

Using Stored Energy: Mastery Check

Learning target: I can show what I know about how producers and consumers get matter and energy, how cellular respiration releases energy from food, how food molecules become fuel, storage or body, and how photosynthesis and cellular respiration are related.

Retrieval and mastery check

About 40 min

Individual

MS-LS1-7 · assesses

MS-LS1-6 · supports

independent practice

writing

Standards connections

MS-LS1-7 (assesses): Items 5, 12 and 13 ask students to describe and draw how food is rearranged into new molecules that release energy or build the body, with atoms conserved; the other items check the vocabulary and ideas the model depends on. No item asks for the steps of the reaction.

MS-LS1-6 (supports): Items 9 and 13 connect photosynthesis to cellular respiration by the roles of oxygen and carbon dioxide and by tracing a carbon atom through both processes.

Purpose: assess · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

Part A: Retrieval (12 items)

1. Which organism is a consumer?

Answer: C. A shelf fungus absorbing the molecules of a fallen log.

Why: The fungus cannot make its own food; it absorbs another organism's matter and energy. The other three are producers that build their own sugar.

Also acceptable: None.

2. Which list gives the reactants and products of cellular respiration correctly?

Answer: B. Reactants: sugar and oxygen. Products: carbon dioxide and water, with energy released.

Why: Option A is photosynthesis; C and D mix the roles.

Also acceptable: None.

3. True or false: A plant's root cells carry out cellular respiration and take in oxygen from air pockets in the soil.

Answer: True.

Why: Root cells cannot photosynthesize and must release energy from sugar by cellular respiration, using oxygen from the air spaces in the soil; roots in flooded soil die for lack of it.

Also acceptable: None.

4. Most of cellular respiration takes place inside cell structures called _____, which are found in plant cells, animal cells and many single-celled organisms.

Answer: mitochondria

Why: The lesson's wording is 'most of' on purpose; the first steps happen outside the mitochondria, and some cells lack them.

Also acceptable: Accept 'mitochondrion.'

5. One sugar molecule contains 6 carbon atoms. When it is fully rearranged by cellular respiration, how many carbon dioxide molecules form, and how many oxygen atoms are in those carbon dioxide molecules altogether? Show the multiplication.

Answer: 6 carbon dioxide molecules form (one for each carbon atom). Each has 2 oxygen atoms, so $6 \times 2 = 12$ oxygen atoms altogether.

Why: Every carbon atom leaves in its own carbon dioxide molecule; the oxygen count is a simple multiplication.

Also acceptable: Accept '6 molecules; 12 oxygen atoms' with the multiplication shown.

6. Explain the difference between breathing and cellular respiration in two sentences, and say how they are connected.

Answer: Breathing is the movement of air into and out of the lungs; it brings oxygen into the body and carries carbon dioxide out. Cellular respiration is the chemical reaction inside cells in which sugar reacts with oxygen to release energy, forming carbon dioxide and water. They are connected because breathing delivers the oxygen that cellular respiration uses and removes the carbon dioxide it produces.

Why: The two sentences must separate transport from reaction; the connection is supply and removal.

Also acceptable: Accept 'plants do cellular respiration without breathing' as additional support.

- Breathing described as moving gases in and out of the body
- Cellular respiration described as a reaction in cells releasing energy
- Connection: breathing supplies oxygen and removes carbon dioxide for the reaction

7. Which food molecule releases the most energy per gram and is used for long-term energy storage?

Answer: C. Fat.

Why: Fat releases about 9 kcal per gram, compared with about 4 for carbohydrates (including starch) and protein.

Also acceptable: None.

8. A rabbit grows new muscle. Where did the carbon atoms in that new muscle come from? Be specific.

Answer: From the carbon atoms in the food the rabbit ate (for example, the proteins and other molecules in grass and leaves), which were digested into small pieces and rebuilt into the rabbit's own proteins. Not from the air the rabbit breathes.

Why: Consumers build their bodies from food, not from carbon dioxide; the air answer is the common error.

Also acceptable: Accept 'from the plants it ate.' A student who adds that the plants got the carbon from the air originally is correct.

- Source is the food (plants) the rabbit ate
- Mentions digestion into pieces and rebuilding, or at least that the atoms came from food molecules

9. Oxygen is a product of one process and a reactant of another. Which pair is correct?

Answer: B. Product of photosynthesis; reactant of cellular respiration.

Why: Photosynthesis gives off oxygen; cellular respiration uses it. Digestion is not a source or user of oxygen.

Also acceptable: None.

10. A snack contains 10 g of carbohydrate and 5 g of fat. Using 4 kcal per gram for carbohydrate and 9 kcal per gram for fat, calculate the total energy in kilocalories.

Answer: $10\text{ g} \times 4\text{ kcal/g} = 40\text{ kcal}$; $5\text{ g} \times 9\text{ kcal/g} = 45\text{ kcal}$; total $40 + 45 = 85\text{ kcal}$.

Why: Note that the smaller mass of fat supplies more energy than the larger mass of carbohydrate.

Also acceptable: Accept 85 kcal with the two multiplications shown.

11. True or false: When a squirrel's cells break down sugar, part of the sugar's mass is converted into energy, which is why the squirrel loses mass.

Answer: False. The sugar's atoms are rearranged into carbon dioxide and water, which leave the body; the mass is lost as those products, not as energy. Energy is released from chemical energy, and matter is conserved.

Why: The statement mixes matter and energy. A fixing phrase such as 'the mass leaves as carbon dioxide and water' earns the second point.

Also acceptable: Accept 'False; matter cannot turn into energy in this reaction.'

- False
- Fix: mass leaves as carbon dioxide and water (atoms conserved), energy is released separately

12. Draw a model of one animal cell carrying out cellular respiration. Show two arrows entering (label the two reactants), two arrows leaving (label the two products), the structure where most of the reaction happens, and the word 'energy' with an arrow to one thing the cell uses it for.

Answer: A cell drawn as a box with a mitochondrion inside; arrows in labeled 'sugar' and 'oxygen'; arrows out labeled 'carbon dioxide' and 'water'; the word 'energy' beside the mitochondrion with an arrow to a use such as 'moving,' 'building new molecules,' 'growth' or 'keeping warm.'

Why: This is the minimal model of the PE: reactants in, products out, the reaction placed in the mitochondria, energy released and used. No steps of the reaction are required or expected.

Also acceptable: A student who adds heat as a second energy output is correct.

- Two reactant arrows labeled sugar and oxygen
- Two product arrows labeled carbon dioxide and water
- Mitochondrion drawn and labeled
- Energy labeled with an arrow to a use

Part B: Synthesis

- 13.** Trace one carbon atom on a round trip: it starts in a carbon dioxide molecule in the air, becomes part of an oak tree, is stored in an acorn, is eaten by a squirrel, and returns to the air. Name the process at each step where the atom is rearranged into a new molecule, say where energy enters the story and where it leaves, and explain why the atom is never used up even though the energy is.

Answer: Model response: The carbon atom begins in a carbon dioxide molecule in the air. It enters an oak leaf, where photosynthesis uses energy from sunlight to rearrange carbon dioxide and water into a sugar molecule, so the atom is now part of sugar; this is where energy enters the story, captured from the sun and stored as chemical energy. The tree links sugars into starch and packs it into an acorn, so the atom is stored, still in a carbohydrate. A squirrel eats the acorn; digestion breaks the starch back into sugar, and the sugar travels in the blood to a muscle cell. In the cell's mitochondria, cellular respiration rearranges the sugar and oxygen into carbon dioxide and water, releasing the stored energy; the cell uses part of it to work and the rest leaves as heat. This is where the energy leaves the story. The carbon atom, now in carbon dioxide again, is breathed out into the air. The atom is never used up because chemical reactions only rearrange atoms into new molecules; the same carbon atom passed through carbon dioxide, sugar, starch, sugar and carbon dioxide and could be captured by another leaf tomorrow. The energy is 'used up' in the sense that it does not cycle back: it arrived as sunlight, was stored in sugar, and finally spread out as heat, so a living world needs a constant new supply of energy even though its atoms are reused.

Why: Full credit requires the two rearranging processes named at the right steps (photosynthesis in the leaf, cellular respiration in the squirrel's cells, with digestion as the step that frees sugar from starch), energy entering as sunlight and leaving as heat, and an explanation of why atoms cycle but energy does not.

Also acceptable: A student who has the atom become part of the squirrel's body (for example, in fat) before returning to the air much later has described a valid longer route; accept it if the processes are named. A student who says the energy is 'destroyed' should be marked down on the last criterion; it is converted to heat and spread out.

- Photosynthesis named at the leaf step with carbon dioxide becoming sugar
- Storage in the acorn as starch (or a carbohydrate)
- Digestion and cellular respiration named for the squirrel, with carbon dioxide breathed out
- Energy enters as sunlight and leaves as heat (and work)
- Explains that atoms are rearranged, not destroyed, while energy does not return

Teacher notes

Suggested scoring: items 1 to 12 at 2 points each (24) and q13 at 8 points (one for each criterion plus three for clarity and accuracy), for 32 total. The items are written to avoid the textbook's simplifications: q3 and q4 require that plants respire and that most (not all) of the reaction is in mitochondria; q8 checks that consumers get carbon from food, not air; q11 checks that mass does not become energy. The atom counting in q5 is the conservation idea from this lesson, not a detail of the reaction's steps, which the MS-LS1-7 assessment boundary excludes. Items 3, 6, 8 and 11 are the quickest diagnostic for the three major misconceptions; if more than a third of the class misses any of them, revisit W6 or W7 before moving on. The extension's oxygen trip is harder than it looks: the oxygen atom in the root water ends up in the oxygen gas released by photosynthesis, is breathed in by the squirrel, and leaves in water formed by cellular respiration.

Scaffold offered to students: Before you start

Read all thirteen items first and put a dot beside the four you feel most sure about; do those first to build momentum. For q13, plan on scrap paper with five boxes in a row (air, leaf, acorn, squirrel, air) and write the process name on each arrow before writing sentences. If you blank on a term, describe what it does; a correct description earns most of the credit.

Extension: Flip the trip

After finishing q13, write a second paragraph that follows an oxygen atom instead of a carbon atom, starting in a water molecule in the oak tree's roots and ending in a water molecule that the squirrel breathes out. Then explain in two sentences why the energy that reached the squirrel cannot be sent back to the sun, even though the atoms can return to the air.