

Name: \_\_\_\_\_ Date: \_\_\_\_\_

## Student Exploration: Cell Energy Cycle

**Vocabulary:** aerobic, anaerobic, ATP, cellular respiration, chemical energy, chlorophyll, chloroplast, cytoplasm, glucose, glycolysis, mitochondria, photosynthesis, radiant energy

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

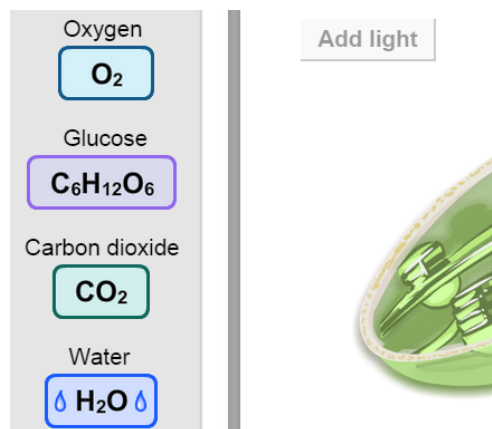
1. What does a plant need to survive and grow? \_\_\_\_\_  
\_\_\_\_\_
2. What does an animal need to survive and grow? \_\_\_\_\_  
\_\_\_\_\_
3. How do animals and plants depend on each other? \_\_\_\_\_  
\_\_\_\_\_

### Gizmo Warm-up

The *Cell Energy Cycle* Gizmo™ illustrates two processes that are essential to life: **photosynthesis** and **cellular respiration**.

Although both of these processes involve a series of complex steps, the inputs and outputs of each process are four relatively simple molecules.

1. What is the chemical formula of oxygen? \_\_\_\_\_
2. **Glucose** is a simple sugar. What is the chemical formula of glucose? \_\_\_\_\_
3. What is the chemical formula of carbon dioxide? \_\_\_\_\_
4. What is the chemical formula of water? \_\_\_\_\_



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| <b>Activity A:</b><br><b>Photosynthesis</b> | <p>Get the Gizmo ready:</p> <ul style="list-style-type: none"> <li>• If necessary, click <b>Reset</b>.</li> <li>• Check that the PHOTOSYNTHESIS tab is selected. Check that <b>Description</b> is turned on.</li> </ul>  |
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**Introduction:** Photosynthesis occurs in the **chloroplast**, an organelle found in plant and algae cells. Within the chloroplast, a green pigment called **chlorophyll** converts the **radiant energy** of sunlight into **chemical energy** that the plant can use.

**Question: What are the inputs and outputs of photosynthesis?**

1. Predict: Of the molecules shown on the MOLECULES pane, which do you think are inputs (ingredients) in photosynthesis? Which do you think are outputs?

Inputs: \_\_\_\_\_ Outputs: \_\_\_\_\_

2. Explore: Drag each molecule from the MOLECULES pane to the chloroplast on the PHOTOSYNTHESIS pane. If a molecule is an input, it will stay in the chloroplast.

Which molecules are inputs in photosynthesis? \_\_\_\_\_

3. Observe: Click **Add light** and look at the **Output**. What are the outputs of photosynthesis?

\_\_\_\_\_

4. Summarize: Although photosynthesis is a complex process involving many reactions, it can be summarized by a simplified formula that shows inputs on the left and outputs on the right. Based on your observations, write a simplified formula for photosynthesis:

\_\_\_\_\_ + \_\_\_\_\_ → \_\_\_\_\_ + \_\_\_\_\_

Turn on **Show input/output formula** to check. Were you correct? \_\_\_\_\_


5. Challenge: To balance the inputs and outputs of photosynthesis, there should be the same number of carbon, oxygen, and hydrogen atoms on each side of the arrow.

A. Is the formula balanced as written? Why or why not? \_\_\_\_\_

\_\_\_\_\_

- B. Now balance the input/output formula by adding coefficients to each molecule. Write the balanced formula below, and then check your work by clicking **Balance**.

\_\_\_\_\_ + \_\_\_\_\_ → \_\_\_\_\_ + \_\_\_\_\_

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| <b>Activity B:</b><br><br><b>Cellular respiration</b> | <u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>Click <b>Reset</b>.</li> <li>Select the RESPIRATION tab.</li> </ul> |  |
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**Introduction:** Cellular respiration occurs in the **cytoplasm** of the cell and in **mitochondria**, organelles found in all complex cells. (Bacteria and other simple organisms do not contain mitochondria.) The Gizmo shows a mitochondrion surrounded by yellow cytoplasm.

**Question: What are the inputs and outputs of cellular respiration?**

1. Predict: Of the molecules shown on the MOLECULES pane, which do you think are inputs (ingredients) in cellular respiration? Which do you think are outputs?

Inputs: \_\_\_\_\_ Outputs: \_\_\_\_\_

2. Explore: Drag each molecule from the MOLECULES pane to the RESPIRATION pane.

Which molecules are inputs in cellular respiration? \_\_\_\_\_

3. Observe: Click **Next**. What happens in the cytoplasm? \_\_\_\_\_

This process is called **glycolysis**. Two pyruvate ( $C_3H_3O_3^-$ ) molecules are produced in glycolysis. The released energy is used to form a net of two **ATP** (adenosine triphosphate) molecules. Energy is later released when ATP molecules are broken down.

4. Observe: Click **Next**. What happens now? \_\_\_\_\_

5. Observe: Click **Next**. What happens in the mitochondrion? \_\_\_\_\_

Energy from the mitochondrion is also stored in the form of ATP. A net of 30 ATP molecules are produced for every two molecules of pyruvate.

6. Analyze: Cellular respiration involves two phases. The **anaerobic** phase does not involve oxygen, while the **aerobic** phase does. Where does each phase take place?

Anaerobic: \_\_\_\_\_

Aerobic: \_\_\_\_\_

**(Activity B continued on next page)**

### Activity B (continued from previous page)

7. Summarize: Based on what you have seen, write a simplified formula for cellular respiration.

\_\_\_\_\_ + \_\_\_\_\_ → \_\_\_\_\_ + \_\_\_\_\_

Turn on **Show input/output formula** to check. Were you correct? \_\_\_\_\_

6. Challenge: To balance the inputs and outputs of cellular respiration, there should be the same number of carbon, oxygen, and hydrogen atoms on each side of the arrow.

A. Is the formula balanced as written? Why or why not? \_\_\_\_\_

\_\_\_\_\_

B. Now balance the input/output formula by adding coefficients to each molecule. Write the balanced formula below, and then check your work by clicking **Balance**.

\_\_\_ \_\_\_\_\_ + \_\_\_ \_\_\_\_\_ → \_\_\_ \_\_\_\_\_ + \_\_\_ \_\_\_\_\_

8. Compare: The aerobic phase of cellular respiration in the mitochondrion produces a net of about 28 to 30 ATP molecules. How does this compare to the energy released in glycolysis?

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\_\_\_\_\_

(Note: Some textbooks state that up to 36 ATP molecules are produced in this phase of cellular respiration. In reality, some energy is lost in the process due to the cost of transporting molecules and imperfect membranes.)

9. Extend your thinking: When you think of the word “respiration,” you might think about the process of breathing, which is actually called *ventilation*. (The respiratory system consists of the windpipe, lungs, etc.)

How is breathing related to cellular respiration? (Hint: Think about both the inputs and the outputs of cellular respiration.)

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| <b>Activity C:</b><br><br><b>The carbon-oxygen cycle</b> | <u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>Click <b>Reset</b>.</li> <li>Select the <b>CYCLE</b> tab.</li> </ul> <div data-bbox="1227 216 1427 321" data-label="Image"> </div> |
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**Question: How is photosynthesis related to cellular respiration?**

1. Form a hypothesis: How do you think photosynthesis is related to cellular respiration?

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2. Predict: Look at the red arrows, and think about the photosynthesis and respiration processes. Each red arrow connects a set of inputs to the outputs of the reaction.

A. Which molecules would you expect to find at the top of the diagram? Explain.

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B. Which molecules would you expect to find at the bottom of the diagram? Explain.

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3. Observe: Drag the **Oxygen**, **Glucose**, **Carbon dioxide**, and **Water** into the CYCLE pane.

A. Which substances are inputs in photosynthesis? \_\_\_\_\_

B. Which substances are outputs of photosynthesis? \_\_\_\_\_

C. Which substances are inputs in respiration? \_\_\_\_\_

D. Which substances are outputs of respiration? \_\_\_\_\_

4. Compare: How are the inputs and outputs of photosynthesis and respiration related to one another?

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**(Activity C continued on next page)**

### Activity C (continued from previous page)

5. Review: In photosynthesis and respiration, energy is converted from one form to another. Light is a form of radiant energy. Glucose and ATP molecules store chemical energy.

A. During photosynthesis, what role is played by the radiant energy of the Sun? Explain your answer. \_\_\_\_\_

\_\_\_\_\_

B. In photosynthesis, what form of energy is sunlight converted to, and how is this energy stored? \_\_\_\_\_

\_\_\_\_\_

C. Does cellular respiration result in a net input of energy or a net output of energy?

Explain. \_\_\_\_\_

\_\_\_\_\_

D. How is the energy produced by respiration stored? \_\_\_\_\_

\_\_\_\_\_

6. Summarize: How are respiration and photosynthesis related to each other? \_\_\_\_\_

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7. Think and discuss: In what ways are plants and animals dependent on each other?

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