Lesson 4: Food for Plants

Introduction

In the last lesson, you explored how inputs of matter and energy interact in the process of photosynthesis to produce glucose and oxygen. In this lesson, you will continue to think about additional interactions of matter and energy that are needed to keep the plant alive.

Lesson Question

Process and Procedure

1. Write your best ideas about the lesson focus question in the space below. Leave space to revise your ideas as you learn throughout this lesson. As you have new ideas, record them in a different color.

Matter and Energy Interactions in Cellular Respiration

2. Read and annotate Plant Growth to begin to think about how a plant uses matter and energy to stay alive. As you read, stop and discuss the questions with your group.

Plant Growth

Plants, like all living organisms, require an input of matter (food) that is used for growth and reproduction. Some of the matter becomes part of the plant's body structure, including roots, stems, leaves, and reproductive structures such as flowers, fruit, and seeds. Some of the matter is used as fuel in chemical reactions.

Stop and Think
What types of matter might a plant use as food for growth and reproduction?

The atoms of the input food molecules include carbon, hydrogen, and oxygen. These atoms are rearranged through chemical reactions to form new molecules such as carbohydrates (starch), amino acids and proteins, lipids (fats), and nucleic acids. These large carbon-based molecules are found throughout a plant's body structures.

Stop and Think
How are the large carbon-based molecules found throughout a plant's body structures the same as, or different than, those found in animal body structures?

A plant needs energy all the time to power the chemical reactions it needs to stay alive. The reactions of photosynthesis require a net input of light energy. However, a plant cannot get energy from the sun at night and, in many climates, the amount and intensity of sunlight is limited in winter. To obtain energy at all times, the plant needs chemical reactions with a net output of energy. In these reactions, the reactant molecules require less energy to break their bonds than the energy released when the product molecules' bonds are formed. Glucose is a molecule that, in reactions with oxygen, provides a net output of energy.

3. Plants often use chemical reactions to join glucose molecules together to form starch molecules. This allows the plant to store more glucose molecules in a smaller space within the plant's cells. Watch your teacher's demonstration of a chemical test for the presence of starch in a plant's leaves. Draw a labeled diagram of your observations below.

4. The reading, *Plant Growth*, stated a plant could obtain energy by reacting glucose with oxygen. If glucose and oxygen are the reactants in the chemical reaction, what molecules might be the products of this reaction? To begin to answer this question, at the end of Lesson 2, a test tube containing *Elodea* and Bromothymol Blue was placed in the dark. Similarly, at the end of Lesson 3, a cup with all the leaf disks floating was placed in the dark. Observe both and complete the chart below.

Investigation Set up	**Observation (What I See)**	**Interpretation (What it means)**
A test tube with *Elodea* in water with Bromothymol Blue was left in the dark.		
A cup in which all the spinach leaf disks were floating was left in the dark.		

Use the space below to add ideas from the class discussion.

5. To think more about how a plant gets energy from reacting glucose with oxygen, we will explore the growth of seeds. Before starting the simulation, read the following information about seeds and germination.

Seed Germination

Seeds are living organisms. A fully developed seed contains an embryo, a store of food reserves, and a tough protective outer layer called a seed coat. The food reserves of a seed are composed primarily of starch. This starch was produced by the seed's parent plant. Until they are in the proper environmental conditions, seeds are dormant – the chemical reactions within the cells of the seed are extremely limited.

For a seed to come out of dormancy and germinate, it needs to take up water. As the seed absorbs water, it swells and the seed coat softens. The swelling seed breaks open the softened seed coat. The absorbed water also activates the chemical reactions in the cells of the seed. Starch molecules are broken down into glucose molecules. Some of the glucose molecules combine with oxygen in chemical reactions with a net output of energy. Some of the glucose molecules are used in chemical reactions to make other large carbon-based molecules that will form the new plant's body structures.

6. Follow your teacher's directions to access the simulation.
   - Read the directions in the box titled, "Setup the Experiment."
   - In the first row of the chart below, make a labeled drawing of your predictions.
   - After making your predictions, click the "Run Experiment" button and add a labeled diagram of the experimental results in the second row.
   - Predict whether the mass of plant material has increased, decreased, or stayed the same by placing a check in the appropriate column.
   - Click the "Get Results" button and record the results of the experiment.

	Experimental Setup 1 **Light: NO** **Water :NO**			**Experimental Setup 2** **Light: YES** **Water :NO**			**Experimental Setup 3** **Light: NO** **Water :YES**			**Experimental Setup 4** **Light: YES** **Water :YES**		
Drawing of Your Prediction												
Drawing of Experimental Results												
Prediction of Mass Change	Increase	Decrease	No change	Increase	Decrease	No change	Increase	Decrease	No change	Increase	Decrease	No change
Initial dry mass of seeds (g)												
Final Dry Mass of Seeds (g)												
Change in Dry Mass (g)												

7. Write your best ideas about why the mass of the plant material increased, decreased or stayed the same for each experimental condition in the chart below.

	Experimental Setup 1 **Light: NO Water: NO**	**Experimental Setup 2** **Light: YES Water: NO**	**Experimental Setup 3** **Light: NO Water: YES**	**Experimental Setup 4** **Light: YES Water: YES**
My ideas about the change in the mass of plant material				

8. As you read earlier, plants get energy from the reaction of glucose and oxygen. Actually, ALL organisms require energy and get it in the same basic way – the process of cellular respiration. To learn and think more about this process and how that energy is used, read the science ideas in the left column of the table below. In the right column, draw a labeled diagram that represents that idea.

Energy and Cellular Respiration

Science Idea	Labeled Drawing of the Idea
Cellular respiration is a chemical reaction. The reactant (input) molecules are glucose and oxygen. The product (output) molecules are carbon dioxide and water.	
During cellular respiration, energy is required to break the bonds between the atoms of the reactants (glucose and oxygen). Unlike photosynthesis, however, this energy input is chemical, not light.	
During cellular respiration, energy is released when atoms bond to form the product molecules (water and carbon dioxide).	
In cellular respiration, the amount of energy required to break the bonds of the reactant molecules (C6H12O6 and O2) is less than the amount of energy released when the product molecules (CO2 and H2O) form. Therefore, the chemical reaction of cellular respiration produces a NET OUTPUT of energy.	
This NET OUTPUT of energy is required to carry out life's functions and sustain life's processes (ex: movement, building body structures, reproduction, maintaining body temperature)	
Some of the glucose made during photosynthesis is used as a reactant for cellular respiration. The oxygen reactant comes from the air. The carbon dioxide produced is released into the atmosphere. Some of the water produced is also released into the atmosphere, while some is retained in the plant cells.	
Plants require oxygen as a reactant to carry out cellular respiration, and they also produce oxygen during photosynthesis. However, plants produce approximately ten times more oxygen during photosynthesis than they use in cellular respiration.	

9. Now that you have drawn representations of the statements above, cut and sort the card set on the next page and tape the appropriate card beside each statement. Compare your representation to the card and discuss with a partner. Your representation may not be exactly the same, but does it reflect the same idea as that on the card? If not, reread the statement together to clarify your understanding.

Energy and Cellular Respiration

photosynthesis atmosphere cells Glucose + oxygen ➡ carbon dioxide + water
Energy in < Energy out NET Energy
O_2 (photosynthesis product) **X 10** = O_2 (CR reactant)
Cellular respiration: glucose + oxygen ➡ carbon dioxide + water
Carbon, oxygen, hydrogen atoms ➡ Carbon dioxide + water + energy out
energy in glucose and oxygen molecules break apart into carbon atoms, oxygen atoms, and hydrogen atoms
NET Energy Life processes: Movement, building, reproduction, body temp. regulation

10. In this lesson, you have explored the energy input and output of cellular respiration. Now consider the input and output of molecules of matter during cellular respiration. You have observed the types of atoms (carbon, hydrogen, and oxygen) that make up the input molecules are the same as those of the output molecules. Does the amount of each type of atom change during the reactions of cellular respiration? In other words, are there the same number of each type of atom at the end of cellular respiration as there are at the beginning?

To think more about this question, read the article, *Conservation of Mass*. As you read, underline important ideas.

Conservation of Mass

The atoms of most naturally occurring elements are very stable at the conditions found in our environment and are not converted to other elements during chemical reactions. Atoms themselves are neither created nor destroyed during chemical reactions. As a result, the number of atoms of one element at the beginning of a chemical reaction will be the same at the end of the reaction. In a closed system, the total number of atoms of each element will stay the same. Scientists refer to these ideas as the Law of Conservation of Mass.

The overall reaction for cellular respiration can be written as:

Glucose + oxygen $\rightarrow$ carbon dioxide + water

Using the pop beads provided to your group, assemble one glucose molecule. Note the color of each type of atom in the key your teacher gives you. Use the Law of Conservation of Mass to determine the number of oxygen molecules needed to produce the output molecules of carbon dioxide and water.

	Glucose $C_6H_{12}O_6$	**Oxygen** O_2		**Carbon dioxide** CO_2	**Water** H_2O
Number of Molecules	1		$\rightarrow$		

11. Based on the reading and pop bead calculation, use a different color to revise or add to your ideas in Step 7 about why the mass of the plant material increased, decreased or stayed the same for each experimental condition. Use a different color to show how your thinking changed.

Synthesize and Summarize Ideas

12. Add your ideas about cellular respiration to your model of the terrarium plant system. Add labels to help others understand your model.

13. Reread your initial response to the lesson focus question. Consider the ideas from the activities you completed in this lesson. If you would like to add to or revise your ideas, do so in a different color.