

Biochemistry of Photosynthesis and Respiration

Unit 1 Lesson Plan · Biology · Secondary 4

This Lesson Plan is a teacher delivery guide for Unit 1 — objectives, timing, materials, and step-by-step lesson structure for all 11 sections. It is designed to be used alongside the companion Topic Note, which carries the full learner-facing content, diagrams, and practice questions in depth.

Note on timing: South Sudan's Curriculum Framework sets official periods-per-week by subject, but the exact current figure for S4 Biology was not available to confirm at time of writing. The period allocations below assume a standard 40-minute period and are a reasonable planning estimate based on section complexity — confirm against your school's actual timetable and the current Curriculum Framework before finalizing your term plan.

Sections and Suggested Periods

Section	Title	Periods
1.1	Necessity of chlorophyll, light energy and CO ₂ for photosynthesis	1
1.2	Limiting factors for photosynthesis	1
1.3	Internal structure of the leaf and its adaptations	1
1.4	Importance of photosynthesis	1
1.5	The process of photosynthesis	2
1.6	Chemical compounds which constitute living organisms	2
1.7	Respiration	2
1.8	Respiratory system in animals	1
1.9	Respiration in other animals	1
1.10	Gaseous exchange in human beings and plants	2
1.11	Gaseous exchange in plants	1
Total		15

Total: 15 periods across Unit 1 (~40 minutes each) — plan across as many weeks as your timetable's weekly Biology periods allow.

1.1 Necessity of Chlorophyll, Light Energy and Carbon Dioxide for Photosynthesis

Learning Objectives	• State the three requirements for photosynthesis. • Explain, using experimental evidence, why each requirement is necessary. • Interpret the results of a starch test correctly.
Materials	Iodine solution; ethanol; a leaf (any locally available broad leaf); beaker; test tube; heat source; two clear jars; local aquatic/soft-stem plant material; wooden splint and matches

Starter (5 min)

Ask: "If you left a plant in a dark cupboard for a week, would it still make food? Why or why not?" Take 2–3 answers without confirming, then say today's lesson will let them test this for themselves.

Main Teaching — Experiment — Testing for Starch and Testing for Gas Release (full steps in the Topic Note)

1. Demonstrate the starch test procedure (boil, decolorize in ethanol, iodine test) on a leaf prepared in advance (or run live if time allows — needs ~20 min lead time for boiling steps).
2. In parallel, set up the gas-release jars (sunlight vs dark box) at the start of the lesson so results are ready to check near the end of the period or at the start of the next one.
3. Guide students to record what each requirement (chlorophyll, light, CO₂) contributes, using the results as evidence, not just as facts to memorise.

Guided Practice / Check for Understanding

Cold-call 3–4 students to explain, in their own words, why the iodine colour change proves photosynthesis occurred (or didn't) in a specific part of a leaf.

Plenary (5 min)

Show the cassava leaf local example from the Topic Note and ask the class to predict the iodine test result before revealing it.

Homework

Students read the Topic Note section 1.1 at home and attempt the three leveled practice questions before the next lesson.

1.2 Limiting Factors for Photosynthesis

Learning Objectives	• Define a limiting factor. • Identify light intensity, CO₂ concentration, and temperature as the three main limiting factors. • Interpret a simple rate-vs-factor graph.
Materials	Copies of the three graphs from the Topic Note (or redraw on the board); local aquatic weed and baking soda (if running the bubble-counting experiment live); a lamp

Starter (5 min)

Ask: "A farmer has perfect sunlight, perfect water, but their crops still grow slowly. What could still be missing?"
Let students speculate before introducing the term 'limiting factor.'

Main Teaching — Experiment — Counting Bubbles Under Different Light Distances (full steps in the Topic Note)

1. Introduce the concept: only the scarcest factor controls the rate at any moment, regardless of how much of the other factors are available.
2. Walk through the three graph shapes (light, CO₂, temperature) on the board, asking students to explain in their own words why each curve flattens or falls where it does.
3. If time and materials allow, run the bubble-counting experiment as a live demonstration rather than only in the Topic Note; otherwise, present the maize field spacing local example and discuss as a class.

Guided Practice / Check for Understanding

Ask pairs to sketch (roughly) what they'd expect the graph to look like if a fourth, fictional factor were introduced, and explain their reasoning.

Plenary (5 min)

Return to the farmer scenario from the starter — ask the class to now correctly diagnose what might be limiting the farmer's crop growth.

Homework

Students complete the Research & Discussion prompts on crop spacing/watering timing from the Topic Note by talking to a family member or observing local crops.

1.3 Internal Structure of the Leaf and Its Adaptations to Photosynthesis

Learning Objectives	• Name the main layers of a leaf in cross-section. • Explain how each layer's structure suits its function in photosynthesis. • Relate stomata position to water loss.
Materials	A real leaf (any broad local leaf) to cut/observe in cross-section if a blade and hand lens are available; petroleum jelly; two identical leaves for the wilting experiment

Starter (5 min)

Hold up a leaf and ask: "Why is a leaf flat and thin rather than round and thick, like a potato?" Take a few guesses before moving into structure.

Main Teaching — Experiment — Comparing Upper and Lower Leaf Surfaces (full steps in the Topic Note)

1. Present the leaf cross-section diagram from the Topic Note and talk through each layer's adaptation, connecting back to what students already know about the requirements for photosynthesis (light, gas exchange).
2. Set up the petroleum jelly wilting experiment at the start of the lesson (or the day before) so results are visible by the end of the period or the next lesson.
3. Discuss the broad-vs-narrow leaf local example (banana vs grass) as a class.

Guided Practice / Check for Understanding

Ask students to label an unlabelled leaf cross-section diagram from memory, then check against the Topic Note diagram in pairs.

Plenary (5 min)

Ask: "Which layer would you expect to be thickest in a plant that grows in full, constant sun — and why?"

Homework

Students complete the Research & Discussion prompt comparing sun-grown vs shade-grown leaves, if such plants are accessible near home.

1.4 Importance of Photosynthesis

Learning Objectives	• List at least three areas of life that depend on photosynthesis. • Explain the role of plants as primary producers in a food chain. • Relate photosynthesis to the carbon cycle.
Materials	None required — discussion-based lesson

Starter (5 min)

Ask students to list, individually, everything they ate or used today that came (directly or indirectly) from a plant. Compare lists as a class.

Main Teaching — Guided Discussion — Tracing a Local Food Chain

1. Build the sorghum food chain example from the Topic Note on the board as a class, inviting students to extend it further (e.g. what eats the goat, what happens to waste).
2. Introduce the five areas of importance (food chains, oxygen, carbon cycle, raw materials, economic importance) as a table, asking students to supply their own local examples for each before revealing the Topic Note's.
3. Discuss briefly: what would change locally if a large area of forest or farmland disappeared?

Guided Practice / Check for Understanding

In pairs, students identify one product in the classroom or their bag that traces back to photosynthesis, and explain the chain in one sentence.

Plenary (5 min)

Revisit the opening list — ask if anyone wants to add or change an item now that they understand primary producers better.

Homework

Students complete the deforestation-consequences hard question and the Research & Discussion prompts from the Topic Note.

1.5 The Process of Photosynthesis

Learning Objectives	• Name the two stages of photosynthesis and where each occurs. • State the role of ATP, NADPH, and RuBisCO in linking the two stages. • Explain why the Calvin cycle depends on the light-dependent stage even though it doesn't use light directly.
Materials	Open space for the role-play demonstration, or desks/hoops to mark two zones; labelled cards or tokens for water, light energy, hydrogen/electrons, ATP, NADPH, CO ₂ , RuBisCO, glucose

Starter (5 min)

Ask: "If a leaf stops getting light, does its ability to build glucose stop instantly, or does it take a little time to run out?" Let students debate briefly — the answer sets up the ATP/NADPH link between stages.

Main Teaching — Demonstration — Modelling the Two Stages (full steps in the Topic Note)

1. Introduce the two stages by name (light-dependent stage; Calvin cycle) and their locations (thylakoid; stroma), avoiding the older informal 'light stage/dark stage' framing to prevent the common night-time misconception.
2. Run the physical role-play demonstration, assigning roles and walking the 'molecules' through both zones.
3. After the role-play, have students individually sketch the two-stage diagram from memory, labelling ATP and NADPH as the connectors.

Guided Practice / Check for Understanding

Ask: "If I remove the ATP/NADPH-carrying students from the demonstration, what happens to the Calvin cycle group?" Use their answer to check the linkage is understood, not just the diagram.

Plenary (5 min)

Correct the common misconception directly: ask the class to explain, in one sentence, why the Calvin cycle is not actually a 'night-time' process.

Homework

Students complete the three leveled practice questions on the two stages from the Topic Note.

1.6 Chemical Compounds Which Constitute Living Organisms

Learning Objectives	• Name the three main organic compound groups and their building blocks. • Distinguish monosaccharides, disaccharides, and polysaccharides with named examples. • Explain condensation and hydrolysis as reverse processes.
Materials	Iodine solution; vinegar; heat source; local food samples (cassava, groundnuts, boiled egg white, sorghum flour paste)

Starter (5 min)

Ask: "What's the difference between the energy you get from a spoon of sugar and a spoon of groundnut oil?"
Let students guess before introducing carbohydrates vs lipids.

Main Teaching — Experiment — Testing Foods for Starch and Protein (full steps in the Topic Note)

1. Introduce the three compound groups using the table from the Topic Note, emphasising the named examples (glucose, sucrose, starch, glycogen, cellulose; amino acids/peptide bonds; triglycerides/phospholipids) rather than only the general categories.
2. Run the food-testing experiment as a class or in small groups, recording results in a simple table.
3. Use the groundnut oil local example to discuss why lipids are more energy-dense than carbohydrates.

Guided Practice / Check for Understanding

Ask pairs to classify five foods from their own diet as carbohydrate, protein, or lipid-dominant, and justify one choice.

Plenary (5 min)

Ask: "Why can humans digest starch but not cellulose, even though both are made of the same glucose units?"
— check understanding of bonding differences, not just vocabulary.

Homework

Students complete the hard question comparing starch, glycogen, and cellulose from the Topic Note.

1.7 Respiration

Learning Objectives	• Distinguish aerobic from anaerobic respiration by process and ATP yield. • Name the main stages of aerobic respiration (glycolysis, Krebs cycle, electron transport chain) and where each occurs. • Explain why anaerobic respiration yields far less ATP than aerobic respiration.
Materials	Sugar; dry yeast; warm water; a small bottle; a balloon; rubber band

Starter (5 min)

Ask students to sprint on the spot for 20 seconds, then describe how their legs feel. Ask why — this sets up the aerobic/anaerobic distinction using their own bodies.

Main Teaching — Experiment — Yeast Fermentation (Anaerobic Respiration) (full steps in the Topic Note)

1. Set up the yeast fermentation experiment at the very start of the lesson, since it needs 30–60 minutes to show a visible result — check it again at the end of the period.
2. While it develops, teach the full aerobic pathway using the diagram from the Topic Note: glucose → glycolysis (+2 ATP) → pyruvate → acetyl-CoA → Krebs cycle (+2 ATP, NADH/FADH₂) → electron transport chain/oxidative phosphorylation (~26–28 ATP).
3. Contrast with anaerobic respiration (stops after glycolysis, 2 ATP only), using the muscle fatigue local example to ground it.

Guided Practice / Check for Understanding

Ask: "Why does the Krebs cycle only produce a small amount of ATP directly, if it's considered essential to aerobic respiration?" — checks whether students understand its real role (generating NADH/FADH₂) versus a common surface-level answer.

Plenary (5 min)

Check the yeast balloon experiment together and relate the inflation to CO₂ production during fermentation.

Homework

Students complete the sprinting hard question from the Topic Note, applying respiration type and ATP yield to a real physical scenario.

1.8 Respiratory System in Animals

Learning Objectives	• Name the respiratory organ used by at least four different animal groups. • List the three features common to all respiratory surfaces. • Explain why surface-area-to-volume ratio affects respiratory adaptation.
Materials	Two identical potatoes (or similar) for the surface-area-to-volume demonstration; a knife; string or paper for measuring

Starter (5 min)

Ask: "Why doesn't a fish just breathe air like we do, if there's more oxygen in air than in water?" Let students guess before introducing gills.

Main Teaching — Demonstration — Comparing Surface Area to Volume (full steps in the Topic Note)

1. Run the potato-cutting demonstration, comparing total surface area of one large cube versus eight small cubes of equal total volume.
2. Introduce the respiratory organ table (amoeba, earthworm, fish, insects, humans) and the three shared features (large surface area, thin, moist, well supplied with blood/fluid).
3. Discuss the local fish/gill example, correcting the common misconception that insects breathe through their mouths (spiracles instead).

Guided Practice / Check for Understanding

Ask students to explain, using the potato demonstration, why small or thin/folded structures make better respiratory surfaces than large solid ones.

Plenary (5 min)

Quick-fire round: name the respiratory organ for five different animals called out by the teacher.

Homework

Students complete the earthworm skin question from the Topic Note.

1.9 Respiration in Other Animals

Learning Objectives	• Explain how amoeba exchanges gases without specialised organs. • Relate diffusion to concentration gradients. • Explain why diffusion alone is insufficient for large organisms.
Materials	A clear glass of still water; food colouring or hibiscus (karkade) tea concentrate

Starter (5 min)

Ask: "Does amoeba have lungs, gills, or skin? If none of these, how does it breathe at all?" Let students sit with the question briefly before the diffusion demonstration.

Main Teaching — Demonstration — Modelling Diffusion Without a Pump (full steps in the Topic Note)

1. Run the food-colouring diffusion demonstration in still water, letting students observe the colour spread with no stirring.
2. Connect this directly to amoeba: gases move purely along a concentration gradient, with no heart or pump needed.
3. Discuss why this only works for very small organisms, using the surface-area-to-volume reasoning from 1.8.

Guided Practice / Check for Understanding

Ask: "If an amoeba-sized organism grew significantly larger but kept the same shape, what problem would it run into?" — checks genuine understanding of the scaling problem, not memorised fact.

Plenary (5 min)

Ask the class to name one other very small organism (real or hypothetical) that might rely on diffusion alone, and justify why.

Homework

Students complete the scaling hard question from the Topic Note.

1.10 Gaseous Exchange in Human Beings and Plants

Learning Objectives	• Name the airway route from trachea to alveoli. • Explain the breathing mechanism (diaphragm and rib cage movement) for inhalation and exhalation. • Explain why the alveolus is well suited to gas exchange.
Materials	Small balloon; plastic bottle with base removed; second balloon; straw or tube; rubber band

Starter (5 min)

Ask students to place a hand on their own chest and take a deep breath. Ask what they notice moving, and what they think is happening inside.

Main Teaching — Demonstration — Modelling the Breathing Mechanism (full steps in the Topic Note)

1. Build and demonstrate the balloon-and-bottle breathing model, pulling and pushing the stretched balloon to show inhalation and exhalation.
2. Introduce the airway route (trachea → bronchi → bronchioles → alveoli) and explain why the branching itself is an adaptation for surface area.
3. Use the alveolus diagram from the Topic Note to explain gas exchange, tying back to the shared respiratory-surface features from 1.8.

Guided Practice / Check for Understanding

Ask pairs to explain, using the model, what is physically happening to chest volume during inhalation and why that causes air to rush in.

Plenary (5 min)

Ask: "Why might someone with thickened alveolar walls feel breathless even without exercising?" — checks understanding of diffusion distance, not just mechanics.

Homework

Students complete the breathing-rate measurement Research & Discussion activity from the Topic Note at home.

1.11 Gaseous Exchange in Plants

Learning Objectives	• Explain how guard cells control gas exchange through stomata. • Explain why the net direction of gas exchange in a leaf reverses between day and night. • Relate stomatal closure to water conservation in dry conditions.
Materials	Clear nail polish; clear tape; a fresh leaf; a hand lens or microscope if available

Starter (5 min)

Ask: "Do plants ever stop 'breathing,' even at night?" Let students debate before introducing net gas exchange direction.

Main Teaching — Experiment — Observing Stomata Under a Hand Lens (full steps in the Topic Note)

1. Run the leaf-peel experiment to observe guard cells and stomata directly, if a hand lens or microscope is available; otherwise use the Topic Note diagram.
2. Present the day-vs-night gas exchange table, correcting the common misconception that plants only ever release oxygen and only ever take in CO₂.
3. Discuss the dry-season stomatal closure local example as a trade-off between water conservation and photosynthesis rate.

Guided Practice / Check for Understanding

Ask: "At what time of day would you expect a leaf's net gas exchange to briefly balance to almost zero?" (near dawn/dusk, as photosynthesis and respiration rates cross over) — a stretch question for stronger students.

Plenary (5 min)

Ask the class to explain, in one sentence each, why closing stomata during the hottest part of the day can benefit a plant despite slowing photosynthesis.

Homework

Students complete the tree-observation Research & Discussion prompt from the Topic Note.