

Follow the Evidence: A Photosynthesis Jigsaw

Learning target: I can work with a team to sort twelve pieces of evidence by the question each one answers, build a claim for each question that cites the cards, and defend our claims to another group.

Collaborative investigation

About 50 min

Jigsaw

MS-LS1-6 · practice

MS-LS2-3 · supports

collaboration

discussion

reading

Standards connections

MS-LS1-6 (practice): Students assemble an evidence-based explanation of where a producer's matter comes from, what light is needed for, what photosynthesis produces and what happens to the sugar. This is the explanation the PE asks for, built collaboratively from evidence cards, without the biochemical mechanism.

MS-LS2-3 (supports): Several cards trace matter between the nonliving air and living producers, and from producers to the organisms that eat them, which is background for modeling matter cycling in an ecosystem.

Purpose: practice · **Time:** about 50 minutes · **Format:** jigsaw

Answers with reasoning

Twelve evidence cards

1 Card 1: The willow and the soil (1648)

A physician planted a 5-pound willow in 200 pounds of dried soil, added only rainwater, and kept dust out. Five years later the tree had gained about 164 pounds. The soil, dried again, had lost about 2 ounces.

2 Card 2: The sealed jars (1804)

A chemist grew plants in sealed containers with measured amounts of carbon dioxide. Plants given carbon dioxide grew; plants in air with the carbon dioxide removed barely grew. The plants gained more mass than the carbon dioxide they took in.

3 Card 3: What a dried plant is made of (modern)

Dry a plant completely and analyze the powder: about 45 percent is carbon, about 45 percent oxygen, about 6 percent hydrogen, and only around 4 percent is minerals. The only carbon a plant can reach is the carbon dioxide in air or water.

4 Card 4: Bubbling leaves (1779)

Green leaves held under water in bright sunlight gave off streams of tiny bubbles; the collected gas made a glowing splint burst into flame. In shade or darkness the bubbles stopped. Roots, flowers and non-green parts never bubbled.

5 Card 5: The foil-covered leaf

A strip of foil was clipped over part of a leaf on a living plant for two days in sunlight. The leaf was then boiled, soaked in alcohol to remove its color, and tested with iodine. The uncovered part turned blue-black, which means starch was present. The covered part stayed yellow-brown: no starch.

6 Card 6: The pond sensor

An oxygen sensor left in a pond full of water plants records the same pattern every day: dissolved oxygen rises through the morning and afternoon, peaks in the late afternoon, and falls steadily through the night to a low point just before dawn.

7 Card 7: The mint and the mouse (1772)

A candle sealed in a glass jar soon went out, and a mouse sealed in a jar could not survive. After a sprig of mint had grown in the jar for several days, the candle burned again and a mouse could breathe. The plant had restored something to the air.

8 Card 8: The two-colored leaf

Some plants have leaves with green patches and white patches. A leaf like this was left in sunlight, then color-stripped and tested with iodine. Only the patches that had been green turned blue-black. The white patches, which have no chlorophyll, showed no starch.

9 Card 9: Under the microscope

A thin slice of a leaf shows cells crowded with small green structures, the chloroplasts; a single cell can hold dozens. A slice of a root from the same plant shows cells with none. In a living elodea leaf you can watch the chloroplasts drifting inside each cell.

10 Card 10: The sprouting potato

A potato left in a dark cupboard for six weeks grew long, pale shoots and became soft and lighter. Iodine testing showed much less starch inside than in a fresh potato. The potato received no light, no soil and no water, yet the shoots grew.

11 Card 11: Cotton and wood

Cotton fiber is nearly pure cellulose, and cellulose is the largest single ingredient of wood. Chemists can break cellulose apart with acid and heat, and what they get is sugar. Cellulose is a long chain made of thousands of linked sugar units.

12 Card 12: The dark jar

A leafy plant was sealed in a jar inside a dark box with gas sensors. Over several hours the carbon dioxide level rose steadily and the oxygen level fell. The plant was alive and green when the jar was opened, but it had lost a little mass.

Part A: Expert round (one set per person)

1. Your expert set: _____. For each of your three cards, write one sentence saying what the card shows and one phrase saying what it does **not** show (for example, 'does not say what the gas is').

Answer: Expected pairs, by card. 1: shows soil is not the source of a tree's mass; does not show where the mass does come from. 2: shows carbon dioxide is needed and that something else (water) adds mass; does not identify oxygen. 3: shows most dry mass is carbon and oxygen traceable to carbon dioxide; does not show that light is needed. 4: shows a gas that supports burning comes from green parts in light; does not measure mass. 5: shows starch forms only in lit parts of a leaf; does not say what the starch is made from. 6: shows oxygen rises by day and falls by night in a pond; does not separate plants from other pond life. 7: shows a plant restores air for a flame and a mouse; does not name the gas or show light is needed. 8: shows starch forms only where chlorophyll is present; does not show light is needed (both patches were lit). 9: shows chloroplasts are in leaf cells and absent from root cells; does not show what they do. 10: shows stored starch is used up to grow shoots in the dark; does not measure the gases. 11: shows cellulose is built from sugar units; does not show where it is made. 12: shows a plant in the dark releases carbon dioxide and uses oxygen; does not show what happens in light.

Why: The 'does not show' half is the skill: students should recognize the limits of each piece of evidence.

Also acceptable: Any accurate limitation earns credit; the list above is not exhaustive.

- All three cards described
- Each has a 'shows' sentence and a 'does not show' phrase that is accurate

Part B: Home group task

1. Lay all twelve cards on the desk. Sort them under the four questions in the group record table. Every card goes under exactly one question, the one it answers best. Expect disagreement; settle it by asking what the card actually measured.
2. For each question, write a one-sentence claim that the cards under it support. Cite the card numbers in parentheses.
3. Find the one card in each column that gives the **weakest** support for your claim, and write why. (Old evidence is not automatically weak; ask what the card could not rule out.)
4. Choose one claim to defend. Prepare a one-minute defense that names the cards and explains how they fit together. Every member must be able to give it.
5. Listen to the neighboring group's challenge, and record the strongest one together with your reply.

Group record (fill in the card numbers)

Question	Card numbers	Our claim (one sentence, cite cards)
Q1. Where does a producer's new matter come from?		
Q2. Is light required, and what is it needed for?		
Q3. What does photosynthesis produce, and where in the plant does it happen?		
Q4. What happens to the sugar after it is made?		

2. Group answer: Which card did your group argue about longest, and under which question did you finally put it? What settled the argument?

Answer: Intended sorting: Q1: cards 1, 2, 3. Q2: cards 4, 5, 6. Q3: cards 7, 8, 9. Q4: cards 10, 11, 12. Most argued-over cards are 4 (light requirement or oxygen product?), 6 (light or product?), 8 (chlorophyll requirement or location?) and 12 (dark, but about what sugar is used for). Any placement settled by what the card measured is acceptable: card 4 under Q3 (the gas relights a splint, so it is oxygen) is defensible; card 8 under Q2 (chlorophyll is a requirement) is defensible.

Why: The sorting is deliberately not clean; several cards answer two questions. Credit the reasoning about what was measured, not the final column.

Also acceptable: Accept any of the alternative placements above with a measurement-based reason.

- Names a card and a final placement
- Explains what settled it in terms of what the card measured or compared

3. Group answer: Write the strongest challenge the neighboring group made to your claim, and your reply. Name the cards used on both sides.

Answer: Common challenges and good replies. Challenge to Q1 ('Card 1 says water, not air'): reply with cards 2 and 3, which show carbon dioxide is needed and supplies most of the dry mass. Challenge to Q2 ('Card 6 could be fish or bacteria changing the oxygen'): reply that card 4 shows the gas comes from green leaves in light, and the pond pattern matches daylight. Challenge to Q3 ('Card 7 never says oxygen'): reply that card 4's gas relights a splint, which is the test for oxygen. Challenge to Q4 ('Card 10 is a potato, not a leaf'): reply that card 12 shows the same gas changes in a leafy plant and card 11 links cellulose and starch back to sugar.

Why: Quality of the exchange matters more than which challenge was made. Look for a specific challenge, card numbers on both sides, and a reply that uses evidence rather than restating the claim.

Also acceptable: Any evidence-based exchange earns credit.

- Records a real challenge with a card number
- Reply cites at least one card

Part C: Individual accountability (complete alone)

4. Cards 1 and 2 are more than 200 years old. Explain why Card 3, from modern instruments, does not make them useless. What does each old card show that Card 3 alone cannot?

Answer: Card 3 says what a plant is made of but not how it got that way or where the matter did not come from. Card 1 rules out soil directly by weighing it, which Card 3 only implies through the 4 percent figure. Card 2 shows carbon dioxide is required and that mass gain exceeds the carbon dioxide taken in, which points to water; Card 3 gives composition but no test of what happens when carbon dioxide is removed. The old cards show cause by changing one thing; the modern card shows result.

Why: Students should distinguish compositional evidence from experimental evidence.

Also acceptable: Accept 'the old cards are experiments; Card 3 is a measurement.'

- States that Card 3 shows composition, not cause
- Names what Card 1 and Card 2 each show that Card 3 cannot

5. Cards 5 and 8 use the same iodine test but answer different questions. Explain what each one holds constant and what each one changes, and why that matters.

Answer: Card 5 holds the leaf's chlorophyll constant (the whole leaf is green) and changes the light (foil versus no foil), so it tests whether light is required to make starch. Card 8 holds the light constant (the whole leaf is lit) and changes the chlorophyll (green patch versus white patch), so it tests whether chlorophyll is required. Changing only one thing at a time is what lets each card answer its own question; if both varied at once, you could not tell which one mattered.

Why: This is a controlled-variable comparison between two classic tests.

Also acceptable: Accept 'Card 5 tests light; Card 8 tests chlorophyll' with the reason.

- Card 5: light varied, chlorophyll constant
- Card 8: chlorophyll varied, light constant
- Explains why one variable at a time matters

6. Cards 10 and 12 both describe plants in the dark. Using both cards, write a short explanation of what a producer does with its sugar when there is no light, and what that tells you about where the lost mass went.

Answer: Without light a producer cannot make new sugar, but its cells still need energy, so they use stored sugar and starch. Card 10 shows the stored starch being used up to grow shoots and the potato getting lighter. Card 12 shows what leaves the plant while this happens: carbon dioxide goes up and oxygen goes down, because the cells react sugar with oxygen and release carbon dioxide. The lost mass did not vanish; its atoms left the plant as carbon dioxide gas.

Why: Full credit connects the two cards: stored sugar used (card 10) and the gases exchanged (card 12), ending with conservation of matter.

Also acceptable: Naming the process as cellular respiration is correct but not required.

- Stored sugar or starch is used for energy in the dark
- Carbon dioxide released and oxygen used, citing card 12
- Lost mass explained as atoms leaving as carbon dioxide

7. Suppose a thirteenth card arrived: 'A plant grown under a green-only lamp for two weeks grew, but only about half as much as an identical plant under a white lamp.' Under which question would you file it, and what would it add that Card 8 does not?

Answer: File it under Q2 (what light is needed for), or under Q3 as evidence about chlorophyll. It adds that green light is used less well than the full mix of colors, but still used: the plant grew about half as much, not zero. Card 8 shows chlorophyll is required but says nothing about which colors of light chlorophyll uses.

Why: This is the accurate statement about green light: absorbed weakly, not not at all. The 'half as much' figure in the imagined card is a plausible teaching value, not a measured one.

Also acceptable: Accept 'it shows that leaves do absorb some green light' as the addition.

- Files it under Q2 or Q3 with a reason
- States that green light still supports some growth
- Contrasts with Card 8's scope

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
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Evidence sorting	All twelve cards placed under a question with a measurement-based reason; alternative placements are argued from what the card measured.	Ten or eleven cards placed with reasons; one or two placed by topic words rather than by what was measured.	Cards sorted mostly by date, by scientist, or by topic words; several placements unexplained.	Cards left unsorted or sorted at random.
Claims with evidence	Four one-sentence claims, each accurate and citing at least two card numbers; the weakest card in each column is identified with a reason.	Four accurate claims with card citations; weakest-card reasoning thin or missing for one column.	Claims present but vague, uncited, or one claim inaccurate.	Claims missing or contradicted by the cards.
Defense and challenge	Every member can give the one-minute defense naming cards; the group records a specific challenge and answers it with card evidence.	Defense given by one or two members; challenge recorded and answered with evidence.	Defense restates the claim without cards, or the challenge is recorded without a reply.	No defense or no record of the exchange.
Individual accountability (Part C)	All four Part C answers accurate, cite cards by number, and show the student understands the group's reasoning rather than copying its result.	Three of four accurate with card citations; one thin or partly incorrect.	Two accurate; the others restate group results without reasoning.	Part C mostly blank or inaccurate.

Teacher notes

Print and cut the twelve cards; shuffle each deck before handing it out so that sorting is genuine. The expert sets (1, 5, 9; 2, 6, 10; 3, 7, 11; 4, 8, 12) each contain one card from three of the four questions so that every student touches most of the story. The historical cards are accurate: van Helmont's willow (published 1648), Priestley's mint (1772), Ingenhousz's submerged bubbling leaves (1779), Saussure's sealed containers (1804). The iodine tests (cards 5 and 8) and the sprouting potato (card 10) are standard classroom demonstrations; the pond oxygen pattern (card 6) is a real daily cycle, and the dark jar (card 12) matches the W5 sealed-jar data. Card 11's statement that acid and heat break cellulose into sugar is accurate and is the basis of some biofuel processes. Several cards answer two questions by design; grade the reasoning, not the column. Keep the discussion on tracing matter and energy and do not introduce the biochemical steps.

Scaffold offered to students: Ask what was measured

If a card is hard to place, do not ask what it is about; ask what was measured. A balance measures matter, so a card about mass goes under Q1. A card that compares light with dark or green with not-green goes under Q2 or Q3, depending on whether it is about a requirement (light, chlorophyll) or about a product and its location (oxygen, starch, chloroplasts). A card about what happens to starch, cellulose or stored sugar goes under Q4.

Extension: The missing card

Your deck has no card that directly shows water being used in photosynthesis; Card 2 only hints at it. Design the experiment that would produce that card. Describe what you would hold constant, what you would change, what you would measure, and what result would support the claim that water contributes matter to the plant. Explain why this is harder to test than carbon dioxide.