

Reading the Leaf: Inputs, Outputs and a Balanced Equation

Learning target: I can read a model of a leaf to tell matter inputs and outputs apart from the energy input, check that atoms are conserved in the photosynthesis equation, and build my own model that traces matter and energy from the sun to a consumer.

Diagrams and models

About 35 min

Individual

MS-LS1-6 · practice

MS-LS2-3 · supports

visual modeling

independent practice

Name _____

Date _____

Period _____

Directions

Study Figure 1 and Figure 2 before you write anything. Figure 1 shows where things enter and leave a leaf. Figure 2 shows the same reaction as a chemical equation, with the molecules counted. Answer Part A from the figures. In Part B, draw your own model; a model is a drawing that explains, so every arrow needs a label.

You will need: This worksheet, Pencil, Colored pencils (optional, for solid and dashed arrows)

A leaf as a workshop: inputs and outputs

Sunlight (energy input)

Has no atoms and no mass. Absorbed by chlorophyll inside the chloroplasts.

Carbon dioxide, CO_2 (matter input)

A gas from the air. Enters through tiny openings on the leaf surface.

Water, H_2O (matter input)

Absorbed by the roots and carried up the stem to the leaf cells.

Chloroplast (where it happens)

A green structure inside each leaf cell. Holds chlorophyll. Not used up.

Sugar, $\text{C}_6\text{H}_{12}\text{O}_6$ (matter output)

Holds the captured energy as chemical energy. Used right away, stored as starch, or built into cellulose.

Oxygen, O_2 (matter output)

A gas. Leaves through the same openings the carbon dioxide came in.

Figure 1. Everything that enters or leaves a leaf during photosynthesis. Three things go in; two things come out. One of the inputs is not matter.



Reactants (left of the arrow)	Products (right of the arrow)
6 molecules of carbon dioxide; each CO ₂ has 1 carbon atom and 2 oxygen atoms	1 molecule of sugar; C ₆ H ₁₂ O ₆ has 6 carbon, 12 hydrogen and 6 oxygen atoms
6 molecules of water; each H ₂ O has 2 hydrogen atoms and 1 oxygen atom	6 molecules of oxygen gas; each O ₂ has 2 oxygen atoms
Light energy: no atoms	Chemical energy, now stored in the sugar: no atoms

Figure 2. The same reaction written as a chemical equation. Each molecule's atoms are listed so you can count them. Light energy appears on the left because the reaction cannot happen without it, but it is not a molecule.

Part A: Read the model

1. In Figure 1, which inputs are matter and which input is energy? How can you tell from the descriptions?

2. Trace the path of one carbon atom. Where is it before photosynthesis, how does it reach the chloroplast, and in which molecule does it end up?

3. Use Figure 2 to count every atom of each kind on each side of the arrow. Show one multiplication below the table (for example, 6 molecules × 2 oxygen atoms = 12 oxygen atoms).

Atoms on the reactant side	Atoms on the product side	Balanced? (yes/no)
Carbon (C)		
Hydrogen (H)		
Oxygen (O)		

4. A leaf makes 10 sugar molecules. How many carbon dioxide molecules did it use, and how many oxygen molecules did it release? Show the calculation.

5. What happens to the light energy that chlorophyll absorbs?
- ☐ A. It becomes part of the sugar's atoms, adding to the sugar's mass.
 - ☐ B. It is used up and disappears once the reaction is over.
 - ☐ C. It ends up stored as chemical energy in the sugar, and is released later when the sugar reacts with oxygen.
 - ☐ D. It is released right away as the oxygen leaves the leaf.
6. A student rewrites the equation as $6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 3 \text{ O}_2$, arguing that 'the sugar used up some of the oxygen.' Use your atom count from q3 to explain why this version is impossible.

7. Figure 1 says the chloroplast is 'not used up.' Why is it in the diagram at all if it is not a reactant or a product?

Part B: Build your own model

-  Draw a whole plant (roots, stem, leaves) with the sun above it and one animal that eats the plant beside it. Use **solid arrows for matter** and **dashed arrows for energy**. Show: (1) sunlight reaching a leaf; (2) carbon dioxide entering and oxygen leaving the leaf; (3) water moving from the roots to the leaf; (4) sugar moving from the leaf to one storage place such as a root or fruit; (5) matter and energy passing to the animal when it eats. Label every arrow with what it carries. Give your model a title.

8. Count the arrows in your model. How many solid (matter) arrows and how many dashed (energy) arrows did you draw? Which arrow was hardest to decide, and why?

9. Every model leaves things out. Name one thing that really happens in a plant that your model does not show, and one thing your model might make someone believe that is not true.

Count by column

For q3, make three columns on scrap paper: C, H, O. Go molecule by molecule. For 6 CO_2 write '6 C' under C and ' $6 \times 2 = 12\text{ O}$ ' under O. For $6\text{ H}_2\text{O}$ write ' $6 \times 2 = 12\text{ H}$ ' under H and '6 O' under O. Then add the O column: $12 + 6 = 18$. Do the same for the product side and compare. If the two sides do not match, you have found a counting slip, not a broken law.

Mass in, mass out

The approximate masses of the molecules in Figure 2 are: CO_2 44 units, H_2O 18 units, $\text{C}_6\text{H}_{12}\text{O}_6$ 180 units, O_2 32 units. Compute the total mass on the reactant side ($6 \times 44 + 6 \times 18$) and on the product side ($180 + 6 \times 32$). Explain what the comparison shows about matter in photosynthesis, and why the light energy does not appear in either total.