Lesson Plan: The Building Blocks of Photosynthesis

Summary
In this lesson, students will use colored blocks to represent the elements in photosynthesis and illustrate how they are broken down and reassembled to create glucose.

Resource Type  Grade Level
Lesson plan  Middle school

Objectives
By the end of this lesson, students should be able to
• Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Chemistry Topics
This lesson supports students’ understanding of the following topics in chemistry:
• Reactions
• Photosynthesis
• Conservation of matter

Time
Teacher Preparation: 20 minutes
Lesson: 45 minutes

Materials
• 6 red cubes
• 18 green cubes
• 12 blue cubes
• Sun’s Energy stickers

(Unifix cubes or Legos work great for this model. You can use any color you want, as long as the amounts stay the same and you change the key on the Student Activity Sheet.)

Safety
No specific safety precautions need to be observed for this lesson.

Vocabulary Terms
• Molecules
• Chemical reaction
• Glucose
• Oxygen
• Hydrogen
• Carbon
• Photosynthesis

Keywords
Photosynthesis, plants, oxygen, carbon-dioxide, respiration, glucose, yields
Teacher Notes

- If blocks are not available in the colors listed in the materials, certainly feel free to change the colors as needed but be sure to change the key as well.
- Other possible substitutions to blocks include K-Nex, colored paperclips, colored rubber bands, even colored string that can easily be tied in bows and pulled back apart.
- Students who perform at a higher level could be asked to apply this same model to respiration given the beginning part of the formula.

Lesson

Student Activity Sheet: Building Blocks of Photosynthesis

Engage

- Students will think-pair-share things that plants needs to survive. The class discussion should address why some things are necessary for plants to grow based on prior knowledge and solid examples. If there is some discrepancy about what plants need to grow, students will be asked to prove their ideas by creating an experiment to test their theory. For example, if students are unsure of whether plants need soil to grow, they should create an experiment investigating what happens to a plant growing without soil and a plant growing with soil.
- When the class has determined that a plant needs water, carbon dioxide, and sunlight to grow, write the final list on the board.

Explore

1. Have the blocks available and write the key on the board that explains what each colored blocks represent:
   - Red = Carbon
   - Blue = Oxygen
   - Green = Hydrogen
2. Ask students to independently list what a plant needs to grow.
3. Ask students, “What is water made of? What elements? Do you know other names for water?” This question should lead to the idea that water is made of H₂O.
4. Write H₂O on the board next to the key. Ask, “What does H₂O mean? Can you make H₂O out of the blocks that are provided?”
5. Have students volunteer and share their models of water. Discuss as a group until the group has decided that water is made out of two hydrogen atoms and one oxygen atom (two green blocks and one blue blue).
6. Tell students; “Plants take in six molecules of water at a time. Please make six molecules of water.”
7. Write on the board “6 H₂O +”
8. Ask students, “Plants need water to survive. What else do they need?” Allow students to answer carbon dioxide.
9. Ask students, “What do you think carbon dioxide looks like?” Allow them time to build their idea and then invite students up to explain their thinking.
10. When the class has decided that carbon dioxide is made up of one carbon atom and two oxygen atoms (one red and two blue blocks), have them use the remaining blocks to make carbon dioxide.
11. Ask students, “How many molecules of carbon dioxide did you make?” When students answer six, add this to your equation on the board: “6 H₂O + 6 CO₂”
12. Ask students, “What else does a plant need to survive?” Most likely they will answer sunlight. Ask, “What is the sunlight made out of? Are there any more blocks to make more molecules? What can you tell about sunlight?” With guidance, students should conclude that sunlight is an energy source.

13. Ask students, “What is the energy source in this model? What is moving the blocks?” They will answer that they are the energy source in the model, and they should realize that in this model they are playing the role of the sun.

14. Give each student a sticker that says “The Sun’s Energy,” so they can remember that they are the energy in the model.

15. Some students may not be able understand that they are using energy. Have them quickly rub their hands together for 15 seconds. When they say they’re tired, ask why. When they state that they are using too much energy rubbing their hands together, emphasize the word energy. Tell students, “You use energy to move things. The sun also gives off energy in a different form. You used a lot of energy to rub your hands together, how do you feel now? That is because you used energy to create that heat from friction, just like the sun uses energy to rearrange the molecules in photosynthesis.” On the equation on the board of “6 H₂O + 6 CO₂” write the “Sun’s Energy” and draw an arrow toward the equation to show that it helps the reaction take place but is not part of the molecular equation itself.

16. On the board, add a yields sign to your equation “6 H₂O + 6 CO₂ \rightarrow 6 O₂” Explain to students that “this symbol is what scientists use in an equation to say ‘yields’. It means that a chemical change is happening between the reactants (the chemicals on the left side of the arrow) and the products (the chemicals on the right side of the arrow).”

17. Ask students, “What does a plant release during photosynthesis?” Students should answer with oxygen.

18. Tell students that, “a plant does give off oxygen. In fact, it gives off six molecules of oxygen in the form of O₂. Can you rearrange your blocks to make six molecules of O₂?”

19. Add oxygen to your equation, “6 H₂O + 6 CO₂ \rightarrow 6 O₂”

20. Say to students, “Now look at all the blocks you have left. What else can the plant make? Use the blocks to make only one molecule of the last remaining chemical a plant makes during this chemical reaction. Figure out the molecular equation and write it down yourself from the blocks you have left.”

21. Have students share the chemical equation of the molecule that they have left. They should come up with C₆H₁₂O₆. Add that to the equation “6 H₂O + 6 CO₂ \rightarrow 6 O₂ + C₆H₁₂O₆.”

22. Ask students what they think this is. Tell them that, “this molecule is called glucose. It is really a type of sugar. Plants got through a process called photosynthesis to make this sugar. When you eat plants, you consume the sugar.”

**Explain**

Have students partner up and illustrate photosynthesis using the chemical equation that they just learned and their own illustrations of what it would look like. Have them share their explanation with the class.

Student examples could be as simple as drawing a plant breathing in air plus a glass of water and sunlight, yielding a bag of sugar and a person breathing in oxygen. On a more complex level, the teacher could have students draw molecules using the traditional ball and stick models. This is an opportunity for students of different levels to demonstrate different understandings through their own illustrations.
Elaborate
Ask students what would happen if they added another element to the process of photosynthesis? For example, what if they substituted ethanol (C₂H₅OH) for the water? Or what if they substituted coffee for water? Allow students to pick their own substitute for a part of the equation and create their own investigation where they can investigate the substitutions of different ingredients and form their own conclusions.

Evaluate

Multiple Choice Questions
1. What do plants need for photosynthesis?
   a. Carbon
   b. Oxygen
   c. Dioxide
   d. Carbon Dioxide*

2. What is C₆H₁₂O₆?
   a. Glucose*
   b. Calories
   c. Sucrose
   d. Carbon Hydroxide

3. What does the arrow in a chemical equation mean?
   a. Equals
   b. Same as
   c. Yields*
   d. Quantifies

4. In what part of the cell does photosynthesis take place?
   a. Mitochondria
   b. Vacuoles
   c. Cell membrane
   d. Chloroplasts*

5. What are the products of photosynthesis?
   a. Carbon dioxide and oxygen
   b. Oxygen and water
   c. Water and carbon dioxide
   d. Oxygen and glucose*

Discussion Questions
- How could you design a test to see if a plant really breathes in carbon dioxide?
- How is the model similar and different from real life?
- What would happen to humans if we didn’t have plants?
- What other species rely on plants for the sugar they provide?
- What other species rely on plants for the oxygen they provide?
- How does this equation illustrate the law of conservation of mass?

**Open Ended Question**
For the evaluation, have students write a paragraph explaining what happens in photosynthesis.

**Next Generation Science Standards**
This lesson supports the following:

Practices of Science and Engineering
- Developing and Using models
- Engaging in argument from evidence
- Using mathematical and computational thinking
- Obtaining, evaluating, and communicating information

Cross-Cutting Concepts
- Energy and Matter: Flows, Cycles, and Conservation

**Disciplinary Core Ideas, Grades 6-8**

**Life science**
- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6)

- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6)

- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (MS-LS1-7)

**Physical Science**
- MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

**Engineering Design**
- The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
• There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)

• Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)

• Models of all kinds are important for testing solutions. (MS-ETS1-4)

• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)

• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)