

Capturing the Sun's Energy: Mastery Check

Learning target: I can show that I know how producers capture light energy and build matter from carbon dioxide and water, trace atoms and energy through the photosynthesis equation, and explain with evidence where a plant's mass and energy come from.

Retrieval and mastery check

About 35 min

Individual

MS-LS1-6 · assesses

MS-ETS1-2 · supports

independent practice

writing

Standards connections

MS-LS1-6 (assesses): The mixed items check the ideas the explanation depends on, and the synthesis paragraph asks for an evidence-based explanation of photosynthesis's role in moving matter and energy into a producer. No item asks for the biochemical mechanism.

MS-ETS1-2 (supports): One item checks the criterion-versus-constraint distinction from the biofuel strand as background for evaluating design solutions.

Purpose: assess · **Time:** about 35 minutes · **Format:** individual

Answers with reasoning

Part A: Retrieval (12 items)

1. Which of these is the **energy** input of photosynthesis?

Answer: C. Sunlight.

Why: Carbon dioxide and water are matter inputs; oxygen is a product. Sunlight is the only energy input.

Also acceptable: None.

2. Which pair names the **products** of photosynthesis?

Answer: B. Sugar and oxygen.

Why: Products are written after the arrow: $C_6H_{12}O_6$ and O_2 .

Also acceptable: None.

3. True or false: a plant's cells use sugar for energy only at night, when photosynthesis has stopped.

Answer: False. Plant cells use sugar for energy at all times, day and night; in daylight photosynthesis simply outpaces that use, so the plant gives off oxygen overall.

Why: This is the day-and-night switch misconception. Credit requires 'false' with the all-times idea.

Also acceptable: Accept 'false, they do it all the time.'

4. Most of the dry mass of a tree comes from which source?

Answer: C. Carbon dioxide taken from the air.

Why: About 90 percent of dry mass is carbon and oxygen traceable to carbon dioxide; water supplies a smaller share (hydrogen); minerals are a few percent; sunlight has no mass.

Also acceptable: None.

5. In the equation $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$, count the oxygen atoms on the reactant side and on the product side. Show the multiplication for each side.

Answer: Reactant side: $6 \times 2 = 12$ (from CO_2) + $6 \times 1 = 6$ (from H_2O) = 18 oxygen atoms. Product side: 6 (in $\text{C}_6\text{H}_{12}\text{O}_6$) + $6 \times 2 = 12$ (from O_2) = 18 oxygen atoms. Equal, so oxygen is balanced.

Why: Both sides total 18. The most common error is forgetting the 6 oxygen atoms inside the sugar.

Also acceptable: Accept the count as a two-column list.

6. Explain why leaves look green, using the words 'absorbs' and 'less'.

Answer: Chlorophyll absorbs red and blue light strongly and absorbs green light less, so more green light is reflected or passes through the leaf and reaches our eyes.

Why: The accurate statement is 'less', not 'none'.

Also acceptable: Accept 'reflects more green light than red or blue.'

- Uses 'absorbs' and 'less' correctly
- States that the green light we see is the light not absorbed

7. Producers link many sugar units into chains. The chain called _____ is stored in roots, seeds and fruits for later use; the chain called _____ forms the stiff walls of plant cells.

Answer: starch; cellulose

Why: Starch is storage; cellulose is structure.

Also acceptable: None.

8. What happens to the light energy a leaf absorbs during photosynthesis?

Answer: B. It is stored as chemical energy in the sugar and released when the sugar reacts with oxygen.

Why: A treats energy as matter; C violates conservation of energy; D confuses the oxygen product with the energy.

Also acceptable: None.

9. A green leaf held under water in bright light gives off a stream of bubbles; the same leaf in the dark gives off none. State two conclusions this evidence supports and one thing it does **not** tell you.

Answer: Conclusions: (1) the leaf releases a gas only when it has light, so light is required; (2) the gas comes from the green leaf itself. Does not tell you: what the gas is (a glowing-splint test would be needed), where the leaf's matter comes from, or whether the leaf is still active in the dark.

Why: Students should separate what the evidence shows from what it leaves open; any one accurate limitation earns the third part.

Also acceptable: Accept 'it does not show that the bubbles are oxygen' or 'it does not show the leaf uses sugar in the dark.'

- Two supported conclusions about light or the leaf as the source
- One accurate limitation

10. A sealed jar with a plant in the light drops from 900 ppm to 600 ppm of carbon dioxide in 20 minutes. An identical jar in the dark rises from 900 ppm to 1000 ppm in the same 20 minutes. Calculate the rate of change for each jar in ppm per minute. Then estimate how fast photosynthesis in the lit jar was actually removing carbon dioxide, assuming the plant releases carbon dioxide at the dark-jar rate at all times.

Answer: Lit jar: $(600 - 900) \div 20 = -300 \div 20 = -15$ ppm per minute. Dark jar: $(1000 - 900) \div 20 = 100 \div 20 = +5$ ppm per minute. If the plant releases 5 ppm per minute at all times, then for the lit jar to fall by 15 per minute, photosynthesis must remove $15 + 5 = 20$ ppm per minute.

Why: Net change equals removal minus release, so removal equals the net fall plus the release rate.

Also acceptable: Accept 20 ppm per minute with the reasoning shown; accept -15, +5 written with words instead of signs.

11. A town choosing a biofuel for its buses writes two statements: 'The fuel must not be made from food crops' and 'The fuel should store as much energy per kilogram as possible.' Label each as a criterion or a constraint and explain the difference in one sentence.

Answer: 'Must not be made from food crops' is a constraint: a fuel either meets it or is ruled out. 'Should store as much energy per kilogram as possible' is a criterion: fuels are compared on how well they do it. A constraint is a limit that cannot be broken; a criterion is a goal a solution meets more or less well.

Why: The pass-or-fail versus better-or-worse distinction.

Also acceptable: Accept 'rule versus goal' phrasing.

- Food-crop statement labeled constraint
- Energy statement labeled criterion
- Difference stated

12. Draw a simple leaf. Show the three inputs and two outputs of photosynthesis as labeled arrows, using solid arrows for matter and a dashed arrow for energy. Mark where the reaction happens inside the leaf cell.

Answer: A leaf with: a dashed arrow in labeled 'light energy' or 'sunlight'; solid arrows in labeled 'carbon dioxide' and 'water' (water arriving from the stem or roots); solid arrows out labeled 'oxygen' and 'sugar' (sugar may be shown staying in or leaving the leaf); a labeled dot or small shape inside a leaf cell marked 'chloroplast'.

Why: Credit requires all five arrows with correct solid-versus-dashed use and the chloroplast marked as the site.

Also acceptable: Accept 'chlorophyll' written at the site if the student also indicates it is inside a cell structure.

- Three inputs with light as dashed
- Two outputs as solid
- Chloroplast marked inside a cell

Part B: Synthesis

13. Write a paragraph of 5 to 7 sentences answering: **Where does a giant sequoia's enormous mass come from, and where does the energy to build it come from?** Your paragraph must name the matter inputs and the energy input, use at least one piece of evidence from this chapter (an experiment, a dataset or a ledger), explain why light cannot be the source of the tree's mass, and say what happens to the energy once it is in the tree.

Answer: Model paragraph: A giant sequoia builds its mass mainly from carbon dioxide taken in from the air and water taken in by its roots, not from the soil. The energy to do this comes from sunlight, which is absorbed by chlorophyll inside the chloroplasts of its needles. Evidence for this comes from the willow experiment, in which a tree gained about 164 pounds while its soil lost only about 2 ounces, and from the sealed greenhouse ledger, where 176 grams of carbon dioxide and 72 grams of water accounted for 126 grams of new plant plus the oxygen given off. Light cannot be the source of the tree's mass because light has no atoms and no mass; it is energy, and matter can only come from other matter. Once captured, the light's energy is stored as chemical energy in the sugar the tree makes. The tree uses some of that sugar for energy by reacting it with oxygen, stores some as starch, and links most of it into cellulose, which is the largest single ingredient of its wood.

Why: Full credit requires the matter inputs, the energy input, one specific piece of evidence with a number, the no-atoms argument against light as a mass source, and the fate of the energy (stored in sugar, released when used, or built into starch and cellulose).

Also acceptable: Evidence may come from the willow (W3), the bubble or sensor data (W5), the greenhouse ledger (W6), or the evidence cards (W8). A paragraph that says 'minerals from soil are a few percent' is adding accurate detail.

- Names carbon dioxide and water as matter inputs and rules out soil as the main source
- Names sunlight as the energy input absorbed by chlorophyll or chloroplasts
- Cites one chapter experiment, dataset or ledger with a number
- Explains that light has no mass or atoms so cannot become the tree's matter
- States what happens to the captured energy

Teacher notes

Items q1 to q12 are scored one point each with q5, q9 and q10 worth two (one for the work, one for the result), for 15 points in Part A; Part B is scored against its five criteria for 5 points. Items q3, q4, q6 and q8 target the chapter's four persistent confusions: the day-and-night switch, soil as food, chlorophyll and green light, and energy as a substance. The q10 figures are new so that students cannot reuse the W5 numbers; the method is the same. If a student answers q4 with water, point them back to dry mass in W6. For q13, any one of the chapter's evidence sources is acceptable, but it must carry a number; the paragraph frame in the scaffold may be offered to students who need it without changing the scoring.

Scaffold offered to students: Paragraph frame for Part B

Sentence 1: A sequoia builds its mass from ___ and ___, not from ___. Sentence 2: The energy comes from ___, which is absorbed by ___ inside the ___. Sentence 3: Evidence: ___ (name an experiment, dataset or ledger and one number). Sentence 4: Light cannot be the source of mass because ___. Sentence 5: Once captured, the energy is ___ in the sugar, and the tree ___. Sentence 6 (optional): The tree builds the sugar into ___ and ___, which is where most of the wood comes from.

Extension: Two-way check

Write one multiple-choice item of your own that a classmate who still believes 'plants eat soil' would get wrong, with four options and the correct answer marked. Then write one numeric item that uses the photosynthesis equation and requires at least two steps to solve. Provide a full key for both, including the calculation, and explain in one sentence what each item is really testing.