Just Breathe: An Introduction to Photosynthesis and Cellular Respiration

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Grade: 7th Grade Science

Time Required: Two class periods—45 minutes each

Standards:

- **SPI 0707.3.1** Compare the chemical compounds that make up the reactants and products of photosynthesis and respiration.
- **SPI 0707.3.2** Interpret a diagram to explain how oxygen and carbon dioxide are exchanged between living things and the environment

Lesson Objectives:

The learner will:

- Construct a model of the chemical compounds making up the reactants and products of photosynthesis and cellular respiration (day 1)
- Explain how oxygen and carbon dioxide are exchanged between living organisms and the environment (day 2)

Central Focus:

Cellular respiration and photosynthesis are biological processes in which matter and energy flow through the biosphere. These two processes are responsible for the exchange of oxygen and carbon dioxide between living organisms and the environment. Photosynthesis converts carbon dioxide and water into oxygen and glucose. Glucose is used as food by the plant and oxygen is a by-product. Cellular respiration converts oxygen and glucose into water and carbon dioxide. Water and carbon dioxide are by-products and ATP is energy that is transformed from the process.

Materials:

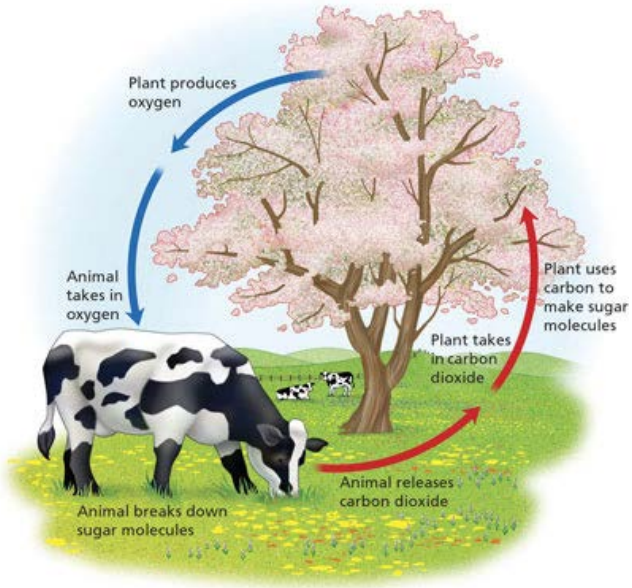
- 18 white marshmallows for oxygen
- 12 green marshmallows for hydrogen
- 6 pink marshmallows for carbon (Marshmallows can be presorted and a set for each pair of students can be placed in a plastic bag).
- 25-30 toothpicks
- Dry erase marker

- Equation mat (Pre-cut and laminated-poster board 22 x 28, cut in half long ways)
- Photosynthesis/cellular respiration article printout https://www.khanacademy.org/science/biology/photosynthesis-in-plants/introduction-to-stages-of-photosynthesis/a/intro-to-photosynthesis (remove light-dependent and Calvin Cycle section)
- Poster paper
- Markers

Background Information:

Plants make sugar by using energy from sunlight to transform carbon dioxide (CO_2), a gas absorbed from the air, and water (H20) taken from the ground by roots into glucose (C6H12O6) and oxygen (O2). This process is called photosynthesis and occurs in the chloroplast of the plant cell. Plants take in carbon dioxide through tiny openings or pores in their leaves called **stomata**. Special cells in the leaves of plants called **guard cells** open and close the stomata.

Cellular respiration is a process that occurs in the mitochondria of all organisms. In this process, both plants and animals break down simple sugars into carbon dioxide and water and release energy in the form of adenosine triphosphate (ATP). The ATP is used for all the processes that occur within a cell that need energy.



Chemical reaction is a process in which one or more substances, the **reactants**, are converted to one or more different substances, the **products**.

- **Reactants** are substances that start a chemical reaction. (ingredients)
- **Products** are substances that are produced in the reaction. (finished results)

The relationship between reactants and products in a chemical reaction can be represented by a chemical equation that has this general form:

Reactants → Products

The arrow (→) shows the direction in which the reaction occurs. In many reactions, the reaction also occurs in the opposite direction. This is represented with another arrow pointing in the opposite direction (←).

The reactants and products in a chemical reaction contain the same **atoms**, but they are rearranged during the reaction. As a result, the atoms end up in different combinations in the products. This makes the products new substances that are chemically different from the reactants.

Photosynthesis is a series of chemical reactions that convert carbon dioxide and water into glucose (sugar) and oxygen in the presence of sunlight.

Reactants — sunlight → Products

Carbon dioxide + Water → Glucose (sugar) + Oxygen

$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Cellular respiration or aerobic respiration is a series of chemical reactions which begin with the reactants of sugar in the presence of oxygen to produce carbon dioxide and water as waste products. This process occurs in the mitochondria, the powerhouse of the cell.

Reactants → Products

Glucose + Oxygen → Carbon dioxide + Water +ATP

$C_6H_{12}O_6 + 6O_2 \rightarrow CO_2 + H_2O$

Chemical equations must be balanced. A **balanced chemical equation** occurs when the number of the different atoms of elements in the reactants side is equal to that of the products side.

Key Terms:

chloroplasts	photosynthesis	cellular respiration
glucose	radiant energy	mitochondria
chlorophyll	stomata	ATP
chemical reaction	reactant	product
carbon dioxide	oxygen	

Day 1 Instruction:

Introduction (5 minutes)

- Motivator: Ask students what they are having/or have had for lunch. Address we, as heterotrophs, can get food for our bodies by eating! Show students an autotroph (either bringing one to class or showing one outside) and ask if the plant can go to the grocery store and get food to eat. Then, have students think what the purpose of breathing in air is. Hook students with these questions by not giving the answers right away and explain we will be investigating these ideas today.
- Refer to objective: Our objective for today is to construct a model of the chemical compounds making up the reactants and products of photosynthesis and cellular respiration

Activity 1 (10 minutes)

Use the following examples as an analogy for students to grasp the concept of reactants and products. Display on white board and discuss what the equations represent:

$$\text{eggs + cake mix + oil} \xrightarrow{\text{heat}} \text{cake}$$

$$\text{wheels + handle bars + frame + seat} \longrightarrow \text{bicycle}$$

Put the word equation for photosynthesis on the white board first.

$$\text{Carbon dioxide + water} \xrightarrow{\text{sunlight}} \text{oxygen + glucose}$$

Have students try to identify the meaning of the equation. Students share with the class their conclusions.

Explain there is more than one way to write an equation for photosynthesis. We can write the formula in words (referring to the equation on the board), or we can write the formula with the molecules' chemical formulas.

Show the chemical equation of photosynthesis.

$$CO_2 + H_2O \xrightarrow[\text{sunlight}]{} O_2 + C_6H_{12}O_6$$

Ask students to make connections between the two equations

Provide students with an analogy connecting the words to the chemical formulas with acronyms like ROYGBIV. Explain what an acronym is and give an example. ROYGBIV, the first letter of each color of the visible light spectrum, red, orange, yellow, green, blue, indigo, violet. Explain chemical formulas are similar to acronyms. It is a way to represent the words.

Extension to Activity 1 (5 minutes)

Part 1: Show students a double scale (justice scales) and ask students how to make them balance (same mass on each side). Chemical equations are just like scales, they have to have the same number of molecules or mass on each side. (The Law of Conservation of Mass is an 8th grade standard).

Part 2: Explain that chemical equations have to balance on both the reactant and product side and that the way we indicate this is with coefficients or numbers in front of molecules to make them balanced on both sides of the equation.

$$6CO_2 + 6H_2O \xrightarrow{\text{sunlight}} 6O_2 + C_6H_{12}O_6$$

Part 3: Explain that components that start on the left side as reactants will always end on the right side as products. Explain how the coefficients are necessary to make the equation balanced.

Activity 2 (20 minutes)

Part 1: Students get into pairs and teacher passes out all materials for the marshmallow modeling activity (worksheets, marshmallows, toothpicks, dry-erase marker, and equation mat)

Part 2: Teacher provides instruction on how to complete the activity referring to each step, models how one might perform the modeling activity, and explains the expectations of the students

Part 3: Students complete the activity

Part 4: Teacher circulates the classroom asking students questions:

1. What do the marshmallows represent?
2. Why do we have to attach the marshmallows together?
3. When modeling the process of photosynthesis (reactants to products), why did you rearrange the marshmallows instead of using new marshmallows?
4. Why is it important for plants to turn carbon dioxide and water into oxygen and sugar? Who benefits from this?
5. What is the purpose of cellular respiration? (scaffolding questions: Is cellular respiration only so humans can breathe? Or is the purpose to create energy for the cell?)
6. Where do plants get the water and carbon dioxide from?
7. Where do humans and other like organisms get oxygen from? How do you know?

Closure (5 minutes)

Revisit the lesson's objective: construct a model of the chemical compounds making up the reactants and products of photosynthesis and cellular respiration. Ask students to answer the following questions on the notecard:

1. How well do you feel you achieved today's objective? And why?
2. What question(s) do you still have about this topic? (list at least one)

Assessment

1. Formative assessment of students' verbal answers during Activity 1. If the sample representation of students does not demonstrate an understanding of the meaning of the equations and the connections between word and chemical equations, all students will need further guided instruction.
2. Formative assessment of student answers during Activity 2 teacher circulation. Students who do not demonstrate a mastery of accurately answering questions regarding the reactants and products of photosynthesis and cellular respiration will be paired with a partner who has demonstrated mastery for the following day's instruction.
3. Criterion-referenced assessment of completed marshmallow activity question sheet. Students who do not demonstrate a mastery of understanding the compounds making up the reactants and products of photosynthesis and cellular respiration will be put in small groups the following class to review misconceptions.
4. Formative assessment of student exit ticket. Student self-reflections and questions will be evaluated and used to direct the following class instruction.

Name: _____

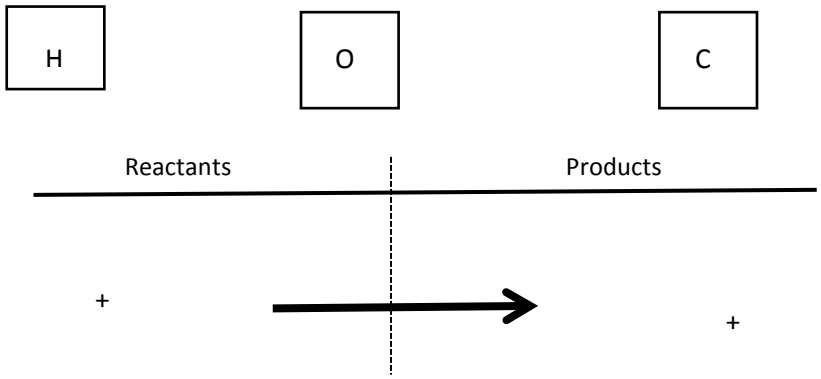
Photosynthesis—Marshmallow Model

Directions: Complete number 1- 7, and then answer the questions on the following page.

Materials Needed Per Pair

- 18 white marshmallows for oxygen
- 12 green marshmallows for hydrogen
- 6 pink marshmallows for carbon
- 25-30 toothpicks
- Dry erase marker
- Equation mat

1. **Use the dry erase marker and label the equation mat as follows:**



2. **Sort the marshmallows in the plastic bag and place the green marshmallows on the "H" for hydrogen, white marshmallows on the "O" for oxygen, and pink marshmallows on "C" for carbon. Toothpicks can be used whole or broken in half for shorter bonds.**

3. **In this activity, marshmallows will represent atoms of different molecules and the toothpicks will represent the bonds that hold the atoms together. To build a molecule of carbon dioxide, use one pink marshmallow and two white marshmallows and toothpicks for bonds. Make 6 of these and place them on the mat on the left side of the plus sign under reactants.**

4. **Build a molecule of water using two atoms of hydrogen (green) and one atom of oxygen (white) and toothpicks. Make 6 of these and place them on the left side of the mat under reactants on the right side of the plus sign.**

5. **In a chemical reaction, the arrow is known as "yields". Plants convert carbon dioxide and water into sugar and oxygen in the presence of sunlight. Use the dry erase marker and draw a sun over the arrow**

6. **Now make the products of photosynthesis using the marshmallows of the reactants. To make a molecule of oxygen, connect two oxygen (white) atoms together. Make 6 of these and place them on the mat to the right of the yield symbol before the plus sign.**

7. **Sugar or glucose is a big molecule. It will take 6 carbon (pink), 12 hydrogen (green), and 6 oxygen (white). Glucose does have a specific arrangement of atoms, but for this activity, just be creative and stick all the remaining atoms together.**

Name: _____

Questions:

1. In your own words, describe why the process of photosynthesis so important.

2. Write the equation for photosynthesis in two ways. (words and chemical symbols)

3. Write the equation for cellular respiration two ways. (words and chemical symbols)

4. In a chemical equation, what are reactants? What are the products? Why is a chemical equation like a “justice” scale?

5. In activity, what did the marshmallows represent? What did the toothpicks represent?

6. Why were students only given enough marshmallows to construct one side of the equation at a time?

7. Explain the relationship between photosynthesis and cellular respiration. Be sure to include the main purpose of both and where they occur inside the cell.

8. Plants have mitochondria and can perform cellular respiration. When would plants need to release energy by cellular respiration?

Answer Key

Questions:

1. Why is the process of photosynthesis so important?
   Photosynthesis is important because it is the process that plants use to transform carbon dioxide into oxygen with the help of sunlight. Animals need oxygen to survive and plants act as nature's air filter by removing harmful carbon dioxide.

2. Write the equation for photosynthesis in two ways. (words and chemical symbols)

Reactants → Products

Carbon dioxide + water —(sunlight)→ oxygen + sugar

$$CO_2 + H_2O \xrightarrow{\text{sunlight}} O_2 + C_6H_{12}O_6$$

$$6CO_2 + 6H_2O \xrightarrow{\text{sunlight}} 6O_2 + C_6H_{12}O_6$$

Some students may write the balanced equation. Teachers will need to specify which is acceptable.

3. Write the equation for cellular respiration two ways. (words and chemical symbols)

Reactants → Products

Glucose + Oxygen → Carbon dioxide + Water + ATP

$$C_6H_{12}O_6 + 6O_2 \rightarrow CO_2 + H_2O$$

Some students may write the balanced equation. Teachers will need to specify which is acceptable.

4. In a chemical equation, what are reactants? What are the products? Why is a chemical equation like a "justice" scale?
   Reactants are the substances that start a chemical reaction, the ingredients.
   Products are the substances produced in a chemical reaction, the end result.
   A chemical equation, just like a justice scale, must have the same mass on both sides to be balanced.

5. In activity, what did the marshmallows represent? What did the toothpicks represent?
   The marshmallows are the atoms of different molecules in the chemical equation of photosynthesis and cellular respiration and the toothpicks are bonds.

6. Why were students only given enough marshmallows to construct one side of the equation at a time?
   Students only had enough marshmallows for one side of the reaction at a time because reactants get used up in the reaction.

7. Explain the relationship between photosynthesis and cellular respiration. Be sure to include the main purpose of both and where they occur inside the cell.
   Photosynthesis is the process that plants use in the presence of sunlight to convert carbon dioxide taken in by their leaves and water taken in through the roots to produce oxygen and sugar (glucose). This process takes place in the chloroplast of the plant cell with the presence of the green pigment of chlorophyll. The main purpose of photosynthesis is to convert radiant energy from the sun into chemical energy that can be used for food. Cellular respiration is the process that occurs in the mitochondria of organisms (animals and plants) to break down sugar in the presence of oxygen to release energy in the form of ATP. This process releases carbon dioxide and water as waste products.

8. Plants have mitochondria and can perform cellular respiration. When would plants need to release energy by cellular respiration?
   Plants would release energy through cellular respiration in times when sunlight is not present. Certain plants, mushrooms and fungi, do not possess the chlorophyll to photosynthesize.

Day 2 Instruction

Introduction (5 minutes)

- Motivator: Revisit the questions posed on the first day of instruction: If a plant cannot simply go to the grocery store to get food to eat, where does it get its food from? What is the purpose of us breathing in air? Explain to students that in both of these cases, humans and plants interact with the environment they are found in.
- Refer to objective: Our objective for today: explain how oxygen and carbon dioxide are exchanged between living organisms and the environment

Activity (35 minutes)

Think (7 minutes)

Part1: Materials are provided to students (markers, poster paper, and age-appropriate article about photosynthesis, cellular respiration, and the cycling of oxygen and carbon dioxide in the environment).

Part 2: Using evidence from the article, students will work independently to make a poster showing the relationship between photosynthesis and cellular respiration. The poster will be a diagram that includes the following:

- Key terms: reactants, products, chemical compounds, photosynthesis, cellular respiration
- The equation for photosynthesis
- The equation for cellular respiration
- An explanation of each process
- The relationship between photosynthesis and cellular respiration
- The organelles where each occur

Pair (20 minutes)

Part 1: Students get in pairs with their table mates, discussing their initial ideas making edits as needed

Part 2: Students use the information on their posters to come up with ideas to demonstrate how oxygen and carbon dioxide are exchanged between living organisms and the environment. (Students are encouraged to be creative. Example: Students can draw a picture on their poster, create a demonstration with a model, write a poem/text/etc., and act out the process or any other way they want to present to their classmates.

Share (8 minutes – each pair gets 4 minutes to share)

Student pairs get with another student pair in a group of 4.

Part1: Student pairs display and present their posters for the other pair, identifying the reactants and products of photosynthesis and cellular respiration

Part 2: Then pairs use their creative method to explain how oxygen and carbon dioxide are exchanged between living organisms.

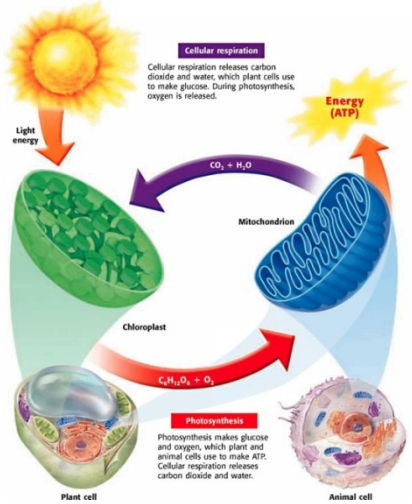
Closure (5 minutes)

Revisit the lesson's objective: explain how oxygen and carbon dioxide are exchanged between living organisms and the environment. Ask students to evaluate how well they believe they accomplished the objective by writing on an exit ticket.

Assessment

1. Formative assessment of student posters. Students who do not demonstrate a mastery of using key words and concepts to illustrate their understanding of cellular respiration and photosynthesis will be placed in a remediation group for the following class. Students in this group will work together to determine their misconceptions and misunderstandings found on their posters.
2. Performance-based assessment of student presentations. Students who do not demonstrate mastery of explaining how oxygen and carbon dioxide are exchanged between living organisms and the environment will need further guidance. Teacher may ask students scaffolding questions to guide their thought processes to a more mature explanation.

Examples of posters:



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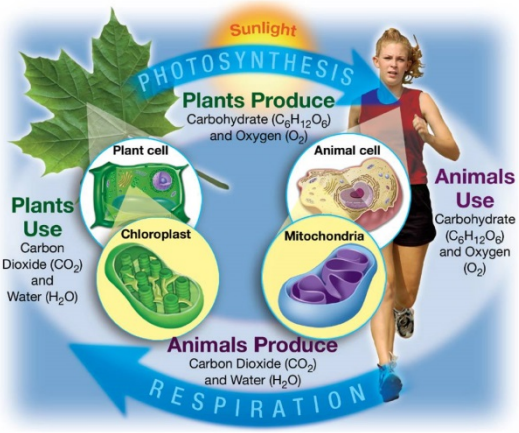

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