



Plant Metabolism: The Balance Between Photosynthesis and Cellular Respiration




Overview:

This lesson is part of a two-part series on metabolism. In the previous lesson: “Photosynthesis: How do Plants Make Their Own Food?” students learned how plants can make their own food and increase their weight. Today students will learn about cellular respiration, or how plants use that food for energy and decrease their weight. Students will run an experiment about a plant’s changing weight using different light conditions to illustrate the balance between photosynthesis and cellular respiration.



*Note: The experiment in this lesson will take five weeks to complete from beginning to end. The students will take their “radish pots” back to their classroom and weigh their plants each week.

Objectives:








At the end of the lesson students will be able to:

-  **Describe** how the process of cellular respiration creates energy by breaking down sugar.
-  **Understand** how the balance of photosynthesis and cellular respiration contributes to the weight of a plant. (Photosynthesis increases weight, while cellular respiration decreases weight.)
-  **Hypothesize** and **test** how different light conditions can contribute to a plant’s weight.



Preparation:

-  Prior to the lesson, review the handout.
-  Prepare radish seeds, two-inch pots, and potting soil for each group to plant.


Materials:

-  Handout: “The Balance Between Photosynthesis and Cellular Respiration”
-  Radish seeds
-  Two inch pots (with holes for drainage)
-  Potting soil
-  Markers
-  Electronic scale
-  Large poster of cellular respiration and photosynthesis equations (in words)

On the Board:

-  Vocabulary
-  Student Reflection Questions

Suggested Snack:

-  Radishes and hummus

Vocabulary:



photosynthesis
weight
energy



glucose
atmosphere



cellular
respiration

Learning Activities:

1. Presentation (25 min.)

- A. Introduce the concept of cellular respiration.
 - Cellular respiration is the opposite of photosynthesis. In photosynthesis, plants use light energy to make sugar and oxygen. In cellular respiration, plants break down sugar to make energy.
- B. Explain to students that a plant's weight comes from how much sugar it contains. Ask students: If a plant is undergoing a lot of cellular respiration and very little photosynthesis, is it gaining weight or losing weight? (losing weight)
 - Explain that the sugar is being broken down and released as energy. This is why it weighs less. Reference the large poster that describes cellular respiration with words.
- C. Ask students: What would cause a plant to undergo a lot of cellular respiration but very little photosynthesis? (no exposure to light, water or carbon dioxide)
 - If plants suddenly run out of water or carbon dioxide or there is no light source, they will undergo cellular respiration to break down existing plant mass for energy.

2. Classroom Activity (5 min.)

- A. Have students complete Exercise #1 on the handout.
- B. Ask students to share their answers with a partner. Then, call on two-three students to share their answers.

3. Garden Activity (20 min.)

- A. Take students into the garden and show them a radish plant and explain how radishes grow and how long it will take to harvest them (this information can be found on the seed packet).
- B. Explain the experiment that they will be performing over the next five weeks. Tell students they will find out what happens to a plant's weight under different light conditions. Today, they will set up an experiment and see what happens in a few weeks.
- C. Pass out the handout and read aloud the following instructions for the experiment.

1. Prepare two 2” pots with soil and radish seeds. Label one pot “#1” and the other “#2.” Weigh each pot on an electronic scale and record their weights below.
2. Place both cups in your classroom near a window with sunlight.
3. Each week, weigh each pot and record on your Handout.
4. After Week 4, label pot #1 “light” and pot #2 “no light.” Leave the pot labeled “light” in the sunny spot in the classroom. Place the pot labeled “no light” in a box where there is no light.
5. After 1 week, weigh both pots. Record their weights on your handout.

D. Divide students into groups of three-four, and provide each group with a pot, soil, and radish seeds.

E. Each week in their classroom, students will weigh their radish pots and record data in their handout.

4. Snack: Serve radishes from the garden paired with hummus as a dip. (5 min.)
5. Have students answer the Reflection Questions in their garden journals. (5 min.)

Student Reflection Questions:

1. Why is it important that plants release oxygen during photosynthesis?
 - **Animals/humans need oxygen to breathe.**
2. What was the hypothesis of the experiment you conducted?
 - **Plants lose weight and eventually die without sufficient sunlight.**

Assessment Questions:

1. Why do plants need both photosynthesis and cellular respiration?
 - **They have to make food for energy (photosynthesis), but then they have to use the energy (cellular respiration) to grow!**
2. Can photosynthesis occur without light energy?
 - **No**

Standards:

Next Generation Science Standards

- LSI.C: Organization for Matter and Energy Flow in Organisms

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.

- PS3.D: Energy in Chemical Processes and Everyday Life

Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)



The Balance Between Photosynthesis and Cellular Respiration

Photosynthesis is a process where plants make food for themselves using carbon dioxide, water, and energy from sunlight. **Cellular respiration** is the process of breaking down this food to get energy.

Photosynthesis can **increase** plant weight (by using carbon dioxide from the atmosphere to make sugar) and cellular respiration can **decrease** plant weight (by releasing carbon dioxide back into the atmosphere). Therefore, changes in a plant's weight depend on the balance between these two processes (photosynthesis and cellular respiration).



Exercise #1

1. Consider the following equations for photosynthesis and cellular respiration. What do you notice about the relationship between them? Are there similar inputs and outputs?

photosynthesis:

carbon dioxide + water + light energy \rightarrow sugar + oxygen

cellular respiration:

sugar + oxygen \rightarrow carbon dioxide + water + energy

2. Imagine that the mass of a plant decreases by 10 grams. What can you conclude about its photosynthesis and cellular respiration activity? Mark the best answer.

- Photosynthesis occurs at a faster rate than cellular respiration.
- Cellular respiration occurs at a faster rate than photosynthesis.
- Photosynthesis and cellular respiration occur at equal rates.

3. Why might the answer you checked in #2 above occur?

Exercise #2

You want to find out what happens to a plant's weight with different light conditions. Today, we will set up an experiment together and see what happens in a few weeks.

Instructions:

1. Prepare two 2" pots with soil and radish seeds planted in them. Label one pot "#1" and the other "#2." Weigh each pot on an electronic scale and record their weights in Table 1.
2. Place both pots in your classroom near a window with sunlight.
3. Each week thereafter, weigh each pot and record below.
4. After Week 4, label pot #1 "light" and pot #2 "no light." Leave the pot labeled "light" in the sunny spot in the classroom. Place the pot labeled "no light" in a box where there is no light.
5. After 1 week, weigh both pots. Record their weights below in Table 2.

Data Collection

Table 1.

Time	Cup #1 Weight (in grams)	Cup #2 Weight (in grams)
Week 0		
Week 1		
Week 2		
Week 3		
Week 4		

Table 2.

Time	Cup #1 Weight (LIGHT, in grams)	Cup #2 Weight (NO LIGHT, in grams)
Week 5		

Discussion Questions

1. Describe what happened to the weights of the cups during Weeks 0-4.
2. Describe what happened to the weights of the cups during Week 5.
3. From Week 4 to Week 5, did the weight of the radish in cup #1 increase or decrease? Explain one possible reason for this change.
4. From Week 4 to Week 5, did the weight of the radish in cup #2 increase or decrease? Explain one possible reason for this change.



The Balance Between Photosynthesis and Cellular Respiration

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Exercise #1

1. Consider the following equations for photosynthesis and cellular respiration. What do you notice about the relationship between them? Are there similar inputs and outputs?

photosynthesis:

carbon dioxide + water + light energy \rightarrow sugar + oxygen

cellular respiration:

sugar + oxygen \rightarrow carbon dioxide + water + energy

The two processes are opposite of each other. Photosynthesis makes sugar and oxygen, while cellular respiration uses up sugar and oxygen. Photosynthesis uses carbon dioxide, water, and light, while cellular respiration makes carbon dioxide, and energy.

2. Imagine that the mass of a plant decreases by 10 grams. What can you conclude about its photosynthesis and cellular respiration activity? Mark the best answer.
 - Photosynthesis occurs at a faster rate than cellular respiration.
 - Cellular respiration occurs at a faster rate than photosynthesis.
 - Photosynthesis and cellular respiration occur at equal rates.

3. Why might the answer you checked in #2 above occur?

There is not enough light, meaning that photosynthesis occurs at a slower rate than cellular respiration. This may also occur if there is not enough water or carbon dioxide.

Exercise #2

You want to find out what happens to a plant's weight with different light conditions. Today, we will set up an experiment together and see what happens in a few weeks.

Instructions:

1. Prepare two 2" plastic pots with soil and radish seeds planted in them. Label one pot "#1" and the other "#2." Weigh each pot on an electronic scale and record their weights in Table 1.
2. Place both cups in your classroom near a window with sunlight.
3. Each week thereafter, weigh each pot and record below.
4. After Week 4, label pot #1 "light" and pot #2 "no light." Leave the pot labeled "light" in the sunny spot in the classroom. Place the pot labeled "no light" in a box where there is no light.
5. After 1 week, weigh both pots. Record their weights below in Table 2.

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Week 5		

Discussion Questions

1. Describe what happened to the weights of the cups during Weeks 0-4.

The weights should have increased.

2. Describe what happened to the weights of the cups during Week 5.

The weight of Pot #1 should increase. The weight of Pot #2 should have decreased.

3. From Week 4 to Week 5, did the weight of the radish in cup #1 increase or decrease? Explain one possible reason for this change.

Pot #1: Weight increased

The plant still has light and water, so it will continue to grow.

4. From Week 4 to Week 5, did the weight of the radish in cup #2 increase or decrease? Explain one possible reason for this change.

Pot #2: Weight decreased

The plant no longer had light, so it could not undergo photosynthesis. This means that the rate of photosynthesis is less than the rate of cellular respiration. More sugar was broken down than was created. (Sugar breaking down = decreased biomass)