

✓ Discussion questions (with example answers)

1. Why measure to the centre of the bob, not to the top of it? The swinging mass acts roughly at its centre, so that is the length that matters. Measuring to the top would make every length a little too short — a systematic error, the same in every reading (lesson 2).
2. What did the pilot change about your method? Usually: timing ten swings instead of one, because human start/stop errors are a smaller fraction of a longer time. Some groups also find they need a fixed mark to count swings from.
3. Why write the analysis down before collecting data? So you can't choose, after seeing the numbers, the graph or the rule that makes the result look best. It also shows a reader which conclusions were planned and which are new ideas to test later.
4. Is "mass doesn't matter" a hypothesis you can test? Yes: change the mass with length and angle fixed, and see whether T changes by more than the uncertainty. If it doesn't, you can say "no change was detected within our uncertainty", not "mass has no effect at all".

✓ Closing check (5 min, with answers)

1. In the length investigation, name the independent variable, the dependent variable and two control variables. (Length; period; any two of mass, release angle, string, timer.)
2. What is a pilot run for? (To test the method on a small scale and improve it before the real data.)
3. Give one thing a good plan decides before any data are collected. (Any of: the analysis, the number of repeats and range, the rule for odd readings.)

Vocabulary

testable question, independent variable, dependent variable, control variable, hypothesis, prediction, period, pilot run, preregistration

Differentiation

- **Support:** give a partly filled plan with the variables named, so students complete the method and analysis lines.
- **Stretch:** ask students to predict the shape of the T against L graph before measuring and record the prediction in their plan.

⚠ Safety

- Clamp or weight the stand so it cannot tip; keep the bob small (50-100 g).
- Keep faces out of the swing path; release from the side, don't throw.
- Keep floor space clear of bags; tie back long hair near the stand.

Teacher notes and misconceptions

- Many students expect a heavier bob to swing faster. Let the mass groups test it rather than telling them.
- "Period" is one full there-and-back swing. Some students count half-swings; agree the definition before the pilot.
- If students' first plans are vague, ask: "Could another group follow this method without asking you anything?"

Lesson 2: Measurement and uncertainty

Back to the unit

Goal

Students tell random error from systematic error and precision from accuracy, see why timing ten swings beats timing one, and calculate a mean and an uncertainty (half the range) from repeated readings.

Materials

- One demonstration pendulum at the front, length 0.60 m (pivot to centre of bob).
- Every student needs a stopwatch or phone timer.
- The worked data below, on a slide or handout.

Steps

✎ Opening (5 min)

Ask: "If ten of you time the same pendulum, will you all get the same number?" Take a show of hands, then test it.

✎ Main activity (35 min)

1. **Everyone times the same thing (10 min).** Start the front pendulum swinging from a small angle. Every student times ten swings at once, starting and stopping on the same count. Collect all the readings on the board. Then repeat with **one** swing.

If your class's numbers are hard to use, use this example set, ten students timing ten swings:

Student	A	B	C	D	E	F	G	H	I	J
Time for 10 swings (s)	15.3	15.6	15.5	15.8	15.4	15.6	15.2	15.7	15.5	15.6

And three students timing **one** swing: 1.3 s, 1.8 s, 1.5 s.

1. **Mean and uncertainty (10 min).** Work through the ten-swing set together:
2. Mean = 155.2 ÷ 10 = **15.52 s**.
3. Range = largest − smallest = 15.8 − 15.2 = **0.6 s**.
4. Uncertainty (half the range) = **±0.3 s**.
5. Report the mean to the same decimal place as the uncertainty: **15.5 ± 0.3 s** for ten swings.
6. Divide both by ten for one period: **T = 1.55 ± 0.03 s**.

Now the single-swing set: mean 1.53 s, half-range 0.25 s, about **16%** of the swing. For ten swings the uncertainty is 0.3 s out of 15.5 s, about **2%**. Ask students to explain the difference: human reaction times are about 0.2 s (simple reaction times are usually on the

order of 200 ms), and that start/stop error is about the same whether you time one swing or ten, so it is a much smaller fraction of a longer time.

1. **Random vs systematic (10 min).** Use two short scenarios:
2. Scenario 1: the ten students' readings scatter on both sides of the mean. Some react a little early, some a little late. This is **random error**: it varies from reading to reading, and repeating and averaging reduces its effect.

3. Scenario 2: one group measured every length to the **top** of a 4 cm bob instead of its centre, so every length is 2 cm too short. Repeating does not help; every reading is wrong the same way. This is **systematic error**. It is found by checking the method or the instrument, not by taking more readings.

4. **Precision vs accuracy (5 min).** Draw two targets on the board:

5. Tight cluster away from the centre: **precise but not accurate** (small random error, a systematic error).
6. Wide scatter around the centre: **accurate on average but not precise** (no systematic error, large random error). Precision describes random error. The closeness of the mean to the true value (called trueness in the ISO terms) describes systematic error. Good measurements need both.

✓ Discussion questions (with example answers)

1. Student G's 15.2 s is the lowest. Was G "wrong"? Not necessarily. All ten readings are within 0.3 s of the mean; G's is part of the normal scatter, so it stays in. A reading would only be suspicious if it were far outside the others (lesson 3).
2. Why not time 100 swings to make the uncertainty even smaller? It would shrink the reaction-time part further, but the swing slowly dies away, counting errors become likely, and it takes far longer. Ten to twenty swings is a sensible trade-off; a good report says why the number was chosen.
3. Would taking more readings fix the "top of the bob" error? No. It is systematic: more readings give a more precise wrong answer. Fix the method (measure to the centre) or correct each length by adding 2 cm.
4. Is ±0.3 s "the error" in the measurement? It is an estimate of how far the mean could reasonably be off because of scatter. It does not include systematic errors nobody has noticed, so it can be too small.

✓ Closing check (5 min, with answers)

1. Times for 10 swings: 12.6 s, 12.9 s, 12.7 s. Find the mean and the uncertainty (half the range). (Mean 38.2 ÷ 3 = 12.73 s ≈ 12.7 s; range 0.3 s; uncertainty ±0.15 s, so about 12.7 ± 0.2 s.)
2. Give one example of a systematic error in the pendulum experiment. (Measuring to the top of the bob; a stopwatch that runs fast; always starting the watch late for the same reason.)
3. Why does timing ten swings give a smaller percentage uncertainty than timing one? (The reaction-time error is about the same either way but is a smaller fraction of a longer time.)

Vocabulary

random error, systematic error, precision, accuracy, trueness, mean, range, uncertainty, reaction time, significant figures

Differentiation

- **Support:** give a table with columns for each reading, total, mean, largest, smallest and half-range.
- **Stretch:** calculate the standard deviation of the ten-swing set (about 0.18 s with a calculator or spreadsheet) and compare it with the half-range. Discuss why courses use different measures of spread.

⚠ Safety

- Only the teacher handles the front pendulum; students stay seated while timing.
- Keep the swing area clear.

Teacher notes and misconceptions

- Students often think an uncertainty means someone made a mistake. Stress that every measurement has one; stating it is honest, not an admission of failure.
- "Human error" is not an explanation in a report. Ask: which human action, and does it push readings randomly or always one way?
- Rounding: the closing check answer gives ±0.15 s, which many courses round to ±0.2 s. Accept either if the reasoning is clear.

Lesson 3: Analysing data honestly

Back to the unit

Goal

Students process repeated readings, deal with an odd reading using the rule they wrote in advance, linearise the pendulum relationship by plotting T^2 against L, find the gradient, calculate g with a rough uncertainty, and explain why a correlation alone does not show a cause.

Materials

- Groups' own data from their investigation, or the worked data below.
- Graph paper or a spreadsheet; calculators.

Steps

✎ Opening (5 min)

Show the formula for a simple pendulum swinging through small angles: **$T = 2\pi\sqrt{(L/g)}$**, where g is the gravitational field strength. Ask: "If this is true, what graph should give a straight line?" Squaring both sides gives $T^2 = (4\pi^2/g) \times L$, so **$T^2$ against L** should be a straight line through the origin with gradient $4\pi^2/g$.

✎ Main activity (35 min)

1. **Process the length data (10 min).** Worked example (times for 10 swings, three repeats each):

L (m)	Run 1 (s)	Run 2 (s)	Run 3 (s)	Mean (s)	± half-range (s)	T (s)	T^2 (s^2)
0.20	9.1	8.8	9.0	8.97	0.15	0.897	0.804
0.40	12.8	12.5	12.7	12.67	0.15	1.267	1.604
0.60	15.6	**14.0**	15.4	see below			
0.80	17.8	18.1	17.9	17.93	0.15	1.793	3.216
1.00	20.2	19.9	20.1	20.07	0.15	2.007	4.027

1. **The odd reading (8 min).** At 0.60 m, run 2 (14.0 s) is 1.4-1.6 s below the other two. The group's plan said: "if one repeat differs from the other two by more than 0.5 s, recount and retake it; if we cannot retake it, report it and say whether we left it out." Ask groups what might cause it. One check: nine swings would take about $0.9 \times 15.5 \approx 14.0$ s, so a miscount of nine swings as ten fits exactly.

The group could not retake the run, so, following their rule, they leave it out **and say so in the report**: - Mean of runs 1 and 3 = 15.50 s, half-range 0.10 s, T = 1.550 s, $T^2 = 2.403\ s^2$. - If they had kept it, the mean would be 15.0 s and $T^2 = 2.25\ s^2$, a point clearly below the line.

There is no rigid mathematical definition of an outlier; deciding is a judgement. That is why the rule is written before the data and every exclusion is reported with its reason. Leaving out a point **because** it spoils the result you hoped for is not allowed.

1. **Graph and gradient (10 min).** Plot T^2 (y-axis) against L (x-axis). The points lie close to a straight line through the origin. A best-fit line gives a gradient of about **4.03 s²/m** (a spreadsheet least-squares fit gives 4.029 with an intercept of −0.006 s², effectively zero).

Then $g = 4\pi^2 \div \text{gradient} = 39.48 \div 4.03 \approx$ **9.80 m/s²**.

1. **A rough uncertainty in g (7 min).** The largest percentage uncertainty in a ten-swing time is at 0.20 m: 0.15 ÷ 8.97 ≈ 1.7%. Squaring T doubles the percentage, about 3.3%, so g is uncertain by roughly 3% of 9.8, about ±0.3 m/s². Result: **g = 9.8 ± 0.3 m/s²**. The accepted value used in physics classrooms, 9.81 m/s², lies inside this range. (This is a rough, worst-point method; the stretch task uses steepest and shallowest lines.)

The mass and angle groups

Ask these groups to share their results. Example data at L = 0.60 m (ten swings, mean of three, each about ±0.2 s):

Mass (g)	**50**	**100**	**200**
Time for 10 swings (s)	15.5	15.6	15.5
Release angle	**10°**	**20°**	**30°**
Time for 10 swings (s)	15.6	15.7	15.8

The mass results show no change larger than the uncertainty. The angle results rise slightly, by about the size of the uncertainty. The full theory predicts that the period does depend a little on amplitude (about 1.7% longer at 30° than for a tiny swing), which is why the formula $T = 2\pi\sqrt{(L/g)}$ is called the small-angle approximation. A class experiment can just about see this, so a fair conclusion is "a small increase, close to our uncertainty", not "angle has no effect".

✓ Discussion questions (with example answers)

1. Why plot T^2 against L instead of T against L? T against L is a curve, and it is hard to tell by eye whether a curve matches a formula. A straight line is easy to judge, and its gradient gives g directly.
2. Was the group right to leave out 14.0 s? Yes, because they used a rule written in advance, found a likely physical cause (a miscounted swing), and reported it. They should also show what difference keeping it would make.
3. The mass group found "no effect". What exactly may they claim? That no change larger than about 0.2 s in ten swings was detected for masses from 50 to 200 g. They cannot claim mass has no effect at all, or outside the range they tested.
4. A survey finds that towns with more ice-cream sales have more drownings. Does ice cream cause drowning? No. Hot weather increases both (a third, confounding variable). In the pendulum experiment we changed L ourselves and kept the rest fixed, which is why we can say length affects the period. Data that are only observed, not controlled, need much more care before claiming a cause.

✓ Closing check (5 min, with answers)

1. Repeats of 11.2 s, 11.4 s and 12.9 s. The plan's rule is "more than 0.5 s from the other two → retake or report". What should the student do? (Retake the 12.9 s run; if that's impossible, report it and its likely cause and state whether it was left out.)
2. A gradient of T^2 against L is 4.10 s^2/m. Calculate g. (39.48 ÷ 4.10 ≈ 9.63 m/s^2.)
3. Name the third variable in the ice-cream example and say what it does. (Hot weather/ temperature; it increases both ice-cream sales and swimming, and so drownings.)

Vocabulary

linearise, gradient, best-fit line, intercept, outlier, exclusion rule, small-angle approximation, correlation, causation, confounding variable

Differentiation

- **Support:** provide axes already scaled and the processed table; students plot and read the gradient.
- **Stretch:** draw the steepest and shallowest lines that still pass through the error bars, find g from each, and use half their difference as the uncertainty. Compare with the ±0.3 m/s^2 estimate.

⚠ Safety

- No practical work in this lesson beyond any remaining data collection; follow lesson 1's precautions if pendulums are used.

Teacher notes and misconceptions

- Students often think a "good" result means matching 9.81 exactly. Praise an honest uncertainty that includes the accepted value, and an honest discussion when it doesn't.
- Some students discard every inconvenient point. Ask them to show the rule they wrote in lesson 1 and to report each exclusion.
- g varies with location by around 0.7% over Earth's surface (about 9.780 m/s^2 at the Equator to about 9.832 m/s^2 at the poles at sea level); 9.81 m/s^2 is a rounded classroom value of standard gravity (9.80665 m/s^2). Don't treat a result of 9.79 or 9.83 as wrong.

Lesson 4: Writing the report

Back to the unit

Goal

Students write up the pendulum investigation in the IMRaD structure (Introduction, Methods, Results, Discussion), with methods another group could repeat, results with uncertainties, and an honest discussion of limitations. They learn why repeatable reports matter to science as a whole.

Materials

- Each group's plan (lesson 1), data and graph (lessons 2-3).
- The "weak report" extract below, printed or on a slide.
- A report template with the headings below.

Steps

✎ Opening (5 min)

Tell students: in 2015, a project called the Reproducibility Project: Psychology redid 100 published psychology studies. Of 97 original studies that had reported significant effects, only 36% replicated successfully, and the effects found were on average about half the original size. Ask: "What would you need from a report to be able to repeat it?" Collect answers: exact method, equipment, numbers of repeats, raw data, how the data were analysed, what was left out and why.

Make clear that this does not mean those scientists were dishonest or that psychology is uniquely unreliable. It shows that repeating work is how science checks itself, and that clear reports make repeating possible.

✎ Main activity (35 min)

1. **Fix a weak report (10 min).** Groups improve this extract, listing every problem they find:

   We did the pendulum experiment. We changed the length and timed it. The results are in the graph. Longer ones were slower. Our answer for g was 9.8 which is basically right, so it worked. There was some human error.

Problems to find (example answers): no question or hypothesis; method too vague to repeat (which lengths? measured to where? how many swings and repeats?); no table or units; "slower" not quantified; no uncertainty on g; "basically right" is not a comparison; "it worked" judges by the answer, not the method; "human error" names no specific error, so it can't be fixed; nothing about the excluded reading.

1. **Write the report (25 min).** Each student writes their own report, using their group's data. Headings and what goes under each:

2. **Title:** says what was measured, e.g. "How the length of a simple pendulum affects its period, and an estimate of g".
3. **Abstract (3-4 sentences, written last):** the question, the method in one line, the main result with its uncertainty, and the main conclusion.
4. **Introduction:** the question, why it matters, the formula $T = 2\pi\sqrt{(L/g)}$, and the hypothesis and prediction from the plan. Cite any source used.
5. **Methods:** equipment and numbered steps in enough detail for another group to repeat the work: how L was measured (pivot to centre of bob), release angle, number of swings timed, number of repeats, the rule for odd readings. Say what changed after the pilot and why.
6. **Results:** a table of raw readings with units, means and uncertainties; the T^2 against L graph with a best-fit line; the gradient and the calculation of g. Report every excluded reading and the reason for it. No interpretation here, just what was found.
7. **Discussion:** compare the result with the prediction and with the accepted value, using the uncertainty (does 9.81 m/s^2 lie within 9.8 ± 0.3 m/s^2?). Name specific random and systematic errors and which way each would push the result. Say what you would change next time. Separate planned conclusions from new ideas ("the angle data suggest a small effect; a planned test with more angles would check this").
8. **References:** every source used, in a consistent format.

✓ Discussion questions (with example answers)

1. Why write the abstract last? It summarises results and conclusions, which you only know at the end.
2. What goes in Results and what goes in Discussion? Results: what was measured and calculated (tables, graphs, numbers with uncertainties). Discussion: what it means, how far it can be trusted, and what to do next.
3. Your g came out as 9.5 ± 0.2 m/s^2, so 9.81 is outside your range. Should you change your data or leave out points until it fits? No. Report it honestly and look for a systematic error that would explain it (for example, lengths measured to the top of the bob make every L too short; work out which way that pushes g). A report that explains a mismatch well is better science than one that hides it.
4. Why report the excluded 14.0 s reading at all? So a reader can judge the decision, and repeat the analysis with or without it.

✓ Closing check (5 min, with answers)

1. What do the letters IMRaD stand for? (Introduction, Methods, Results, and Discussion.)
2. Give two details that must be in the Methods section for the pendulum. (Any two of: how L was measured, number of swings timed, number of repeats, release angle, bob mass, the rule for odd readings.)
3. Rewrite "there was some human error" as a useful sentence. (Example: "Starting and stopping the stopwatch by hand adds a random error of a few tenths of a second; timing ten swings reduced its effect on T to about 2%.")

Vocabulary

IMRaD, abstract, methods, results, discussion, limitation, reproducibility, replication, reference

Differentiation

- **Support:** provide sentence starters for each section ("We measured … by …", "Our value of g, … ± … m/s², is within/outside …").
- **Stretch:** read the Methods section of a short published school-level investigation or a science-fair report and identify one detail you would need to repeat it that is missing.

⚠ Safety

- No practical work in this lesson.

Teacher notes and misconceptions

- Students often treat the accepted value as the goal. Mark the honesty and quality of the uncertainty and discussion, not closeness to 9.81 m/s².
- Avoid presenting the replication figures as "most science is wrong". The figure is about one project in one field; the lesson is that checking and clear reporting matter everywhere.
- Some students copy each other's reports because the data are shared. Shared data are fine; the writing, graph and discussion should be each student's own.

Lesson 5: Peer review

Back to the unit

Goal

Students review another student's pendulum report using a checklist, write specific and kind comments, respond to the review of their own report, and take the closing check. The lesson ends by launching the extended independent investigation.

Materials

- Each student's report from lesson 4, with names replaced by a number.
- The review checklist below, printed.
- The closing check (10 questions, 20 marks).
- The extended investigation timeline and topic list below.

Steps

✎ Opening (5 min)

Explain that before most scientific papers are published, other experts in the field read them and recommend changes or rejection. This is **peer review**, and in academic publishing the reviewers are usually anonymous. Peer review catches many problems, but not all: reviewers usually see only the report, not the lab, which is why clear methods and repeating work still matter (lesson 4).

Today's reviews use numbers, not names, so that comments are about the report rather than the person.

✎ Main activity (25 min)

1. **Review (15 min).** Each student gets one report and fills in the checklist:

Question	Yes / partly / no	Where in the report? Comment
Could I repeat the method from this report alone?		
Are units and uncertainties given for every result?		
Is every excluded reading reported, with a reason?		
Does the graph match the table?		
Is the calculation of g correct? (check one step yourself)		
Does the discussion compare the result with the accepted value **using the uncertainty**?		
Are specific errors named, with the direction each would push the result?		
Are sources referenced?		

Then write a short review: **one thing done well; up to three most important changes, each specific** (say where, what, and why); and any small corrections.

Model the difference: - Not useful: "Your method is bad." - Useful: "Methods, step 2: you don't say where L was measured to. If it was the top of the bob, every L is short by the bob's radius, which would make g too small. Please state it."

1. **Respond (10 min).** Students read the review of their own report and write a short response, one line per comment: what they changed, or why they disagree. Disagreeing politely with a reason is acceptable; ignoring a comment is not.

✓ Closing check (15 min, 10 questions, 20 marks)

Answers and mark guidance follow each question. Two marks each.

1. A student asks: "Does the temperature of water affect how fast sugar dissolves?" Name the independent variable, the dependent variable and two control variables. Answer: independent: water temperature; dependent: time to dissolve (or mass dissolved in a set time); controls: any two of mass of sugar, volume of water, stirring, sugar grain size. 1 mark for IV and DV both correct, 1 mark for two valid controls.
2. What is a pilot run for? Give one change a pilot might lead to. Answer: a small trial to test the method before real data (1); e.g. timing ten swings instead of one, changing the range, adding a marker to count from (1).
3. Times for ten swings: 24.6 s, 24.9 s, 24.3 s. Find the mean time, its uncertainty (half the range), and the period T with its uncertainty. Answer: mean 24.6 ± 0.3 s (1); T = 2.46 ± 0.03 s (1).
4. Classify each as a random or systematic error: (a) a thermometer that always reads 2 °C too high; (b) stopwatch readings that scatter above and below the mean because of reaction time. Answer: (a) systematic (1); (b) random (1).
5. What does "precise but not accurate" mean? Give an example from the pendulum experiment. Answer: readings close to each other but all away from the true value (1); e.g. every length measured to the top of the bob, giving consistent repeats but a g that is too small (1).
6. A graph of T^2 against L has a gradient of 3.98 s^2/m. Calculate g, showing the formula you used. Answer: $g = 4\pi^2 \div$ gradient (1) $= 39.48 \div 3.98 \approx 9.92$ m/s^2 (1).
7. Ten-swing repeats are 30.1 s, 30.3 s and 27.2 s. The plan's rule is "more than 0.5 s from the other two → retake, or report and explain". What should the student do, and what is a likely cause? Answer: retake it, or if that's impossible exclude it and report it with the reason (1); a miscount of nine swings as ten, since $0.9 \times 30.2 \approx 27.2$ s (1).
8. A survey finds students who sleep more get higher test marks. Give one possible third (confounding) variable, and one way to test whether sleep itself makes a difference. Answer: any reasonable confounder, e.g. less screen time late at night, health, fewer after-school jobs (1); a described design, not one to run in class: either a controlled comparison where sleep is changed and other factors are kept as similar as possible, with appropriate ethics approval, or an observational comparison that also records the confounder and compares students who are similar on it (1). Accept either.
9. Which IMRaD section should contain (a) the table of raw readings, (b) an explanation of why your g came out lower than expected? Answer: (a) Results (1); (b) Discussion (1).
10. Rewrite this review comment so it is specific and useful: "Your graph is wrong." Answer: any comment that says where, what and why, e.g. "On the graph, the point at L = 0.60

m is plotted at 2.25 s², but the table gives 2.40 s². Please check which is right." 1 mark for a specific location/problem, 1 for a reason or suggested fix.

No pass mark is set. Use the results to decide what to reteach before the extended investigation.

✎ Launching the extended investigation (5 min, then several weeks)

Suggested timeline (about six weeks of part-time work; shorten to two weeks if needed):

Week	Student does	Teacher checks before the next step
1	Chooses a question; writes a one-page plan (lesson 1 headings), including the analysis and the rule for odd readings, and a risk assessment	**Approves plan and risk assessment** before any data are collected
2	Pilot run; revises plan	Revised plan
3-4	Collects data; keeps a dated lab notebook with all raw readings	Notebook spot-check
5	Drafts IMRaD report	Draft submitted
6	Peer review in pairs; writes response to review; submits final report and response	Final mark

Example questions, chosen because they need only equipment from earlier units and are low risk:

- How does drop height affect the bounce height of a ball? (physics; links to grade 9 forces)
- How does the number of layers of insulation affect how fast a cup of warm water cools? (use warm tap water, not boiling)
- How does light intensity affect the rate at which leaf discs float? (links to grade 7 photosynthesis)
- How does surface area or concentration affect a reaction rate, using only the reactions and concentrations in grade 11 rates of reaction?
- How does the density of a plant species change along a transect from a path? (links to grade 10 ecology)
- How does the amount of salt in water affect the germination of cress seeds?

Vocabulary

peer review, reviewer, response to reviewers, anonymous review, lab notebook, risk assessment

Differentiation

- **Support:** reviewers answer only the first four checklist rows; authors respond to the two most important comments.
- **Stretch:** reviewers check the g calculation from the raw data themselves and say whether they get the same answer.

⚠ Safety

- No practical work this lesson.
- For the extended investigation: no data collection before the teacher approves the plan and risk assessment. Investigations involving other people (surveys, reaction-time tests), animals, microorganisms, mains electricity, heating beyond warm tap water, or chemicals not used in earlier units need explicit teacher approval under the school's own safety and ethics rules.

Teacher notes and misconceptions

- Some students write only praise, others only criticism. Require one strength and specific changes.
- Students may treat a reviewer's comment as an order. Say clearly that authors may disagree with a reason; reviewers can be wrong too.
- Anonymity is easy to break in a small class. Its point here is to keep comments about the work; remind students that kindness rules still apply.