

Fixing Dario's Notebook: Eight Claims About Producers

Learning target: I can find the errors in a student's notes about how producers get matter and energy, explain what went wrong in each one, and rewrite the notes correctly.

Error analysis

About 35 min

Individual

MS-LS1-6 · practice

writing

independent practice

Standards connections

MS-LS1-6 (practice): Each notebook entry contains a flawed explanation of how matter or energy moves through a producer. Diagnosing and correcting them sharpens the explanation students will construct for the PE, without entering the biochemical mechanism.

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

Answers with reasoning

Dario's notebook: Capturing the Sun's Energy — Entry 1. Plants get their food from the soil. Their roots pull food up through the stem, which is why farmers add fertilizer. **Entry 2.** In photosynthesis, sunlight is changed into sugar. The more sunlight a leaf gets, the more sugar atoms it has. **Entry 3.** Leaves are green because chlorophyll absorbs green light better than any other color. **Entry 4.** Plants take in carbon dioxide through tiny openings in their leaves, and the oxygen they make leaves through the same openings. **Entry 5.** During the day a plant only does photosynthesis. At night it switches over to using sugar for energy, and that is the only time it gives off carbon dioxide. **Entry 6.** The equation is $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 3\text{O}_2$. It is three oxygen molecules because the sugar keeps half of the oxygen for itself. **Entry 7.** The energy from the sun is locked inside the sugar molecule. When the molecule breaks, the energy pops out. **Entry 8.** Starch and cellulose are completely different substances from sugar, so a plant must absorb them from the ground.

Part A: Diagnose and rewrite each entry

- Entry 1. Right or wrong? If wrong: what did Dario confuse, and what is the correct version? (Think about what 'food' means for a plant and what fertilizer actually supplies.)

Answer: Wrong. A plant's food is the sugar it makes itself from carbon dioxide and water using light energy; roots take in water and small amounts of minerals, not food. Fertilizer supplies minerals that help the plant work, but minerals are only a few percent of a plant's dry mass. Rewrite: 'Plants make their own food, sugar, in their leaves from carbon dioxide and water using light. Roots absorb water and minerals; fertilizer adds minerals, not food.'

Why: This is the soil-as-food belief that the willow experiment and the greenhouse ledger both refute.

Also acceptable: Accept 'minerals are like vitamins, not like meals' as the explanation of fertilizer.

- Identifies that soil supplies water and minerals, not food
- Rewrite states that sugar is made in leaves from carbon dioxide and water with light

2. Entry 2. Right or wrong? If wrong: find the word that treats energy as if it were matter, and rewrite the entry so that matter and energy are kept apart.

Answer: Wrong. The phrase 'sunlight is changed into sugar' treats light as if it were matter, and 'sugar atoms' from sunlight makes the same mistake. Light has no atoms; the atoms in sugar come from carbon dioxide and water. Rewrite: 'In photosynthesis, light energy is absorbed by chlorophyll and used to rearrange carbon dioxide and water into sugar. The light's energy ends up stored as chemical energy in the sugar. More light means more sugar can be made, as long as carbon dioxide and water are available.'

Why: Energy-as-substance is the chapter's central confusion. The rewrite must say the atoms come from the matter inputs and the light supplies energy.

Also acceptable: Accept 'light powers the reaction; it does not become the sugar.'

- Identifies 'changed into' or 'sugar atoms' as the error
- Rewrite names carbon dioxide and water as the atom source and light as energy

3. Entry 3. Right or wrong? If wrong: explain what chlorophyll actually does with green light compared with red and blue light, and rewrite the entry.

Answer: Wrong, it is backwards. Chlorophyll absorbs red and blue light strongly and green light weakly, so more of the green light bounces off or passes through the leaf, and that is the light that reaches our eyes. A leaf still absorbs some green light; it just absorbs less of it. Rewrite: 'Leaves look green because chlorophyll absorbs green light less than it absorbs red and blue light, so more green light leaves the leaf.'

Why: The accurate version avoids both the textbook's 'does not absorb green' and Dario's reversal. Students need the comparison: less green absorbed, not none.

Also acceptable: Accept 'reflects most green light' if the student does not claim zero absorption.

- States that green is absorbed least, red and blue most
- Rewrite says reflected or transmitted green light is what we see

4. Entry 4. Right or wrong? Explain your decision with one piece of evidence from this chapter.

Answer: Right. Carbon dioxide enters through tiny openings on the leaf surface and oxygen leaves through them. Evidence: the sealed-jar data (W5) showed the carbon dioxide level falling only when a leafy plant was in the light, and leaves held under water in light give off oxygen bubbles (W3); the gases had to pass in and out of the leaves.

Why: This is the trap entry; it is correct. Students who 'fix' it are pattern-matching rather than reading.

Also acceptable: Accept evidence from Ingenhousz's bubbling leaves (W3) or the leaf diagram (W4).

- Marks it right
- Gives one relevant piece of evidence

5. Entry 5. Right or wrong? If wrong: what does a plant's cells do with sugar during the day, and why does the plant still seem to 'only' give off oxygen then? Rewrite the entry.

Answer: Wrong. A plant's cells use sugar for energy all the time, day and night, and that always releases carbon dioxide. During the day photosynthesis takes in carbon dioxide and releases oxygen much faster than the cells release carbon dioxide, so overall the plant gives off oxygen; the carbon dioxide release is still happening underneath. Rewrite: 'Plant cells use sugar for energy at all times. In daylight, photosynthesis outpaces that, so the plant gives off oxygen overall; at night only the sugar use continues, so the plant gives off carbon dioxide.'

Why: The 'switch' belief comes from reading the day-and-night figure as two separate modes. The net-versus-underlying idea from W5 q10 is the correction.

Also acceptable: Accept 'net' or 'overall' language in any form; the word respiration is not required.

- States that sugar use and carbon dioxide release continue in daylight
- Explains that photosynthesis outpaces it in light, so the net effect is oxygen out

6. Entry 6. Right or wrong? If wrong: count the oxygen atoms on each side of Dario's equation and show the mismatch, then write the correct equation.

Answer: Wrong. Reactant side: 6 CO_2 has 12 oxygen atoms and $6 \text{ H}_2\text{O}$ has 6, total 18. Dario's product side: $\text{C}_6\text{H}_{12}\text{O}_6$ has 6 oxygen atoms and 3 O_2 has 6, total 12. Six oxygen atoms have vanished, which cannot happen. The sugar does keep 6 oxygen atoms, but the remaining 12 must leave as 6 O_2 . Correct equation: $6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2$.

Why: Atom counting is the check. Dario's 'keeps half' reasoning fails because $18 - 6 = 12$ oxygen atoms, which is 6 molecules of O_2 , not 3.

Also acceptable: Accept the count written as a table.

- Shows 18 oxygen atoms on the left and 12 on Dario's right
- Writes the correct equation with 6 O_2

7. Entry 7. Right or wrong? If wrong: what has to happen for the stored energy to be released, and what other substance is needed? Rewrite the entry.

Answer: Wrong. Energy is not released simply because a sugar molecule 'breaks'; pulling any bond apart actually takes energy. The stored chemical energy is released when the sugar reacts with oxygen to form carbon dioxide and water, a reaction a cell carries out in many small steps. Rewrite: 'The sun's energy is stored as chemical energy in the sugar. A cell releases that energy by reacting the sugar with oxygen, which produces carbon dioxide and water.'

Why: The guardrail is that breaking bonds does not release energy; energy is released over the whole reaction with oxygen. Keep the student version to 'reacts with oxygen'; do not go further into the chemistry.

Also acceptable: Accept 'the energy comes out when sugar and oxygen react' without the note about bond-breaking taking energy; the key point is that oxygen and a reaction are needed.

- States that a reaction with oxygen is required to release the energy
- Rewrite avoids 'breaking releases energy'

8. Entry 8. Right or wrong? If wrong: where do starch and cellulose actually come from, and how are they related to sugar? Rewrite the entry.

Answer: Wrong. Starch and cellulose are not absorbed from the ground; the plant builds them from its own sugar by linking many sugar units into long chains. Starch is the plant's storage form, and cellulose is the material of cell walls. Rewrite: 'Plants link sugar units together to make starch for storage and cellulose for cell walls. Both are made inside the plant from the sugar it produced.'

Why: This entry combines the soil-as-source error with a misunderstanding that starch and cellulose are unrelated to sugar.

Also acceptable: Accept 'chains of sugar' for both.

- States that starch and cellulose are built from sugar units inside the plant
- Rewrite names a use for each

Part B: Find the pattern

Most mistakes in science notes are not random. A single confused idea can produce several wrong sentences. Look back over the entries you marked wrong and sort them.

9. Sort the wrong entries into the three root causes. An entry may fit more than one row. In the second column write one sentence per row.

Answer: Root cause A (energy as a substance): entries 2 and 7. Dario needs to understand that light and chemical energy have no atoms; energy is captured, stored and released, but never becomes stuff. Root cause B (matter appearing or disappearing): entries 1, 6 and 8 (and 2, since it has sugar atoms appearing from light). Dario needs to understand that every atom in a plant came in as carbon dioxide, water or a mineral, and the counts on both sides of the equation must match. Root cause C (plants switching processes): entry 5. Dario needs to understand that cells use sugar at all times and that in light photosynthesis simply outpaces it.

Why: The sorting is more important than exact placement; entry 2 can legitimately sit in two rows. Entry 4 is correct and should not appear.

Also acceptable: Accept entry 7 in row B if the student explains that 'energy pops out' treats energy like a substance leaking from matter, which is really row A.

- Each wrong entry placed in at least one plausible row
- Entry 4 not listed
- One accurate sentence per row

10. Write a short note to Dario (4 to 6 sentences) that explains the **one** idea which, if he understood it, would fix the largest number of his entries. Name the entries it fixes and give him a way to check himself next time.

Answer: Model note: 'Dario, the one idea to hold onto is that matter and energy are different things, and matter is never created or destroyed. Light is energy, so it cannot turn into sugar (entry 2) and it cannot pop out of a molecule like a trapped object (entry 7); it is stored as chemical energy and released when sugar reacts with oxygen. Every atom in a plant came from carbon dioxide, water or minerals, so food cannot come from soil (entry 1), starch and cellulose must be built from the plant's own sugar (entry 8), and the oxygen atoms in the equation have to balance at 18 on each side (entry 6). Next time, ask two questions of every sentence: does this treat energy as a substance, and did any atoms appear or vanish?'

Why: The most powerful single idea is matter-versus-energy plus conservation of matter, which repairs five of the seven wrong entries. A student who chooses 'plants use sugar all the time' has picked an idea that fixes only entry 5 and should be credited only partially.

Also acceptable: A student who names conservation of matter alone (fixing entries 1, 6, 8) and separately mentions energy is still giving a strong answer.

- Names one unifying idea
- Links it explicitly to at least three entries
- Gives Dario a self-check

Teacher notes

Entry 4 is correct on purpose; expect some students to 'fix' it and use that as a discussion point about reading before correcting. Entries 2 and 7 carry the matter-versus-energy confusion in two forms; entry 7 also carries the common shorthand that energy is 'in the bonds' and released when they break. Keep the correction at the seventh-grade level: the energy is released when sugar reacts with oxygen; do not open the biochemistry. Entry 3 corrects both Dario's reversal and the textbook's simplification: leaves absorb green light weakly, not not at all. Entry 5 is the day-and-night switch suggested by the textbook's Figure 3 labels; the W5 sealed-jar rates give the evidence for the accurate version. For q9, entry 2 belongs in two rows; accept either or both.

Scaffold offered to students: Three test questions

When you are unsure whether an entry is wrong, run these three tests. Test 1: Does it say light or energy turns into stuff, or stuff turns into energy? Energy is not a substance. Test 2: Count atoms: do any atoms appear or disappear? They never do. Test 3: Does it say a plant stops using sugar, or stops needing something, at some time of day? A plant's cells use sugar for energy every hour of the day and night. If an entry fails a test, you have found the error.

Extension: Write the ninth entry

Write a new notebook entry of your own about biofuels that contains exactly one hidden error of the 'energy is a substance' type or the 'matter appears from nowhere' type. Trade with a partner and diagnose each other's entry. Then write a sentence explaining why the error you planted is tempting: what everyday experience makes it feel true?