# 7th Grade Science Unit:
## Photosynthesis & Respiration

### Unit Snapshot

<table>
<thead>
<tr>
<th>Topic: Cycles of Matter and Flow of Energy</th>
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<tbody>
<tr>
<td><strong>Grade Level:</strong> 7</td>
</tr>
<tr>
<td><strong>Duration:</strong> 10 Days</td>
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</table>

### Summary

The following activities allow students to understand that matter is transferred continuously between one organism to another and between organisms and their physical environment.

### Clear Learning Targets

**“I can”...statements**

- ____ distinguish between photosynthesis and cellular respiration
- ____ identify photosynthesis and respiration using chemical formulas
- ____ carry out experiments that illustrate similarities and differences in photosynthesis and cellular respiration

### Activity Highlights and Suggested Timeframe

<table>
<thead>
<tr>
<th>Day</th>
<th><strong>Engagement:</strong> The objective of this activity is to engage students and formatively assess student knowledge related to the cycles of matter and energy flow within the biotic components of an ecosystem (video).</th>
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</thead>
<tbody>
<tr>
<td>Days 2-4</td>
<td><strong>Exploration:</strong> The objective of the following activities is to give students the opportunity to explore the structures of a leaf, which contribute to the processes of photosynthesis and cellular respiration. Students will be engaged in using a microscope as well as completing an Explore Learning Gizmo examining Cell Energy.</td>
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<tr>
<td>Days 5-6</td>
<td><strong>Explanation:</strong> The objective of the following activity is to develop students’ knowledge of photosynthesis and respiration through the creation of a visual display in the form of a foldable or manipulative.</td>
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<tr>
<td>Day 7-9</td>
<td><strong>Elaboration:</strong> The objective of the following activity is to develop students’ knowledge of the processes of photosynthesis and cellular respiration through a variety of laboratory experiments.</td>
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<tr>
<td><strong>Day 10 and on-going</strong></td>
<td><strong>Evaluation:</strong> The objective of the assessments is to focus on and assess student knowledge and growth to gain evidence of student learning or progress throughout the lesson.</td>
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<tr>
<td>Days 11-12</td>
<td><strong>Extension/Intervention:</strong> Based on the results of the short-cycle assessment facilitate extension and/or intervention activities.</td>
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NEW LEARNING STANDARDS:
7.LS.1 Matter is transferred continuously between one organism to another and between organisms and their physical environments.

- Plants use the energy in light to make sugars out of carbon dioxide and water (photosynthesis). These materials can be used and immediately stored for later use. Organisms that eat plants break down plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.
- Energy can transform from one form to another in living things. Animals get energy from oxidizing food, releasing some of its energy as heat.
- The total amount of matter and energy remains constant, even though its form and location change.

SCIENTIFIC INQUIRY and APPLICATION PRACTICES:
During the years of grades K-12, all students must use the following scientific inquiry and application practices with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas:

- Asking questions (for science) and defining problems (for engineering) that guide scientific investigations
- Developing descriptions, models, explanations, and predictions.
- Planning and carrying out investigations
- Constructing explanations (for science) and designing solutions (for engineering) that conclude scientific investigations
- Using appropriate mathematics, tools, and techniques to gather data/information, and analyze and interpret data
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating scientific procedures and explanations

*These practices are a combination of ODE Science Inquiry and Application and Frame-work for K-12 Science Education Scientific and Engineering Practices

COMMON CORE STATE STANDARDS for LITERACY in SCIENCE:

- CCSS.ELA-Literacy.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
- CCSS.ELA-Literacy.RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
- CCSS.ELA-Literacy.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- CCSS.ELA-Literacy.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
- CCSS.ELA-Literacy.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- CCSS.ELA-Literacy.RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
- CCSS.ELA-Literacy.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

*For more information: [http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf](http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf)
STUDENT KNOWLEDGE:

Prior Concepts
Grades 3-5: Populations of organisms can be categorized by how they acquire energy. Food webs can be used to identify the relationships among organisms. Energy entering ecosystems as sunlight is transferred and transformed by producers into energy that organisms use through the process of photosynthesis. That energy then passes from organism to organism as illustrated in food webs. Grade 6: Atomic Molecular Theory, Cell Theory and the function of cell organelles, including mitochondria and chloroplast, are studied.

Future Application of Concepts
High School: The chemical flow of energy during reactions will be explored as the molecular structure of molecules is studied.

MATERIALS:

Engage
- Computer Access
- Various Handouts

Explore
Gizmo Cell Energy Cycle
- ExploreLearning.com Activity
- Computer Access

Preparing a Wet Mount Slide
- Cover Glass
- Distilled Water
- Eye Dropper
- Sample to be observed
- Slides

Examining Plants Observation
- Cover Glass
- Distilled Water
- Eye Dropper
- Microscope
- Plant-Elodea Leaf etc.
- Sample to be observed
- Slides

Explain
- Prentice Hall Life Science Textbook
- Paper
- Coloring Materials
- Scissors

Elaborate
Elodea & Photosynthesis Lab
- Distilled Water
- Elodea Plant
- Goggles
- Light Source
- Ruler/Meter Stick
- Sodium Bicarbonate
- Test Tubes

VOCABULARY:

Primary
- Biomass
- Photosynthesis
- Respiration
- Sustainability

Secondary
- Bromothymol Blue Solution
- Chlorophyll
- Chloplast
- Energy
- Guard cells
- Indicator
- Mitochondria
- Stomata
- Yeast
**BTB and Evidence of Photosynthesis Lab**
- Beaker
- Bromothymol Blue Solution
- Elodea
- Foil
- Goggles
- Graduated cylinder
- Straw
- Test tubes

**Beastie Yeasties**
- Balloon
- Dry Yeast
- Glass containers or soda bottle
- Measuring Tape
- Sugar
- Tablespoon/teaspoon
- Thermometer
- Warm Water

**GIZMO Plants and Snails**
- Computer Access
- GIZMO Handouts

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<th>SAFETY</th>
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| • Review and go over CCS Lab Safety Guidelines and procedures.  
| • Reiterate safe usage of microscopes and glass slides.  
| • Reiterate to students that BRB Solution is poisonous and should not be consumed.  
| • Students should be wearing goggles when using glassware and or chemicals.  |

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<th>ADVANCED PREPARATION</th>
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| • Gather and check to see if microscopes are in working condition.  
| • Preview all unit plans, handouts and videos.  
| • Gather recommended materials for various activities.  
| • Prepare BRB solution with a 5 to 1 ratio to water.  |

| ENGAGE (1 Day) | **Objective**: The objective of this activity is to engage students and formatively assess student knowledge related to photosynthesis. Students will be creating several charts and viewing a video on the growth of a plant.  
|---------------|  
| What is the teacher doing?  
| • Teacher will introduce the lesson by showing a time lapse video clip of a plant growing.  
| Use the following website:  
| http://www.dnalc.org/resources/dnatoday/120229-maize-timelapse.html  
| • Ask questions about the video clip and have them complete handout.  
| • Ask the students about the term photosynthesis and have them discuss prior knowledge.  
| • Teacher will pass out prepared Alphabet Chart for  |

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<thead>
<tr>
<th>What are the students doing?</th>
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| 1. Students will be engaged in completing handout while observing the Maize Plant Growth video.  
| 2. Students will discuss Photosynthesis terms that they already know.  |
- Review the expectations of the Alphabet Chart.
- Walk around the room to assist students.
- Facilitate share-out and have students fill in any missing letters.
- Time Depending: Have students watch
  - Have them use the 3, 2, 1 Literacy Review as they watch. They can use the movie to complete more information on their Alphabet Chart Page.

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<td>3.</td>
<td>Complete Alphabet Chart</td>
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<td>4.</td>
<td>Students will discuss and share photosynthesis terms with peers.</td>
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<td>5.</td>
<td>Observe and complete 3,2,1 Literacy Review and/or complete for homework.</td>
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</table>
Objective: The objective of the following activities is to give students the opportunity to explore the structures of a leaf, which contribute to the processes of photosynthesis and cellular respiration. Students will be engaged in using a microscope as well as completing an Explore Learning Gizmo examining Cell Energy.

<table>
<thead>
<tr>
<th>What is the teacher doing?</th>
<th>What are the students doing?</th>
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<tbody>
<tr>
<td><strong>GIZMO Cell Energy Cycle</strong> (Day 2)</td>
<td><strong>Gizmo Cell Energy Cycle</strong> (Day 2)</td>
</tr>
<tr>
<td>- Review and discuss previous concepts covered and review homework. Students will go over the 3,2,1 Literacy Review. Use review to continue to fill in Photosynthesis Alphabet WS.</td>
<td>1. Review the 3,2,1 Literacy Review through discussion. Students can add more words and concepts that are discussed to the Photosynthesis: Alphabet WS.</td>
</tr>
<tr>
<td>- Students will be working on the explorelearning.com GIZMO Cell Energy Cycle.</td>
<td>2. Students will be engaged in either working collaboratively as a class or individual to complete the Cell Energy Cycle.</td>
</tr>
<tr>
<td>- Activity can be completed as a whole group or individually.</td>
<td>3. For review or HW, students will work on Photosynthesis and Cellular Respiration: Pieces and Parts WS.</td>
</tr>
<tr>
<td>- Use the Teacher Background Information for assistance on these topics.</td>
<td></td>
</tr>
<tr>
<td>- For review or HW, students will work on Photosynthesis and Cellular Respiration: Pieces and Parts WS.</td>
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**EXPLORE**

(3 Days)
(How will the concept be developed? How is this relevant to students' lives? What can be done at this point to identify and address misconceptions?)

**How to Prepare a Wet Mount Slide** (Day 3)
- Review Lab Safety Rules and Guidelines.
- Introduce using the microscope and how to create a Wet Mount Slide.
- Students need to be careful when handling the glass slides.
- Using the provided procedures, allow students to practice preparing wet mount slides.

**Examining Plants Activity** (Day 3 & 4)
- After practicing how to prepare a wet mount slide, teacher will explain and review observations for the Elodea Examining Plants lab. (Elodea can be purchased at most local pet stores)
- Teacher can also use other

**Examining Plants Activity** (Day 3 & 4)
- Students will use knowledge obtained from Preparing a Wet Mount Slide in this activity.
- Make wet mount slide of an Elodea leaf or other plant.
- Draw a detailed diagram of an elodea plant cell on all three
plants to look at cell structure.
- Consider reviewing the different parts and functions of a plant cell. Note: Cell organelles and their functions were covered in sixth grade.
- Instruct students to label the following structures: Cell wall, cell membrane, nucleus, cytoplasm and chloroplasts, stomata, etc.
- Teacher can monitor student engagement levels by walking around the classroom.
- Assist students with questions and procedures.
- Review and go over when students are complete.

<table>
<thead>
<tr>
<th>Objective: The purpose of this activity is for students create a foldable/manipulative to illustrate their knowledge of photosynthesis and respiration.</th>
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<tbody>
<tr>
<td>What is the teacher doing?</td>
</tr>
<tr>
<td>1. Review the various concepts learned during the Explore Activities.</td>
</tr>
<tr>
<td>2. Consider doing a close read on the topics of Photosynthesis and Respiration.</td>
</tr>
<tr>
<td>3. Students can read Prentice Hall Life Science Textbook, Chapter 3 Sec. 3, pp. 86-90 on Photosynthesis. Respiration is covered in Chapter 3, Sec. 4, pp. 91-94.</td>
</tr>
<tr>
<td>5. Teacher will provide structure for photosynthesis and cellular respiration manipulative.</td>
</tr>
<tr>
<td>6. Introduce and identify important features that students will need to illustrate.</td>
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<tr>
<td>7. Consider reviewing worksheets/activities from earlier in the lesson to use as resources for the foldable.</td>
</tr>
</tbody>
</table>

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<thead>
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<th>What are the students doing?</th>
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<tbody>
<tr>
<td>1. Students will be engaged in active review and discussion of previous concepts.</td>
</tr>
<tr>
<td>2. Students will be reading to gain more information on the processes of photosynthesis and respiration.</td>
</tr>
<tr>
<td>3. Students will be working on increasing vocabulary and knowledge of photosynthesis and cellular respiration using teacher provided resources.</td>
</tr>
<tr>
<td>4. Students will be working on foldable following guidelines and expectation set by the teacher.</td>
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</tbody>
</table>
**Objective:** The objective of the following activity is to develop students' knowledge of the processes of photosynthesis and cellular respiration through a variety of laboratory experiments.

<table>
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<th>What are the students doing?</th>
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</table>
| - Review the Photosynthesis/Respiration Foldables reiterating the differences and similarities with photosynthesis and respiration.  
- For Elaborate Activities, teacher has choice of several different activities for students to work on to allow for learning and exploration.  
- See Teacher Background Information for the different activities/labs for further instruction.  
- When using Bromothymol Blue Solution, teacher should review proper safety procedures. | 1. Students will be actively involved in reviewing concepts learned during the previous class days.  
2. Students need to take care when using lab materials and follow all CCS Lab Safety Guidelines. |

**Elaborate**
(3 Days)
(How will the new knowledge be reinforced, transferred to new and unique situations, or integrated with related concepts?)

<table>
<thead>
<tr>
<th>Elodea &amp; Photosynthesis Lab (Day 7)</th>
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</thead>
</table>
| Gather the different materials that are required for the lab.  
Explain to students to use great care when using the light and glassware.  
See Teacher Background Information. | 3. Students need to take care when using lab materials and follow all CCS Lab Safety Guidelines. |

<table>
<thead>
<tr>
<th>BTB and Evidence of Photosynthesis Lab (Day 8)</th>
<th>BTB and Evidence of Photosynthesis Lab (Day 8)</th>
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</thead>
</table>
| Gather the different materials that are required for the lab.  
Explain to students to use great care when using the light and glassware.  
See Teacher Background Information. | 4. Students need to take care when using lab materials and follow all CCS Lab Safety Guidelines. |

<table>
<thead>
<tr>
<th>Beastie Yeasties (Day 9)</th>
<th>Beastie Yeasties (Day 9)</th>
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</table>
| Gather the different materials that are required for the lab.  
Explain to students to use great care when using the light and glassware.  
See Teacher Background Information. | 5. Students need to take care when using lab materials and follow all CCS Lab Safety Guidelines. |
**GIZMO Plants and Snails**

Students will be working on the Explorelearning.com GIZMO Cell Energy Cycle.
- Activity can be completed as a whole group or individually.
- Use the Teacher Background Information for assistance on these topics.

**Objective:** The objective of the assessments is to focus on and assess student knowledge and growth to gain evidence of student learning or progress throughout the lesson.

**EVALUATE**

(What opportunities will students have to express their thinking? When will students reflect on what they have learned? How will you measure learning as it occurs? What evidence of student learning will you be looking for and/or collecting?)

<table>
<thead>
<tr>
<th>EVALUATE</th>
<th>FORMATIVE</th>
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<tbody>
<tr>
<td></td>
<td>How will you measure learning as it occurs?</td>
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<tr>
<td></td>
<td>1. Alphabet Chart</td>
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<tr>
<td></td>
<td>2. All In One Teacher Resource Pages</td>
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<td></td>
<td>3. Photosynthesis and Cellular Respiration Pieces and Parts Worksheet</td>
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<td></td>
<td>4. Comparing Photosynthesis and Respiration Chart</td>
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<table>
<thead>
<tr>
<th>EVALUATE</th>
<th>SUMMATIVE</th>
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<td>What evidence of learning will demonstrate to you that a student has met the learning objectives?</td>
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<tr>
<td></td>
<td>1. Photosynthesis and Cellar Respiration Foldable</td>
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<tr>
<td></td>
<td>2. Short Cycle Assessment</td>
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</table>

**Extension/Intervention**

- Photosynthesis WebQuest-Nova Illumination
- How to Make a Recycled Pop Bottle Hanging Planter

**Extension**

- Plants take in all substances they need to grow through their roots.
- Plants get energy they need through roots.
- Leaves take in water.
- Sunlight is helpful but not critical to the growth of a plant.
- Sun light helps a plant grow by keeping it warm.
- Plants breath by inhaling carbon dioxide and exhaling oxygen.
- Plants obtain their energy directly from the sun.

**Strategies to address misconceptions:**

Consider using [www.unitedstreaming.com](http://www.unitedstreaming.com) video clips, models, on-line simulation and diagrams to help address student misconceptions.
| DIFFERENTIATION          | Lower-Level: Consider pairing students for completing the foldable. When completing lab activities consider making groups with a variety of levels and strengths.  
|                         | Higher-Level: Students can be paired with lower level students to help instruct and reinforce learning content.  
|                         | Strategies for meeting the needs of all learners including gifted students, English Language Learners (ELL) and students with disabilities can be found at the following sites:  
| ADDITIONAL RESOURCES     | **Textbook Resources:**  
|                         | *Prentice Hall Life Science*  
|                         | • Chapter 3 Sec. 3 Photosynthesis pp. 86-90  
|                         | • Chapter 3 Sec. 4 Respiration pp. 91-94  
|                         | **Textbook Labs:**  
|                         | *Prentice Hall Life Science Laboratory Manual*  
|                         | • Investigating Stoma pp. 68-71  
|                         | **Websites:**  
|                         | **Discovery Ed:**  
|                         | • Cellular Energy: Cellular Respiration (1:15)  
|                         | • The Process of Photosynthesis (5:05)  
|                         | **Movies:**  
|                         | • The Photosynthesis Song-YouTube- (1:52) [http://www.youtube.com/watch?v=C1_uez5WX1o](http://www.youtube.com/watch?v=C1_uez5WX1o)  
|                         | • Bill Nye The Science Guy (23:06) - [http://www.youtube.com/watch?v=HD8L83LOy4k](http://www.youtube.com/watch?v=HD8L83LOy4k)  

Time Lapse of Growing Maize Plants

http://www.dnalc.org/resources/dnatoday/120229-maize-timelapse.html

Directions: Watch the video of a maize plant growing. Observe what is occurring and answer the following questions.

1.) How long does it take before you see the maize plant appear?

2.) Do you think this is a normal amount of time for a maize seedling to appear? Research the correct answer and cite your source.

3.) What is the “flashing” of light throughout the video?

4.) What is the significance of the “flashing” light?

5.) What is the weather like during the 105 day growing season?

6.) After watching the video, list the environmental conditions that help the plant to grow.

7.) In the box below draw a picture of a corn plant showing in each environmental condition.
Time Lapse of Growing Maize Plants

http://www.dnalc.org/resources/dnatoday/120229-maize-timelapse.html

Directions: Watch the video of a maize plant growing. Observe what is occurring and answer the following questions.

1.) How long does it take before you see the maize plant appear? __________

2.) Do you think this is a normal amount of time for a maize seedling to appear? Research the correct answer and cite your source.

   Answers will vary

3.) What is the “flashing” of light throughout the video? It is the sun rising and settling each day.

4.) What is the significance of the “flashing” light? It shows the sun which plants need to grow.

5.) What is the weather like during the 105 day growing season? Sunny with some rain.

6.) After watching the video, list the environmental conditions which help the plant to grow.

   Sun and the rain

7.) In the box below draw a picture of a corn plant showing in each environmental condition.

   Have students draw arrows towards the plant. This will be the beginning of a first visual to understand photosynthesis. Tell students that with one more “ingredient/element/factor” they will have the beginning of a process called photosynthesis. Have them try and guess what else is in the atmosphere that might help plants grow.

   Answer: carbon dioxide. Breathe heavy, as if you are out of breathe, as you walk around the room, giving them a clue about carbon dioxide. Have them add CO2 to the drawing above.
## PHOTOSYNTHESIS ALPHABET CHART

**Directions:** Place as many words/terms/phrases in each box that help define/describe/illustrate the word PHOTOSYNTHESIS.

<table>
<thead>
<tr>
<th>A</th>
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**PHOTOSYNTHESIS ALPHABET CHART**

**Directions:** Place as many words/terms/phrases in each box that help define/describe/illustrate the word PHOTOSYNTHESIS.

| A | Absorb  
   | Adapted  
   | Atmosphere |
|---|---|
| B |  |
| C | Carbon Dioxide  
   | Chemical Energy  
   | Chlorophyll  
   | Chloroplast |
| D |  |
| E |  |
| F | Function |
| G | Glucose  
   | Guard Cells |
| H |  |
| I |  |
| J |  |
| K |  |
| L | Leaves  
   | Light |
| M | PHOTOSYNTHESIS |
| N | Nutrients |
| O | Oxygen |
| P |  |
| Q |  |
| R |  |
| S | Starch  
   | Stomata  
   | Store  
   | Sugar |
| T | Transfer |
| U |  |
| V |  |
| W | Water  
   | Wilt |
| X |  |
| Y |  |
| Z | Xylem Tubes |

Identify 3 facts from the video that are “NEW” to you:

________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

Create your own definitions for 2 words that you “NOW” understand:

________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________

Summarize 1 idea that you still “DO NOT” understand:

________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
________________________________________________________________________________________________________________________
Learning Objectives
Students will…
- Discover the reactants and products of the photosynthesis reaction.
- Balance the photosynthesis equation.
- Identify where in the cell photosynthesis occurs.
- Discover the reactants and products of cellular respiration.
- Balance the respiration equation.
- Describe the stages of cellular respiration.
- Compare the energy output of aerobic and anaerobic respiration.
- Explain how cellular respiration and photosynthesis are related.

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

Lesson Overview
All day long we breathe in and out, but why? Oxygen is a key reactant in cellular respiration, the chemical reactions that release energy from food. Without oxygen, we would not be able to produce enough energy to live. Cellular respiration and the complementary photosynthesis reaction are explored in the Cell Energy Cycle Gizmo.

The Student Exploration sheet contains three activities:
- Activity A – Students explore the process of photosynthesis.
- Activity B – Students explore the process of cellular respiration.
- Activity C – Students determine how photosynthesis is related to cellular respiration.

Suggested Lesson Sequence
1. Pre-Gizmo activity (10 – 15 minutes)
Ask your students what animals and plants need to survive. What substances are found in the air we exhale, and how might these substances be useful to a plant? What substances produced by plants are helpful to the survival of animals? Could animals survive on Earth without plants? Could plants survive without animals?

2. Prior to using the Gizmo (10 – 15 minutes)
Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. Gizmo activities (15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. Discussion questions (15 – 30 minutes)
In many ways, cells can be compared to the structures and institutions that keep a city running. As students are working or just after they are done, discuss the following questions:

- What two substances does a plant need for photosynthesis?
- What are the products of photosynthesis?
- What is the balanced equation for photosynthesis?
- What two substances do animals and plants need for cellular respiration?
- What are the two main stages of cellular respiration?
- How does the energy produced by anaerobic respiration compare to the energy produced by aerobic respiration?
- How is the equation for photosynthesis related to the equation for cellular respiration?

5. **Follow-up activity: Respiring yeast cells**

   Yeasts are simple, unicellular fungi that are used to make bread and beer. When yeast undergoes aerobic respiration, they produce carbon dioxide gas. Bubbles of carbon dioxide in bread dough will cause the bread to expand as it is baked, giving it a fluffy texture. Yeast that undergoes anaerobic respiration will produce alcohol as a by-product.

   Several yeast experiments are described in the [Selected Web Resources](#) on page three of this document. Remember to follow all safety directions carefully.

   There are several other Gizmos that relate to the *Cell Energy Cycle* Gizmo. The *Photosynthesis Lab* Gizmo allows students to measure rates of photosynthesis, and *Plants and Snails* explores how photosynthesis and respiration are related. Links to these Gizmos can be found in the [Selected Web Resources](#).

**Scientific Background**

Photosynthesis and cellular respiration are complementary processes. During photosynthesis, the energy of sunlight is used to combine carbon dioxide (CO₂) and water (H₂O) into glucose (C₆H₁₂O₆). Oxygen is released as a waste product of photosynthesis. The balanced chemical equation for photosynthesis is:

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

During respiration, organisms use oxygen to extract energy from the chemical bonds in glucose. The balanced chemical equation for cellular respiration is the reverse of the photosynthesis equation:

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

The simple symmetry of these equations disguises the complexity of the processes involved. Cellular respiration, for example, takes place in three phases: glycolysis, the *Krebs cycle*, and the *electron-transport chain*.

- **Glycolysis** occurs in the cytoplasm. A molecule of glucose (C₆H₁₂O₆) is broken down into two molecules of pyruvic acid (C₃H₄O₃) and two hydrogen ions (H⁺). Glycolysis produces a net gain of two ATP molecules. (ATP, or adenosine triphosphate, is a molecule that is used as an energy source in cellular reactions.) No oxygen is required for glycolysis.

- **The Krebs cycle** (also called the *citrus acid cycle* or the *tricarboxylic acid cycle*) occurs in the mitochondria. The Krebs cycle is a series of eight enzyme-regulated reactions that break down pyruvic acid into carbon dioxide. The result is a variety of high-energy molecules: 6 NADH, 2 FADH₂, and 2 ATP.
In the electron-transport chain (ETC), electrons from NADH and FADH$_2$ are transferred from one substance to another. In the process their energy is harvested to form ATP molecules. A total of 32 to 34 ATP molecules are formed in this process. At the end of the chain, the electrons combine with hydrogen ions and oxygen to form water molecules, which are released as a waste product along with the carbon dioxide.

**Biology connection: Deep-sea vent communities**

In 1977, a team of marine geologists was studying the sea floor near the 2,500-meter-deep Galapagos Rift zone. They were not surprised to find plumes of hot water above the rift zone, an area where the ocean crust was splitting apart and new crust was forming from molten magma. What shocked the scientists were photographs of vigorous communities of tubeworms, crabs, snails, shrimp, and many other creatures living on the sea floor near the vents. How could these creatures thrive so far away from the energy of sunlight?

It turned out that the base of the food chain in these communities was a group of primitive bacteria, called *Archaea*, that obtain energy from the oxidation of hydrogen sulfides. This process, called *chemosynthesis*, produces enough biomass to support a strange and diverse community of organisms.

**Selected Web Resources**

Yeast respiration lab: [http://serendip.brynmawr.edu/exchange/waldron/cellrespiration](http://serendip.brynmawr.edu/exchange/waldron/cellrespiration)
Yeast lab: [http://www.umsl.edu/~microbes/pdf/Swell%20Lab.pdf](http://www.umsl.edu/~microbes/pdf/Swell%20Lab.pdf)
Cellular respiration and fermentation: [http://biology.clc.uc.edu/Courses/bio104/cellresp.htm](http://biology.clc.uc.edu/Courses/bio104/cellresp.htm)
Photosynthesis: [http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookPS.html](http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookPS.html)

Related Gizmos:

Student Exploration: Cell Energy Cycle

**Vocabulary**: aerobic respiration, anaerobic respiration, 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 reactions involve a series of complex steps, the basic reactants and products in 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? _______

**Activity A: Photosynthesis**

**Get the Gizmo ready:**

- If necessary, click **Reset**.
- Check that the PHOTOSYNTHESIS tab is selected. Check that **Description** is turned on.
**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 reactants and products of photosynthesis?**

1. **Predict:** Of the molecules shown on the CHEMICALS pane, which do you think are reactants (ingredients) in photosynthesis? Which do you think are products?
   
   Reactants: ___________________________   Products: ___________________________
   
2. **Explore:** Drag each molecule from the CHEMICALS pane to the chloroplast on the PHOTOSYNTHESIS pane. If a molecule is a reactant, it will stay in the chloroplast.
   
   Which molecules are reactants in photosynthesis? ___________________________
   
3. **Observe:** Click **Add light** and look at the **Output.** What are the products of photosynthesis?
   
   ___________________________________________________________________________

4. **Summarize:** A chemical equation shows reactants on the left side of an arrow, and products on the right, like this: reactant + reactant → product + product.
   
   Based on your observations, what is the chemical equation for photosynthesis?
   
   ___________________________________________________________________________
   
   Turn on **Show chemical equation** to check. Were you correct? _____________

5. **Challenge:** A chemical equation is balanced when each side of the equation includes the same number of each type of atom.
   
   A. Is the equation balanced as written? Why or why not? ___________________________
       ___________________________________________________________________________
   
   B. If you are familiar with balancing equations, balance the photosynthesis equation. Write the balanced equation below, and then check your work by clicking **Balance.**
       ___________________________________________________________________________
<table>
<thead>
<tr>
<th>Activity B: Cellular respiration</th>
<th>Get the Gizmo ready:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get the Gizmo ready:</td>
<td>Click <strong>Reset</strong>.</td>
</tr>
<tr>
<td></td>
<td>Select the RESPIRATION tab.</td>
</tr>
</tbody>
</table>

**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 green mitochondrion surrounded by blue cytoplasm.

**Question:** What are the reactants and products of cellular respiration?

1. **Predict:** Of the molecules shown on the CHEMICALS pane, which do you think are reactants (ingredients) in cellular respiration? Which do you think are products?

   Reactants: ___________________________    Products: ___________________________

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

   Which molecules are reactants in cellular respiration? ______________________________

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

   ____________________________________________________________________________

   This process is called **glycolysis**. The word **Pyruvic** is short for pyruvic acid, a product of glycolysis. Glycolysis produces energy, which is stored in the form of **ATP** (adenosine triphosphate) molecules. Glycolysis results in a net production of two ATP molecules.

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. Thirty ATP molecules are produced for every two molecules of pyruvic acid.

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

   Anaerobic respiration: _________________________________________________________

   Aerobic respiration: _________________________________________________________

(Activity B continued on next page)
Activity B (continued from previous page)

7. **Summarize:** Based on what you have seen, what is the overall chemical equation for cellular respiration?

_______________________________________________________________

Turn on *Show formula of chemical equation* to check. Were you correct? ______________

8. **Challenge:** A chemical equation is balanced when each side of the equation includes the same number of each type of atom.

   A. Is the equation balanced as written? Why or why not? ______________________

   __________________________________

   __________________________________

   B. If you are familiar with balancing equations, balance the cellular respiration equation. Write the balanced equation below, and then check your work by clicking **Balance**.

   __________________________________

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 reactants and the products of cellular respiration.)

   __________________________________

   __________________________________

   __________________________________

   __________________________________

10. **On your own:** If no oxygen is present, pyruvic acid breaks down to form lactic acid. You can feel the effects of lactic acid if you exercise very hard. One way to produce lactic acid is to do a “wall sit,” supporting yourself against a wall in a sitting position. Try doing this for a few minutes. What do you feel in your thigh muscles?

   __________________________________

   __________________________________

   __________________________________
Activity C: The carbon-oxygen cycle

Get the Gizmo ready:
- Click Reset.
- Select the CYCLE tab.

Question: How is photosynthesis related to cellular respiration?

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

_________________________________________________________________________
_________________________________________________________________________

2. Predict: Look at the red arrows, and think about the photosynthesis and respiration reactions. Each red arrow connects a set of reactants to the products of the reaction.

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

      _______________________________________________________________________
      _______________________________________________________________________

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

      _______________________________________________________________________
      _______________________________________________________________________

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

   A. Which substances are reactants in photosynthesis? ____________ ____________
   B. Which substances are products of photosynthesis? ____________ ____________
   C. Which substances are reactants in respiration? ____________ ____________
   D. Which substances are products of respiration? ____________ ____________

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

   _______________________________________________________________________
   _______________________________________________________________________

(Activity C continued on next 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. In the photosynthesis chemical equation, does the radiant energy of the Sun act as a reactant or a product? Explain your answer. 

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

   C. In the respiration equation, does energy act as a reactant or a product? Explain.

   D. How is the energy produced by respiration stored?

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

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

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

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)
[Note: The purpose of these questions is to activate prior knowledge and get students thinking. Students are not expected to know the answers to the Prior Knowledge Questions.]

1. What does a plant need to survive and grow?

   *Answers will vary. [Plants need water, air (CO\(_2\)), soil, and light.]*

2. What does an animal need to survive and grow?

   *Answers will vary. [Animals need food, oxygen, and water.]*

3. How do animals and plants depend on each other?

   *Answers will vary. [Plants provide animals with food, oxygen, and sometimes water. Animals provide plants with carbon dioxide and sometimes water.]*

**Gizmo Warm-up**

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

Although both of these reactions involve a series of complex steps, the basic reactants and products in each process are four relatively simple molecules.

4. What is the chemical formula of oxygen? \(O_2\)

5. **Glucose** is a simple sugar. What is the chemical formula of glucose? \(C_6H_{12}O_6\)

6. What is the chemical formula of carbon dioxide? \(CO_2\)

7. What is the chemical formula of water? \(H_2O\)
Activity A: Photosynthesis

Get the Gizmo ready:
- If necessary, click Reset.
- Check that the PHOTOSYNTHESIS tab is selected. Check that Description is turned on.

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 reactants and products of photosynthesis?

Predict: Of the molecules shown on the CHEMICALS pane, which do you think are reactants (ingredients) in photosynthesis? Which do you think are products?

Reactants: ___________________________ Products: ___________________________
Predictions will vary.

8. Explore: Drag each molecule from the CHEMICALS pane to the chloroplast on the PHOTOSYNTHESIS pane. If a molecule is a reactant, it will stay in the chloroplast.

Which molecules are reactants in photosynthesis? \( CO_2 \) and \( H_2O \)

9. Observe: Click Add light and look at the Output. What are the products of photosynthesis?

\( C_6H_{12}O_6 \) and \( O_2 \) are the products of photosynthesis.

10. Summarize: A chemical equation shows reactants on the left side of an arrow, and products on the right, like this: reactant + reactant \( \rightarrow \) product + product.

Based on your observations, what is the chemical equation for photosynthesis?

\( CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2 \)

Turn on Show chemical equation to check. Were you correct? Check answers

11. Challenge: A chemical equation is balanced when each side of the equation includes the same number of each type of atom.

C. Is the equation balanced as written? Why or why not?

No. There are more C, H, and O atoms on the right side of the equation.

D. If you are familiar with balancing equations, balance the photosynthesis equation. Write the balanced equation below, and then check your work by clicking Balance.

\( 6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 \)
Activity B: Cellular respiration

Get the Gizmo ready:
- Click Reset.
- Select the RESPIRATION tab.

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 green mitochondrion surrounded by blue cytoplasm.

Question: What are the reactants and products of cellular respiration?

11. **Predict**: Of the molecules shown on the CHEMICALS pane, which do you think are reactants (ingredients) in cellular respiration? Which do you think are products?

   Reactants: ___________________________ Products: ___________________________

   *Predictions will vary.*

12. **Explore**: Drag each molecule from the CHEMICALS pane to the RESPIRATION pane.

   Which molecules are reactants in cellular respiration? **C₆H₁₂O₆ and O₂**

13. **Observe**: Click Next. What happens in the cytoplasm? **The C₆H₁₂O₆ molecule turns into two Pyruvic acid molecules, releasing energy.**

   This process is called **glycolysis**. The word **Pyruvic** is short for pyruvic acid, a product of glycolysis. Glycolysis produces energy, which is stored in the form of **ATP** (adenosine triphosphate) molecules. Glycolysis results in a net production of two ATP molecules.

14. **Observe**: Click Next. What happens now? **The pyruvic acid molecules enter the mitochondrion.**

15. **Observe**: Click Next. What happens in the mitochondrion? **CO₂, H₂O, and a large amount of energy is released.**

   Energy from the mitochondrion is also stored in the form of ATP. Thirty ATP molecules are produced for every two molecules of pyruvic acid.

16. **Analyze**: Cellular respiration involves two phases. **Anaerobic respiration** does not involve oxygen, while **aerobic respiration** does. Where does each phase take place?

   Anaerobic respiration: **Anaerobic respiration takes place in the cytoplasm.**

   Aerobic respiration: **Aerobic respiration takes place in the mitochondrion.**

(Activity B continued on next page)
Activity B (continued from previous page)

17. **Summarize:** Based on what you have seen, what is the overall chemical equation for cellular respiration?

\[ C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O \]

Turn on **Show formula of chemical equation** to check. Were you correct? **Check answers**

18. **Challenge:** A chemical equation is balanced when each side of the equation includes the same number of each type of atom.

   C. Is the equation balanced as written? Why or why not?
   
   *No. There are more C, H, and O atoms on the left side than the right.*

   D. If you are familiar with balancing equations, balance the cellular respiration equation. Write the balanced equation below, and then check your work by clicking **Balance**.

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

19. **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 reactants and the products of cellular respiration.)

   *When we breathe in, we take in oxygen, which is one of the reactants in cellular respiration. When we breathe out, we release carbon dioxide and water vapor, two of the products of cellular respiration.*

20. **On your own:** If no oxygen is present, pyruvic acid breaks down to form lactic acid. You can feel the effects of lactic acid if you exercise very hard. One way to produce lactic acid is to do a “wall sit,” supporting yourself against a wall in a sitting position. Try doing this for a few minutes. What do you feel in your thigh muscles?

   *The “wall sit” exercise will produce a burning sensation in the thigh muscles.*
Activity C: The carbon-oxygen cycle

Get the Gizmo ready:
- Click Reset.
- Select the CYCLE tab.

Question: How is photosynthesis related to cellular respiration?

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

   *Hypotheses will vary.*

2. **Predict**: Look at the red arrows, and think about the photosynthesis and respiration reactions. Each red arrow connects a set of reactants to the products of the reaction.
   
a. Which chemicals would you expect to find at the top of the diagram? Explain.
   
   $C_6H_{12}O_6$ and $O_2$: *Both are products of photosynthesis and reactants in respiration.*

   b. Which chemicals would you expect to find at the bottom of the diagram? Explain.
   
   $CO_2$ and $H_2O$: *Both are products of respiration and reactants in photosynthesis.*

3. **Observe**: Drag the **Oxygen**, **Glucose**, **Carbon dioxide**, and **Water** into the CYCLE pane.
   
a. Which substances are reactants in photosynthesis? $CO_2$ and $H_2O$
   
b. Which substances are products of photosynthesis? $C_6H_{12}O_6$ and $O_2$
   
c. Which substances are reactants in respiration? $C_6H_{12}O_6$ and $O_2$
   
d. Which substances are products of respiration? $CO_2$ and $H_2O$

4. **Compare**: How are the reactants and products of photosynthesis and respiration related to one another?

   *The reactants of photosynthesis ($CO_2$ and $H_2O$) are the same as the products of respiration. The products of photosynthesis ($C_6H_{12}O_6$ and $O_2$) are the same as the reactants of respiration.*

(Activity C continued on next 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. In the photosynthesis chemical equation, does the radiant energy of the Sun act as a reactant or a product? Explain your answer.

   *The radiant energy of the Sun acts as a reactant because it is required by photosynthesis but is not produced by photosynthesis.*

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

   *Photosynthesis converts radiant energy to chemical energy, which is stored in glucose molecules.*

   c. In the respiration equation, does energy act as a reactant or a product? Explain.

   *In respiration, energy acts as a product because energy is produced in the respiration reaction.*

   d. How is the energy produced by respiration stored?

   *The energy produced by respiration is stored as ATP molecules.*

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

   *Respiration is the reverse of photosynthesis. Respiration uses glucose and oxygen to produce energy, carbon dioxide, and water. Photosynthesis uses carbon dioxide, water, and energy to produce glucose and oxygen.*

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

   *Animals depend on plants for food, oxygen, and other uses such as shelter and clothing. Plants depend on animals for carbon dioxide and sometimes for water. [Some plants also depend on animals for pollination, seed dispersal, and soil nutrients.]*
PHOTOSYNTHESIS AND CELLULAR RESPIRATION: PIECES AND PARTS

Plants are incredible organisms! They can make all their own food from the simple inputs of: carbon dioxide from the air, water and radiant energy, better known sunlight. This process is called photosynthesis. The food that plants produce through photosynthesis is called glucose, which is a type of sugar. Plants also produce oxygen as a product of photosynthesis. This means that plants are able to capture the radiant energy of the sun to turn carbon dioxide (CO₂) from the air into the carbon-based molecules of life called carbohydrates, thus establishing the foundation of energy for all living things. While at the same time plants provide oxygen essential to the survival of most living organisms as well. (Clipart from: 2.bp.blogspot.com)

A simpler way to rewrite this paragraph about the chemical process of photosynthesis would be in the form of a chemical equation:

\[
\text{INPUTS/ REACTANTS} = \text{PRODUCTS} \\
\text{Carbon dioxide} + \text{Water} + \text{Energy/ Sunlight} = \text{Sugar/ Glucose} + \text{Oxygen} \quad \text{OR} \\
\_\_\_\_\_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \\
\]

(Please note: that glucose which is the product of photosynthesis is a sugar which is a carbon based molecule better known as a carbohydrate.)

Procedure: Part One
Use the bold words in the paragraph above to complete the chart below and to design a diagram showing the process of photosynthesis:
PHOTOSYNTHESIS AND CELLULAR RESPIRATION: PIECES AND PARTS

Plants are incredible organisms! They can make all their own food from the simple inputs of: carbon dioxide from the air, water and radiant energy, better known sunlight. This process is called photosynthesis. The food that plants produce through photosynthesis is called glucose, which is a type of sugar. Plants also produce oxygen as a product of photosynthesis. This means that plants are able to capture the radiant energy of the sun to turn carbon dioxide (CO\textsubscript{2}) from the air into the carbon-based molecules of life called carbohydrates, thus establishing the foundation of energy for all living things. While at the same time plants provide oxygen essential to the survival of most living organisms as well. (Clipart from: 2.bp.blogspot.com)

A simpler way to rewrite this paragraph about the chemical process of photosynthesis would be in the form of a chemical equation:

\[
\text{INPUTS/ REACTANTS} = \text{PRODUCTS} \\
\text{Carbon dioxide + Water + Energy/ Sunlight} = \text{Sugar/ Glucose + Oxygen} \quad \text{OR} \\
6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Energy/ Light} = \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2
\]

(Please note: that glucose which is the product of photosynthesis is a sugar which is a carbon based molecule better known as a carbohydrate.)

Procedure: Part One

Use the bold words in the paragraph above to complete the chart below and to design a diagram showing the process of photosynthesis:

<table>
<thead>
<tr>
<th>INPUT</th>
<th>PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Water</td>
<td>Sugar (glucose)</td>
</tr>
<tr>
<td>Sunlight (radiant energy)</td>
<td></td>
</tr>
</tbody>
</table>

Misconception: Some students may think that soil provides the plant with food. Explain to your students that plants make their own food and soil only provides or “holds” one of the raw materials needed for photosynthesis (the process of using light to create “food”) to take place: that raw material is WATER. See page 89 Addressing Misconceptions in the TE.
Photosynthesis and Respiration Background Information

Plants capture sunlight within their green leaves to combine carbon dioxide and water to make food. The captured light energy is then converted to chemical energy and is stored in the food that is made by green plants. The light used in photosynthesis is absorbed by green pigment within a plant cell called chlorophyll.

Leaves appear green because of the presence of a pigment called chlorophyll which absorbs others colors of the light spectrum, while reflecting green light. Chlorophyll (as well as other pigments) is located within the plant cell’s organelles called chloroplasts. In chloroplasts, light energy causes water drawn from the soil to split into molecules of hydrogen and oxygen.

In plants, the roots absorb water from the soil. The water then moves up through the plant’s stem to the leaves. Carbon dioxide is one of the gases in the air. Carbon dioxide enters the plant through small openings on the undersides of the leaves called stomata. Once in the leaves, the water and carbon dioxide move into the chloroplasts.

In a series of chemical reactions, the hydrogen combines with carbon dioxide from the air, forming a simple sugar. Oxygen from the water molecules is given off in the process. From sugar, along with nutrients from the soil, green plants can make starch, fat, protein, vitamins, and other complex compounds necessary for life. Photosynthesis supplies the chemical energy needed to produce these compounds.

Chloroplasts are tiny pill-shaped organelles and the site for photosynthesis. This is where the absorbed light energy produces glucose which “feeds” the plant… and, in fact, the whole rest of the world, too!

Most chemical activities that take place within a cell need an energy source to drive them. Inside a cell is and organelle called the mitochondria. Mitochondria releases energy from the food stored in the cell through the process of cellular respiration. Cellular respiration is the process in which oxygen (O2) is chemically combined with food (glucose) molecules within the cell to release energy.

Both plant and animal cells get energy in the form they need through cellular respiration. Because respiration is a chemical process, it can be shown in a chemical equation.
Food (glucose) + oxygen = carbon dioxide + water + energy

Notice that in addition to releasing energy, cellular respiration also produces CO2 and H2O.

NOTE: The term respiration has two meanings:
1. The process by which air is moved into and out of your lungs.
2. The process by which the chemical energy of “food” is released as energy.

Cellular Respiration

Cellular Respiration takes place in the cell.

homeschoolersresources.blogspot.com

Relationship between Photosynthesis and Respiration

Photosynthesis

Respiration

Sun provides all the energy in the form of light

Carbon Dioxide given out to Air

Light energy from the Sun

Water given out to surroundings

Carbon Dioxide from the surrounding Air

Water from the soil

CHLOROPHYLL in chloroplast of green plants

Oxygen given out during Photosynthesis

Animals eat Food

Sugar in food

Oxygen used during respiration

Food used by animals during respiration to produce energy to live and grow

Food

Water given out during Photosynthesis

Photosynthesis:
Plants use sunlight, carbon dioxide (CO₂), and water (H₂O) to produce carbohydrate (C₆H₁₂O₆) and oxygen (O₂).

Respiration:
Animals use carbohydrate (C₆H₁₂O₆) and oxygen (O₂) to produce carbon dioxide (CO₂) and water (H₂O).
How to Prepare a Wet Mount Slide

Wet mount microscope slides are used with live organisms when the observer needs to view the subject while it is in motion or is reacting to some sort of environmental stimulus. The wet mount preparation procedure is relatively simple

Materials:
Cover Glass
Distilled Water
Eye Dropper
Sample to be observed
Slides

Procedures: How to Prepare a Slide

1.) Place a clean slide onto the work surface.

2.) Place the sample to be observed in the center of the slide. If the sample is already in a liquid suspension, skip to Step 5. If not, you will need to add a liquid medium to suspend the sample for viewing.

3.) Add a drop of distilled water over the top of the sample.

4.) Place the cover glass next to the droplet along one edge as shown in the diagram. The side resting against the glass will act as the pivot point as you lower the cover glass over the sample.

5.) Lower the cover glass into place. As you hinge the glass downward, the drop will spread outward and suspend the sample between the slide and cover glass for optimal viewing.
Objective: To locate the primary structures on a leaf that are used to complete photosynthesis.

Materials:
Cover Glass
Distilled Water
Eye Dropper
Microscope
Plant-Elodea Leaf etc.
Sample to be observed
Slides

Procedures:
1.) Obtain a small piece of a plant/lettuce leaf and create a wet mount slide of the plant. (If the plant is too thick you may have to try and separate the plant into a thinner section. Do this by breaking the plant back and pulling gently, a thin piece of the plant should pull away.)

2.) Begin on lower power and using the course adjustment knob focus in on the plant slide. Continue to medium power and using the course adjustment knob, focus in on the plant slide. Lastly, move to high power and using the fine adjustment knob, focus in on the plant slide.

3.) Make a VERY DETAILED drawing of what you are observing on each of the three powers under the microscope. REMEMBER: Exact color is as important to your observation as is the size and scale of each drawing. Use the circle space below to draw the section of your slide that you are observing.

4.) Label the following structures on the diagram chloroplasts, chlorophyll, cytoplasm

<table>
<thead>
<tr>
<th>CELL PART</th>
<th>FUNCTION/PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroplast</td>
<td>Located in the plant cell, they help capture energy from sunlight</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>A green pigment found in the cells of plants that captures energy from sunlight to produce food.</td>
</tr>
<tr>
<td>Cytoplasm</td>
<td>The material within a cell apart from the nucleus.</td>
</tr>
</tbody>
</table>

5.) Describe the function of each of these parts.
Name______________________TEACHER KEY________________________Per.____________Date____________

Magnification ________________________________
What do I See?
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Magnification ________________________________
What do I See?
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Magnification ________________________________
What do I See?
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chlorenchyma

cytoplasm

cell wall
EXAMINING PLANTS ACTIVITY

Objective: To locate the primary structures on a leaf that are used to complete photosynthesis.

Materials:
Cover Glass
Distilled Water
Eye Dropper
Microscope
Plant-Elodea Leaf etc.
Sample to be observed
Slides

Procedures:
1.) Obtain a small piece of a plant/lettuce leaf and create a wet mount slide of the plant.
   (If the plant is too thick you may have to try and separate the plant into a thinner section. Do this by breaking the plant back and pulling gently, a thin piece of the plant should pull away.)

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4.) Label the following structures on the diagram chloroplasts, chlorophyll, stomata
5.) Describe the function of each of these parts.

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<tbody>
<tr>
<td>Chloroplast</td>
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<tr>
<td>Chlorophyll</td>
<td></td>
</tr>
<tr>
<td>Stomata</td>
<td></td>
</tr>
</tbody>
</table>
Name____________________________ Per.________________ Date________________

Magnification __________________________
What do I See?
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Magnification __________________________
What do I See?
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Magnification __________________________
What do I See?
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# COMPARING PHOTOSYNTHESIS & RESPIRATION

**Directions:** Using knowledge that you have obtained, compare and contrast photosynthesis and respiration.

<table>
<thead>
<tr>
<th></th>
<th>PHOTOSYNTHESIS</th>
<th>RESPIRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where does it occur?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When does it occur?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is needed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is created?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What happens to food?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Formula</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**COMPARING PHOTOSYNTHESIS & RESPIRATION**

**Directions:** Using knowledge that you have obtained, compare and contrast photosynthesis and respiration.

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<th>PHOTOSYNTHESIS</th>
<th>RESPIRATION</th>
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</thead>
<tbody>
<tr>
<td>Where does it occur?</td>
<td>Occurs in green plants bearing chloropll pigments</td>
<td>Occurs in living cells</td>
</tr>
<tr>
<td>When does it occur?</td>
<td>Occurs in the presence of light</td>
<td>Occurs all the time</td>
</tr>
<tr>
<td>What is needed?</td>
<td>Uses carbon dioxide and water</td>
<td>Uses oxygen and glucose</td>
</tr>
<tr>
<td>What is created?</td>
<td>Oxygen is created</td>
<td>Carbon dioxide is created</td>
</tr>
<tr>
<td>What happens to food?</td>
<td>Food manufactured</td>
<td>Food broken down</td>
</tr>
<tr>
<td>Chemical Formula</td>
<td>[6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Energy}/ \text{Light} = \text{C}_6\text{H}_12\text{O}_6 + 6\text{O}_2]</td>
<td>[\text{C}_6\text{H}_12\text{O}_6 + \text{O}_2 = \text{H}_2\text{O} + \text{CO}_2 + \text{Energy (36 ATP)}]</td>
</tr>
<tr>
<td></td>
<td>Light energy is converted into chemical energy and stored</td>
<td>Chemical energy is partly converted into heat energy and partly into useful energy</td>
</tr>
</tbody>
</table>
PHOTOSYNTHESIS & CELLULAR RESPIRATION FOLDABLE

FOLD DIRECTIONS:

1. Fold a sheet of paper in half horizontally (hamburger) so that one side is one inch longer than the other side.
2. Cut the shorter side in half, up towards the fold (mountain top) to create two flaps.

Sample Foldable


LABEL FRONT OF FLAPS

1. Label the LEFT flap, PHOTOSYNTHESIS. Draw an accurate diagram of what occurs during photosynthesis. Be sure to label the different gasses and reactants that help make this process happen.
2. Label the RIGHT flap, CELLULAR RESPIRATION. Draw an accurate diagram of what occurs during cellular respiration. Be sure to label the different gasses and reactants that help make this process happen.

LABEL BACK OF FLAPS

1. On the LEFT BACK flap include the following:
   b. What are the reactants? Products?
   c. Define photosynthesis.
2. On the RIGHT BACK flap include the following:
   a. Equation for cellular respiration? Chemical symbol and words.
   b. Define cell respiration.
PHOTOSYNTHESIS & CELLULAR RESPIRATION FOLDABLE

FOLD DIRECTIONS:

3. Fold a sheet of paper in half horizontally (hamburger) so that one side is one inch longer than the other side.
4. Cut the shorter side in half, up towards the fold (mountain top) to create two flaps.

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   a. Equation for cellular respiration? Chemical symbol and words.
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**Elodea & Photosynthesis Lab Teacher Background Information**

**Background Information:** Elodea is a common “exotic” aquarium plant that has also escaped into some local waterways. Elodea is an excellent plant for our studies of photosynthesis and cells because it is easy to grow, and readily available. The leaves are only a few cells thick so they will be easy for us to observe under the microscope to look at cells and cell parts.

Recall from earlier discussions and studies, that photosynthesis requires certain raw materials and produces certain products, one of which is released by the cells as a gas. You have read about the process of photosynthesis, and now you will act as any scientist would and ask to see the proof! How can you see the proof however, since gases are colorless and oxygen and carbon dioxide are both odorless too?

**Problem:** To what extent does distance from a light source (5cm, 10cm, & 15cm) affect the rate of photosynthesis (measured in bubbles / 3 min.) in Elodea water plants?

**Materials:**  
Elodea Plant  
Sodium Bicarbonate  
Test Tubes  
Distilled Water  
Ruler/Meter Stick  
Light Source  
Goggles

**Research:**  
1) Write down the equation for photosynthesis?  
2) Where do plants get the CO₂ for this process (what organisms release this gas)?  
3) What organelle in plants is responsible for photosynthesis (producing food)?  
4) What is the pigment found in this organelle that absorbs light to power photosynthesis?  
5) If a plant were under water and was photosynthesizing, what gas would be visibly bubbling from the plant?

**Hypothesis:**

**PART A. Setting Up the Experiment**

1. Obtain a green sprig of Elodea. Remove several leaves from around the cut end of the stem. Slice off a portion of the stem at an angle and lightly crush the cut end of the stem.  
2. Place a small pinch of sodium bicarbonate into a test tube (this increases carbon dioxide in the water).
3. Place the plant into the test tube, stem end up.
4. Filled the test with distilled water so that the stem is completely submersed.

**PART B. Running the Experiment**

1. Place a source of light about 5 cm from the plant.
2. Wait one minute
3. After one minute, count and record the number of oxygen bubbles rising from the cut end of the stem for 3 minutes. If bubbles fail to appear after 2 minutes repeat part A.
4. Run a second 3 minute trial at 10 cm from the light sources (sun, room, overhead lamp, lamp, grow light). Record your results.
5. Run a third trial 3 minute trial with at a 15 cm distance from a light and record your results.
6. Prepare a graph of your results. The X-axis will be distance from light (IV) and the Y-axis will be number of bubbles (DV) in 3 minutes.

**Data Table:**

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<th>Distance from light source (cm)</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
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**Graph:**

![Graph](image)
1) Did your data support your hypothesis? Explain.

2) What went well with the experiment?

3) What went wrong with the experiment?

4) What new problems (questions for study) arose as you did this experiment?

5) What did you learn from this experiment?
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![Graph](image-url)
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4) What new problems (questions for study) arose as you did this experiment?

5) What did you learn from this experiment?
BTB and Evidence of Photosynthesis TEACHER BACKGROUND INFORMATION

Background Information:

Photosynthesis is the process during which a plant’s chlorophyll traps light energy and sugars (glucose) are produced. In plants, photosynthesis occurs only in cells with chloroplasts. The chemical reaction for photosynthesis is:

\[
\text{Sunlight (light energy) + 6 H}_2\text{O (water) + 6CO}_2 \text{ (carbon dioxide) } \rightarrow 6 \text{O}_2 \text{ (oxygen gas) + C}_6\text{H}_12\text{O}_6 \text{ (glucose)}
\]

In this experiment we will be using a chemical indicator called Bromothymol Blue (BTB). Bromothymol blue solution, BTB, can indicate the presence of carbon dioxide in water. When there is little or no carbon dioxide (CO2) present, BTB will show a blue color. Depending upon the amount of carbon dioxide, BTB will change to green or yellow. Yellow indicates more carbon dioxide.

Materials:

- 3 test tubes
- Beaker
- Graduated cylinder
- Bromothymol Blue Solution
- Straw
- Foil
- Elodea
- Goggles

***SAFETY NOTE*** Consider diluting the BTB Solution with water in a ratio of 5 to 1. Explain to students that when they are measuring the CO2 levels they should be exhaling not inhaling.

Procedure:

1) Place 1 ml of Bromothymol Blue in a beaker and 30 ml of water.
2) Observe the color of the solution.
3) Pour 10 ml of the solution into a test tube and cap it.
4) Introduce CO2 into the remaining solution in the beaker. To do this: use a straw to slowly and gently blow carbon dioxide from your lungs into the solution until it turns yellow. Be sure to gently exhale not inhale.
5) Pour the remaining solution in the beaker (now yellow) evenly into the other two test tubes. Record the color of each.
6) Take one 6 cm piece of elodea and place it in one of the test tubes with the carbon dioxide rich BTB solution (yellow), and cap it.
7) Cap the remaining test tube that does not have an elodea plant in it.
8) Place the test tubes near a light source.
9) Allow the test tubes to sit undisturbed overnight.
10) Record the color of each test tube while holding each in front of a white background.
Data Analysis Questions:

1) Which test tube(s) showed a color change in this investigation?

2) What does a color change indicate in this investigation?

3) Explain what is occurring in this lab.

<table>
<thead>
<tr>
<th>Test Tube #1</th>
<th>Test Tube #2</th>
<th>Test Tube #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTB Solution</td>
<td>BTB Solution w/ CO2</td>
<td>BTB Solution w/ CO2 &amp; Elodea Plant</td>
</tr>
<tr>
<td>Covered</td>
<td>Covered</td>
<td>Covered</td>
</tr>
<tr>
<td>(Control Group)</td>
<td>(Covered)</td>
<td>(Covered)</td>
</tr>
</tbody>
</table>

Color at Start

(Include any other observations)

Hypothesis: What will happen to each test tube (color change) and why (scientific reason)?

Color after 24 Hours
BTB and Evidence of Photosynthesis

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Photosynthesis is the process during which a plant’s chlorophyll traps light energy and sugars (glucose) are produced. In plants, photosynthesis occurs only in cells with chloroplasts. The chemical reaction for photosynthesis is:

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\]

\[
\text{ (chloroplasts) } \quad \text{ (roots) } \quad \text{ (stomata) } \quad \text{ (stomata) } \quad \text{(food = glucose OR sugar)}
\]

In this experiment we will be using a chemical indicator called Bromothymol Blue (BTB). Bromothymol blue solution, BTB, can indicate the presence of carbon dioxide in water. When there is little or no carbon dioxide (CO2) present, BTB will show a blue color. Depending upon the amount of carbon dioxide, BTB will change to green or yellow. Yellow indicates more carbon dioxide.

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8) Place the test tubes near a light source.

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Name:_________________________________________ Per._________ Date__________

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<tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Color at Start**

(Include any other observations)

**Hypothesis:** What will happen to each test tube (color change) and why (scientific reason)?

**Color after 24 Hours**
Background Information:
Respiration is the process by which cells take in oxygen and release carbon dioxide and energy. It is the step-by-step breakdown of high energy glucose molecules to release energy. Respiration takes place in all living cells day and night. Cells carry out the process of cellular respiration in order to meet all of their needs. Energy produced from glucose by cellular respiration is required for the survival of all living things. The organelle where cellular respiration takes place in cell is the mitochondrion. The mitochondrion is the organelle that makes energy from food for the cell's activities. When living things respire they produce heat energy. The chemical equation for respiration is: (Photo from: amuslima.com)

Glucose (C6H12O6) + Oxygen (6 O2) → Carbon dioxide (6CO2) + Water (6H2O) + Energy

Problem: To observe how organisms use sugar to create energy.

Materials:
- Balloon
- Dry Yeast
- Glass containers or soda bottle
- Measuring Tape
- Sugar
- Tablespoon/spoon
- Thermometer
- Warm Water

Procedures:
1) Put 1 spoonful of yeast and 2 spoonfuls of sugar in the soda bottle.
2) Fill the bottle ¾ full of warm water.
3) QUICKLY stretch the balloon over the opening of the bottle.
4) Seal with masking tape.
5) Shake the bottle to speed up the reaction.
6) Measure the diameter of the balloon every 2 minutes.
7) Shake as needed to mix the ingredients.
8) Repeat steps 1 and 2.
9) Insert a thermometer or temperature probe in the bottle.
10) Measure the temperature every 2 minutes.
11) Complete the data table and graphs.
12) Analyze your results and complete the Making Conclusions Questions.
Data:

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Diameter (cm)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
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<td></td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data Analysis: Using the data from the table above create two graphs, one to measure the change in the diameter of the balloon and one to measure the temperature inside of the bottle. Remember to use a title and to label the X and Y axis.
Making Conclusions:

1.) After completing your two graphs, describe the relationships shown in the graphs:
   a.) Time & temperature
   
   b.) Time & diameter of the balloon

2.) What is the gas that filled the balloon? Where did it come from? Explain your answer.

3.) Explain why the temperature changed during the experiment.
BEASTIE YEASTIES

Background Information:
Respiration is the process by which cells take in oxygen and release carbon dioxide and energy. It is the step-by-step breakdown of high energy glucose molecules to release energy. Respiration takes place in all living cells day and night. Cells carry out the process of cellular respiration in order to meet all of their needs. Energy produced from glucose by cellular respiration is required for the survival of all living things. The organelle where cellular respiration takes place in the cell is the mitochondrion. The mitochondrion is the organelle that makes energy from food for the cell's activities. When living things respire they produce heat energy. The chemical equation for respiration is: (Photo from: amuslima.com)

\[
\text{Glucose} \ (C_6H_{12}O_6) + \text{Oxygen} \ (6 \ O_2) \rightarrow \text{Carbon dioxide} \ (6CO_2) + \text{Water} \ (6H_2O) + \text{Energy}
\]

Problem: To observe how organisms use sugar to create energy.

Materials:
- Balloon
- Dry Yeast
- Glass containers or soda bottle
- Measuring Tape
- Sugar
- Tablespoon/spoon
- Thermometer
- Warm Water

Procedures:
13) Put 1 spoonful of yeast and 2 spoonfuls of sugar in the soda bottle.
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15) QUICKLY stretch the balloon over the opening of the bottle.
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17) Shake the bottle to speed up the reaction.
18) Measure the diameter of the balloon every 2 minutes.
19) Shake as needed to mix the ingredients.
20) Repeat steps 1 and 2.
21) Insert a thermometer or temperature probe in the bottle.
22) Measure the temperature every 2 minutes.
23) Complete the data table and graphs.
24) Analyze your results and complete the Making Conclusions Questions.
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<thead>
<tr>
<th>Time (minutes)</th>
<th>Diameter (cm)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
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<td>4</td>
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<td>12</td>
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<td>14</td>
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<td>16</td>
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<tr>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Data Analysis:** Using the data from the table above create two graphs, one to measure the change in the diameter of the balloon and one to measure the temperature inside of the bottle. Remember to use a title and to label the X and Y axis.
Making Conclusions:

1.) After completing your two graphs, describe the relationships shown in the graphs:
   a.) Time & temperature
   
   b.) Time & diameter of the balloon

2.) What is the gas that filled the balloon? Where did it come from? Explain your answer.

3.) Explain why the temperature changed during the experiment.
Teacher Guide: Plants and Snails

Learning Objectives
Students will:
- Use an indicator to measure concentrations of oxygen and carbon dioxide.
- Design controlled experiments to test hypotheses.
- Discover what gases are used and produced by animals.
- Discover what gases are used and produced by plants (in light and dark).
- Explain how animals and plants help each other survive.

Vocabulary
bromthymol blue (BTB), carbon dioxide-oxygen cycle, interdependence

Lesson Overview
The Plants and Snails Gizmo™ allows students to discover the nature of oxygen intake and carbon dioxide release in animals in both light and in the dark.

The Student Exploration contains three activities:
- Activity A – Students design their own series of trials in order to gather data on the changing levels of O₂ and CO₂ in plants and animals in both light and dark.
- Activity B – Students look more closely at the effects of snails and plants together, studying the concept of interdependence.
- Activity C – Students discover the relationship between the changing gas levels, concluding that oxygen is converted to carbon dioxide and vice versa.

Suggested Lesson Sequence

Pre-Gizmo Activity  Use care in completing the Pre-Gizmo Activity  
6. ❏ 5 – 10 minutes
Bromthymol blue’s ability to indicate the presence of carbon dioxide in a solution is easily demonstrated. Place about 10 mL of bromthymol blue solution (inexpensive and available from major science supply shops) into a test tube. Then place a straw into the solution and blow gently through the straw. BE CAREFUL NOT TO INHALE! BTB IS POISONOUS. After a few minutes of blowing, the solution should begin to turn yellow, indicating the presence of carbon dioxide.

7. ❏ 10 – 15 minutes
Prior to using the Gizmo
Before students are at the computers, pass out the Student Explorations and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers yet. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.
8. **Gizmo activities** *(15 – 20 minutes per activity)*
   Assign students to computers. Students can work individually or in small groups. Have them work through the Student Exploration with the help of the Gizmo. Walk around to check student progress and answer questions as students work. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

9. **Discussion questions** *(10 – 20 minutes)*
   As students are working or just after they are done, discuss the following questions:
   - Do plants breathe (exchange gases) in the same way that animals do?
   - What is an “indicator” and how are they useful to scientists?
   - Do plants create more oxygen than they use? How do you know?

10. **Follow-up activity: Demonstrating gas exchange in plants** *(2 – 5 days)*
    You can demonstrate parts of this laboratory in the classroom. Elodea is a popular aquarium plant and is likely available from local aquarium supply stores. Bromthymol blue is available from major science supply houses. Prepare several test tubes containing the BTB solution and several sprigs of Elodea. Cork the tubes and then place several of them in a dark location like a closet. Place several others on a sunny windowsill. Check the tubes periodically over the course of the next week. The tubes on the windowsill should turn blue. The tubes in the closet should turn yellow.

### Scientific Background

Indicators are important tools used by biologists and chemists. An **indicator** is a substance that changes color when it comes in contact with some specific chemical.

**Bromthymol blue** (also known as bromothymol blue and as BTB) is a commonly used indicator that indicates whether a solution is an acid, a base, or neutral. In a neutral solution, bromthymol blue is green. In an acid it turns yellow and in a base it turns blue. (See below.)

<table>
<thead>
<tr>
<th>Solution pH</th>
<th>Color (with bromthymol blue indicator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidic</td>
<td>Yellow</td>
</tr>
<tr>
<td>Neutral</td>
<td>Green</td>
</tr>
<tr>
<td>Basic</td>
<td>Blue</td>
</tr>
</tbody>
</table>

When **carbon dioxide** (CO\(_2\)) is dissolved in water, the water becomes a mild acid (the acid in soda) and bromthymol blue turns the water yellow. When **oxygen** (O\(_2\)) is dissolved in water, the water becomes a base and bromthymol blue turns it blue. This makes BTB particularly useful in studying of respiration and photosynthesis, both of which involve oxygen and carbon dioxide.

**Respiration** takes place all the time, day and night, in plants and in animals. During respiration the plant or animal takes in oxygen and releases carbon dioxide. **Photosynthesis** takes place only in plants AND only when light is present. During photosynthesis, plants take in carbon dioxide and they release oxygen.

During the daylight hours, plants are engaged in both processes at the same time. However, the amount of oxygen produced through photosynthesis is usually greater than the amount of oxygen that the plant uses in respiration. In fact, the amount of oxygen produced by plants during the daylight hours is generally greater than the amount that they consume during an entire day/night cycle. As a result plants produce more oxygen than they use, which is critical for the survival of other living creatures (like animals), which require oxygen but don’t produce any on their own.
Environmental Connection
A potential environment crisis has recently been receiving a great deal of attention from scientists, the news media, and governments around the world. The concern is global warming – a gradual increase in the temperature of Earth’s atmosphere.

Global warming is not an unnatural event. It has occurred many times throughout Earth’s history (along with its counterpart, global cooling), but scientists are concerned that the current trend may be more than a natural cycle – that it may be a direct result of human activity.

Earth’s generally mild climate is due in large part to the greenhouse effect. The greenhouse effect refers to the fact that heat which radiates away from Earth’s surface and its oceans is captured by certain “greenhouse gases.” These gases hold the heat within the atmosphere rather than letting it escape to outer space. Without these gases, the temperature would fluctuate widely between day and night and the overall average temperature on Earth would be much colder.

Carbon dioxide is one of the most common greenhouse gases. Recent human activities, such as the burning of fossil fuels, have greatly increased the amount of carbon dioxide in the atmosphere. (Carbon dioxide is a product of the burning process.)

Another factor that may be playing a role in the increase in CO₂ is ongoing deforestation – the felling of mature forests to make room for agriculture or urban expansion. Fewer trees means that less photosynthesis takes place.

Concern is growing that the current global warming trend may be a direct result of our unnatural addition of greenhouse gases to the atmosphere.

Selected Web Resources
Photosynthesis lab: http://passporttoknowledge.com/scic/photosynthesis/educators/plantsbreathe.html
PBS/Nova resource on photosynthesis: http://www.pbs.org/wgbh/nova/methuselah/photosynthesis.html#
EPA site on climate change: http://www.epa.gov/climatechange/science/index.html
Student Exploration: Plants and Snails

Vocabulary: bromthymol blue (BTB), carbon dioxide-oxygen cycle, indicator, interdependence

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

1. What important gas do we take in when we breathe?
   ________________________________________________________________

2. Why don’t we run out of the important gases that we need to stay alive?
   ________________________________________________________________
   ________________________________________________________________

Gizmo Warm-up
In the Plants and Snails Gizmo™, each of the test tubes contains water and a small amount of bromthymol blue (BTB). BTB is a chemical indicator. An indicator changes color when the chemicals in the water change.

1. With the lights set to on, drag a snail into one test tube and a plant into another. Press Play ( ). After 24 hours, what is the color of each tube?
   ________________________________________________________________
   ________________________________________________________________

2. Select Show oxygen and CO₂ values. Place the O₂/CO₂ probe in each tube. The probe will show you the levels of two gases, oxygen (O₂) and carbon dioxide (CO₂), in the tubes. We call these amounts the gas levels.
   
   A. When the water turns blue, which gas is most common? ______________________
   
   B. When the water turns yellow, which gas is most common? ______________________
   
   C. What does it tell you when the water is green? ________________________________
Activity A: Gases in and gases out

Get the Gizmo ready:
- Click Reset (☐).
- Clear all of the test tubes.
- Turn on Show oxygen and CO₂ values.

Question: What gases do plants and animals take in and what do they give off?

1. **Collect data**: Use the Gizmo to learn what gases plants and animals take in and give off. Try it in both light and dark. Record your results below. If you do more than five experiments, write your extra results in your notebook or on separate sheets of paper.

<table>
<thead>
<tr>
<th>What is in the tube</th>
<th>Lights: on/off</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

2. **Analyze**: Study your data on gases given off by plants.
   - A. What gas do plants give off in the light? ____________________________________________
   - B. How about in the dark? ____________________________________________

3. **Analyze**: Study your data on gases given off by animals.
   - A. What gas do animals give off in the light? ____________________________________________
   - B. How about in the dark? ____________________________________________
   - C. How do these results compare to your plant results? ____________________________________________

4. **Infer**: Describe the carbon dioxide-oxygen cycle by completing the sentences below:
   - *Animals breathe in* ________________ and breathe out ________________.
   - *In sunlight, plants take in* ________________ and release ________________.
Activity B: Interdependence

Get the Gizmo ready:
- Click Reset.
- Clear all of the test tubes.
- Turn the light switch to on.
- Check Show oxygen and CO₂ values.

Question: How do plants and animals depend on each other?

1. **Observe:** Put one sprig of Elodea and one snail in a test tube with the lights on. Click Play.
   - A. Does the color of the water in the tube change? ________________
   - B. What happens to the O₂ and CO₂ levels? ____________________________

2. **Predict:** Without using the Gizmo, predict what you think will happen to the gas levels in each case listed below. (Leave the **Actual result** column blank for now.)

<table>
<thead>
<tr>
<th>Tube</th>
<th>Prediction</th>
<th>Actual result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 snails, 2 sprigs,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lights on</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 snail, 2 sprigs,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lights on</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 snail, 2 sprigs,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lights off</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. **Run Gizmo:** Now run the Gizmo to test your predictions. Record your findings in the table.

4. **Generalize:** Describe how plants and animals each contribute to the survival of the other. (This type of cooperative relationship is called **interdependence**.)

________________________________________________________________________
________________________________________________________________________

5. **Challenge:** Simulate a 24-hour day (12 hours of light, 12 hours of dark). How many snails and plants do you need to keep a stable environment? Explain any discoveries you make.

________________________________________________________________________
________________________________________________________________________
Activity C:
Linking O₂ and CO₂

Get the Gizmo ready:
- Click Reset.
- Clear all of the test tubes.
- Turn the light switch to on.
- Check Show oxygen and CO₂ values.

Question: How are the amounts of oxygen and carbon dioxide related to each other?

1. **Observe:** Put two Elodea sprigs into a test tube. Put the O₂/CO₂ probe into the tube with the Elodea. Click Play. As the Gizmo runs, Pause ( ) it a few times.

   A. How do the oxygen (O₂) and carbon dioxide (CO₂) levels change over time?

   ____________________________________________

   B. What is always true about the total amount of O₂ and CO₂ in the test tube?

   ____________________________________________

   C. What happens when the CO₂ reaches zero? ____________________________________________

2. **Revise and repeat:** Click Reset and run the experiment again, this time with the lights off.

   A. How do the gas levels change? O₂ ______________ CO₂ ______________

   B. What is the total of O₂ and CO₂? ____________________________________________

3. **Revise and repeat:** Click Reset. Remove the plants. Repeat the experiment with two snails.

   A. How do the gas levels change? O₂ ______________ CO₂ ______________

   B. What is the total of O₂ and CO₂? ____________________________________________

   C. Why do the gas levels stop changing in this case? ________________________________

        ____________________________________________

4. **Challenge:** The total of the O₂ and CO₂ in the test tubes always stayed the same. Why do you think this is? (Hint: Molecules of carbon dioxide, CO₂, are made of carbon, C, bonded together with two molecules of oxygen, O.)

        ____________________________________________

        ____________________________________________
Plants and Snails

**Answer Key**

**Vocabulary**: bromthymol blue (BTB), carbon dioxide-oxygen cycle, indicator, interdependence

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

[Note: The purpose of these questions is to activate prior knowledge and get students thinking. Students are not expected to know the answers to the Prior Knowledge Questions.]

3. What important gas do we take in when we breathe?

   *Oxygen*

4. Why don’t we run out of the important gases that we need to stay alive?

   *Answers may vary. [It’s likely that not all students will know that plants make oxygen during photosynthesis.]*

**Gizmo Warm-up**

In the *Plants and Snails* Gizmo™, each of the test tubes contains water and a small amount of *bromthymol blue* (BTB). BTB is a chemical indicator. An indicator changes color when the chemicals in the change.

3. With the lights set to *on*, drag a snail into one test tube and a plant into another. Press *Play* ( ). After 24 hours, what is the color of each tube?

   *The tube with the plant in it is kind of blue. The tube with the snail in it is kind of yellow.*

4. Select *Show oxygen and CO₂ values*. Place the O₂/CO₂ probe in each tube. The probe will show you the levels of two gases, oxygen (O₂) and carbon dioxide (CO₂) in the tubes. We call these amounts the gas levels.

   A. When the water turns blue, which gas is most common? *Oxygen (O₂)*

   B. When the water turns yellow, which gas is most common? *Carbon dioxide (CO₂)*

   C. What does it tell you when the water is green?

      *The levels of oxygen (O₂) and carbon dioxide (CO₂) are about equal.*
Activity A:
Gases in and gases out

Get the Gizmo ready:
- Click Reset ( ).
- Clear all of the test tubes.
- Turn on Show oxygen and CO\textsubscript{2} values.

Question: What gases do plants and animals take in and what do they give off?

5. Collect data: Use the Gizmo to learn what gases plants and animals take in and give off. Try it in both light and dark. Record your results below. If you do more than five experiments, write your extra results in your notebook or on separate sheets of paper.

Answers will vary. [Below are some possible experiments with their expected results.]

<table>
<thead>
<tr>
<th>What is in the tube</th>
<th>Lights: on/off</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 plants</td>
<td>Off</td>
<td>The water turned pale green and the O\textsubscript{2} level went down.</td>
</tr>
<tr>
<td>3 snails</td>
<td>On</td>
<td>The O\textsubscript{2} level went down. The water turned yellow and the snails died.</td>
</tr>
<tr>
<td>3 plants</td>
<td>On</td>
<td>The O\textsubscript{2} level went up. The water turned very blue and there were bubbles. Then the bubbles stopped and the plants turned brown.</td>
</tr>
<tr>
<td>4 plants and 4 snails</td>
<td>Off</td>
<td>The O\textsubscript{2} level went to zero, the snails died, and then the plants died as well.</td>
</tr>
</tbody>
</table>

6. Analyze: Study your data on gases given off by plants.
   A. What gas do plants give off in the light? *Oxygen* (O\textsubscript{2})
   B. How about in the dark? *Carbon dioxide* (CO\textsubscript{2})

7. Analyze: Study your data on gases given off by animals.
   A. What gas do animals give off in the light? *Carbon dioxide* (CO\textsubscript{2})
   B. How about in the dark? *Carbon dioxide* (CO\textsubscript{2})

   How do these results compare to your plant results? In the light, plants give off oxygen. Animals give off carbon dioxide in the light.

8. Infer: Describe the **carbon dioxide-oxygen cycle** by completing the sentences below:

   Animals breathe in oxygen (O\textsubscript{2}) and breathe out carbon dioxide (CO\textsubscript{2}).

   In sunlight, plants take in carbon dioxide (CO\textsubscript{2}) and release oxygen (O\textsubscript{2}).
Activity B: Interdependence

Get the Gizmo ready:
- Click Reset.
- Clear all of the test tubes.
- Turn the light switch to on.
- Check Show oxygen and CO\textsubscript{2} values.

Question: How do plants and animals depend on each other?

6. Observe: Put one sprig of Elodea and one snail in a test tube with the lights on. Click Play.
   
   A. Does the color of the water in the tube change? No.
   
   B. What happens to the O\textsubscript{2} and CO\textsubscript{2} levels?

   *Answers will vary, but students should note that the levels are both still close to 6.0.*

7. Predict: Without using the Gizmo, predict what you think will happen to the gas levels in each case listed below. (Leave the Actual result column blank for now.)

<table>
<thead>
<tr>
<th>Tube</th>
<th>Prediction</th>
<th>Actual result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 snails, 2 sprigs, lights on</td>
<td>Predictions will vary.</td>
<td>O\textsubscript{2} and CO\textsubscript{2} levels both remain about 6.0.</td>
</tr>
<tr>
<td>1 snail, 2 sprigs, lights on</td>
<td>Predictions will vary.</td>
<td>The O\textsubscript{2} level increases and the CO\textsubscript{2} level decreases.</td>
</tr>
<tr>
<td>1 snail, 2 sprigs, lights off</td>
<td>Predictions will vary.</td>
<td>The CO\textsubscript{2} level increases and the O\textsubscript{2} level decreases.</td>
</tr>
</tbody>
</table>

8. Run Gizmo: Now run the Gizmo to test your predictions. Record your findings in the table.

9. Generalize: Describe how plants and animals each contribute to the survival of the other. (This type of cooperative relationship is called interdependence.)

   *Animals need oxygen to live. They use the oxygen and make CO\textsubscript{2}. In light conditions, plants use CO\textsubscript{2} and make oxygen. Animals depend on the oxygen produced by plants for survival, and plants depend on the CO\textsubscript{2} produced by animals for survival.*


   *Answers may vary. [The most stable result comes from combining 4 plants with 1 snail. The combination of 3 plants and 1 snail works too; there is some excess oxygen, but the plants do still get enough carbon dioxide.]*
Activity C: Linking O$_2$ and CO$_2$

Get the Gizmo ready:
- Click **Reset**.
- Clear all of the test tubes.
- Turn the light switch to **on**.
- Check **Show oxygen and CO$_2$ values**.

Question: How are the amounts of oxygen and carbon dioxide related to each other?

1. **Observe**: Put two Elodea sprigs into a test tube. Put the O$_2$/CO$_2$ probe into the tube with the Elodea. Click **Play**. As the Gizmo runs, **Pause** it a few times.

   A. How do the oxygen (O$_2$) and carbon dioxide (CO$_2$) levels change over time?

      *The O$_2$ level goes up and the CO$_2$ level goes down.*

   B. What is always true about the *total* amount of O$_2$ and CO$_2$ in the test tube?

      *The total of O$_2$ and CO$_2$ stays the same – about 12 ppm (parts per million).*

   C. What happens when the CO$_2$ reaches zero?

      *The O$_2$ level reaches 12 ppm and stays there.*

2. **Revise and repeat**: Click **Reset** and run the experiment again, this time with the lights **off**.

   A. How do the gas levels change? O$_2$ *decreases* CO$_2$ *increases*

   B. What is the total of O$_2$ and CO$_2$? *The total stays at 12 ppm.*

3. **Revise and repeat**: Click **Reset**. Remove the plants. Repeat the experiment with two snails.

   A. How do the gas levels change? O$_2$ *decreases* CO$_2$ *increases*

   B. What is the total of O$_2$ and CO$_2$? *The total stays at 12 ppm.*

   C. Why do the gas levels stop changing in this case? *The snails die, so they stop using up oxygen and giving off carbon dioxide.*

4. **Challenge**: The total of the O$_2$ and CO$_2$ in the test tubes always stayed the same. Why do you think this is? (Hint: Molecules of carbon dioxide, CO$_2$, are made of carbon, C, bonded together with two molecules of oxygen, O.)

   *Sample answer: The total amount of O$_2$ and CO$_2$ remains the same because the number of oxygen molecules produced by plants is equal to the number of carbon dioxide molecules produced by animals. [Note: CO$_2$ is not directly converted to O$_2$ by plants, but the numbers of molecules of each are the same in the photosynthesis equation.]*
PHOTOSYNTHESIS WEBQUEST

Illuminating Photosynthesis

☐ Type in the following link:
   http://www.pbs.org/wgbh/nova/methuselah/photosynthesis.html#

☐ Read the introduction entitled “Illuminating Photosynthesis” by Rick Groleau

☐ Click on the link that reads: “Go to Illuminating Photosynthesis.”

☐ Read the introductory poem.

☐ Click on “The Cycle” at the top of the box

1. Click on each of the following items, and explain what happens:
   a. The shade over the window: ________________________________
   b. The container of water: ________________________________
   c. The child: ________________________________

2. a. What gas does the child provide for the plant to use?  __________________
   b. What gas does the plant provide for the child to use?  __________________
   c. Will the plant continue to produce this gas if the shade over the window is closed? (try it out to see!) __________________

3. According to this animation, what 3 main things does the plant need for photosynthesis to occur?
   (1) __________________
   (2) __________________
   (3) __________________

☐ Click on “The Atomic Shuffle” at the top of the box.

☐ Read the introductory poem, and click on “Next”

4. What type of molecule is shown in the leaf?  __________________

5. Draw one of the molecules below, as it is shown in the leaf.
6. According to the reading, these molecules “do not come from the tap.” What two places do they come from?

(1) __________________ (2) __________________

☐ Click on “Next” and watch carefully. You may click on “replay” to watch this again.

7. a. What is “stripped” from each water molecule?

_______________________________

b. From where does the cell get the energy to do this? _________________

c. The stripped molecules form pairs. Where does it go after this?

_______________________________

☐ Click on “Next”

8. a. What gas enters the leaf? _________________

b. This gas enters through “holes” in the leaf. What are they called? _________________

☐ Click on “Next”

9. What molecule is formed once again? _________________

☐ Click on “Next”

10. Another molecule is formed (“and boy is it sweet”). Draw this molecule below as shown

[Blank Box]
11. What is the name of this molecule? ______________________________

☐ Click on “Three Puzzlers” at the top of the box.

12. Answer each of the following questions, and explain in your own words.

a. Can a tree produce enough oxygen to keep a person alive? Explain.
   ______________________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________

b. Can a plant stay alive without light?
   ______________________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________

c. Can a plant survive without oxygen? Explain.
   ______________________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________