Visualizing Photosynthesis and Cellular Respiration

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Summary

This is a hands-on activity that is used to visualize the chemical processes Photosynthesis and Cellular respiration. The attached sheet guides students through the process, and has many simple (assessable) steps needed to process through the activity.

Learning Goals

Reinforcement of Chemical equations for Photosynthesis & Cellular Repiration... Observe conservation of mass, Demonstrate understanding of content, and model development.

Context for Use

This is a two day lab that should be used AFTER explaining Photosynthesis and/or Cellular Respiration. It requires Organic Chemistry Model kits, but could probably use gumdrops and toothpicks as well.

Subject: Biology:Cell Biology:Cell Processes:Metabolism:Photosynthesis, Respiration

Resource Type: Activities:Classroom Activity

Grade Level: High School (9-12)

Description and Teaching Materials

The activity walks the students through the processes of Photosynthesis and Cellular Respiration. Students should be placed into groups (I like groups of 2). This allows them to collaborate without getting lost.

There are multiple check points throughout the activity that allow students to work independently at their own pace, but it is also comprehensive and builds upon itself. Students have to explain/describe/model their retention and understanding multiple times as they progress through the activity.

Personally I do Photosynthesis and Cellular Respiration together, but it could easily be separated into two independent sections. Visualizing Photosynthesis and Cellular Respiration Using Chemical Models (Microsoft Word 66kB Dec22 09)

Teaching Notes and Tips
Assessment

The activity is turned in, and answers are checked as well as giving points for Instructor Signatures/Initials

Standards

STRAND 4: LIFE SCIENCE
Substrand 2. Interdependence among Living Systems
Standard 1. Ecosystems
Standard 2. Flow of energy and matter
Introduction

Photosynthesis

Photosynthesis is one of the most important biological events that occur on this planet. It is defined as the process by which plants use solar energy to convert the raw materials carbon dioxide (CO₂) and water (H₂O) into glucose (C₆H₁₂O₆) for use as an energy source. Also during this process, oxygen gas is produced as the byproduct that all aerobically-respiring organisms (such as ourselves) are dependent upon. The general chemical equation for photosynthesis is

\[ 6 \text{H}_2\text{O} + 6 \text{CO}_2 + \text{solar energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \]

Following photosynthesis, the glucose constructed within plant cells can then be used as a source of energy and materials for cellular activities such as growth, reproduction and the synthesis of more complex materials such as starch, proteins, and fats. The existence of all naturally-occurring organic molecules (any molecule containing carbon, hydrogen, and oxygen), and therefore, all sources of energy, can be traced back to the process of photosynthesis.

Using colored pencils/crayons color the chemicals in both equations above. Be sure to use the following colors for each molecule(s)... **(STEP 1)**

- Water → Blue
- Carbon Dioxide → Red
- Glucose → Green
- Oxygen → Orange
- Sunlight (Energy) → Yellow
**Respiration**

Energy is defined as the ability to do work. The cells of all organisms, and therefore, all organisms, require a continuous supply of energy for the performance of their daily, vital activities. Carbohydrates, especially glucose, generally provide this energy through the process of respiration. Simply stated, respiration is the release of energy from energy-storing compounds. It is represented by the chemical equation:

\[
C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy (heat, light, ATP, etc.)}
\]

You should be careful to notice that the process of cellular respiration is essentially the reverse of photosynthesis. The catabolic breakdown (burning) of glucose requires the presence of oxygen and yields energy and carbon dioxide. This process is generally the same when any organic molecule is respired (or burned) whether it is glucose in a living animal or plant cell, wood in a fire, or gasoline in a car. The breakdown of any energy storing chemical releases carbon dioxide as a byproduct, which may then be used by plants in the photosynthetic process.

Using colored pencils/crayons color the chemicals in both equations above. Be sure to use the following colors for each molecule(s)… *(STEP 2)*

- Water \(\rightarrow\) Blue
- Carbon Dioxide \(\rightarrow\) Red
- Glucose \(\rightarrow\) Green
- Oxygen \(\rightarrow\) Orange
- ATP (Energy) \(\rightarrow\) Yellow
Photosynthesis and Cellular Respiration

Assignment
Use a molecular model kit to simulate the processes of Photosynthesis. Begin by constructing 6 carbon dioxide molecules and 6 water molecules. (This is done in the Chloroplasts of plant cells) Put the remaining pieces of your kit away and construct one molecule of glucose through the process of photosynthesis. If you do this correctly, you should have exactly 6 oxygen molecules left. Once you have constructed your molecule of glucose raise your hand, and explain the process to your instructor.

___________ (Instructor’s initials) Photosynthesis has been successfully completed. Once this has been signed move on to cellular respiration… (STEP 3)

If time allows, you should try modeling cellular respiration. Use a molecular model kit to simulate the processes of Cellular Respiration. Begin by constructing a 6 carbon molecules of glucose. Add to this your 6 oxygen molecules. (This should be ready to go if you did photosynthesis correctly 😊) Breaking these molecules apart, use the Carbon Oxygen and Hydrogen to construct the products of Cellular Respiration. (This is done in the mitochondria) If you do this correctly, you should have exactly 6 molecules of Carbon Dioxide, and 6 molecules of Water left. Once you have constructed your molecules of Water and Carbon dioxide raise your hand, and explain the process to your instructor.

___________ (Instructor’s initials) Cellular Respiration has been successfully completed. Once this has been signed move on to analysis questions…(STEP 4)

Hint: Glucose can exist in an open-chain or ring form. At pH 7, the ring form is predominant. Also, be aware that glucose has several isomers (compounds with the same molecular formula, but a different arrangement of atoms in the molecule). Some examples of these isomers include dextrose, galactose, fructose, and mannose. (Notice that they all end in –ose which tells you the are carbohydrates/sugars)

Questions: (STEP 5)

1. Glucose is what type of sugar --- monosaccharide, disaccharide, or polysaccharide?

2. How does a plant obtain carbon dioxide for photosynthesis, and how does it enter the plant?

3. In what plant organ does photosynthesis occur?

4. What is the source of the carbon in the sugars made by plants?

5. The oxygen released by plants comes from what reactant in photosynthesis?

6. Inside what organelle does photosynthesis occur?

7. The energy for photosynthesis is ________________.
8. Where is this energy stored in glucose?

9. Name the process that breaks down sugars to release energy to do cellular work.

10. What energy molecule is used by cells to do work?

11. What waste gas is given off during cellular respiration, and how does this help plants?

12. Where does cellular (aerobic) respiration occur in plants and animals (organelle name)?

13. Which bonds of ATP are high energy bonds?

14. What sugar is found in ATP?

15. How do cells use the energy from ATP?

NOW… Let’s put it all together!! (STEP 6)

PHOTOSYNTHESIS EQUATION
On the teacher desk(s)/Demo tables there are some Chemical kits that have already been assembled. Use these chemical models to show the complete equation for photosynthesis. *DO NOT DISSASSEMBLE ANY OF THESE MOLECULES…EVERYTHING YOU NEED IS THERE*. There are also some index cards that can be used to complete the equation. Be sure to use ALL of the correct chemicals, and symbols in order to physically assemble the Photosynthesis Equation. Feel free to use the entire desk/table. (There are only 3 Equation kits so you may have to wait your turn) Once you have constructed your equation of photosynthesis raise your hand, and explain the process to your instructor.

__________ (Instructor’s initials) Photosynthesis has been successfully completed. Once this has been signed move on to cellular respiration…

CELLULAR RESPIRATION
Using the same molecules from the photosynthesis equation, repeat the exercise to show cellular respiration. Again *DO NOT DISSASSEMBLE ANY OF THESE MOLECULES…EVERYTHING YOU NEED IS THERE*. There are index cards that can be used to complete the equation. Be sure to use ALL of the correct chemicals and symbols in order to physically assemble the Cellular Respiration Equation. Once you have constructed your equation raise your hand, and explain the process to your instructor.

__________ (Instructor’s initials) Cellular Respiration has been successfully completed.