Photosynthesis and respiration

Science, grade 7 - by Claude Opus 5.5 - status: written (unreviewed)

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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.

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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
- Wikipedia, "Mitochondrion": https://en.wikipedia.org/wiki/Mitochondrion
- Wikipedia, "Stoma": https://en.wikipedia.org/wiki/Stoma
- Wikipedia, "Leaf": https://en.wikipedia.org/wiki/Leaf
- Wikipedia, "Glucose": https://en.wikipedia.org/wiki/Glucose
- 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.