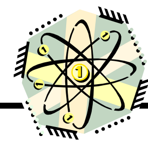
# Intradisciplinary Connections

See pages 30-31 for the complete wording of the Texas Essential Knowledge & Skills addressed in this learning experience.



## Physical Science

- Interactions of matter and energy
- Transfer of energy
- Properties and changes in matter

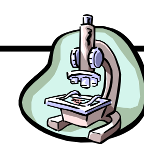
## History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge

## Properties, Systems, & Change

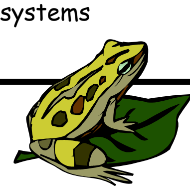
## Science and Technology

- Understandings about science and technology
- Abilities of technological design



## Life Science

- Structure and function in living systems
- Regulation and behavior
- Populations and ecosystems



## Overview of Learning Experiences

| | |
|---|---|
| TEKS | **7.8** The student knows that complex interactions occur between matter and energy. The student is expected to:<br>(B) identify that radiant energy from the Sun is transferred into chemical energy through the process of photosynthesis |
| Engage | ✦ Students observe changes in the color of bromthymol blue indicator solution changes from blue to yellow-green when $CO_2$ is bubbled into it by a person blowing through a straw. |
| Explore | ✦ Students observe changes in the color of bromthymol blue indicator solution when $CO_2$ is present or absent to provide clues about plant's uptake of $CO_2$ during photosynthesis<br>✦ Students observe how the presence or absence of light affects a plant's uptake of $CO_2$, using an indicator solution.<br>✦ Students observe other substances that are used during photosynthesis, such as water, chlorophyll, and light energy.<br>✦ Students observe other substances that are produced during photosynthesis, such as glucose, which is a form of chemical energy. |
| Explain | ✦ Students communicate their findings from the engage and explore activities to demonstrate that plants take in carbon dioxide gas, and give off oxygen gas.<br>✦ Students communicate their observations of stomata and xylem tubes.<br>✦ Students observe other substances that are produced during photosynthesis and relate them to the photosynthesis equation. |
| Elaborate | ✦ Students use their knowledge of the raw materials and products of photosynthesis to design original experiment that answers their own question about photosynthesis<br>✦ Students use an investigation-planning guide to help design their experiment. |
| Evaluate | **SUMMATIVE ASSESSMENT**<br>✦ Students demonstrate their understanding by completing performance tasks that include sequencing cards of the photosynthesis equation, making a drawing of photosynthesis occurring in a leaf, and the design, testing and report of their photosynthesis experiment.<br>✦ A rubric score will assess the completion the performance tasks, and the quality of the experimental design and report. |

# ENGAGE

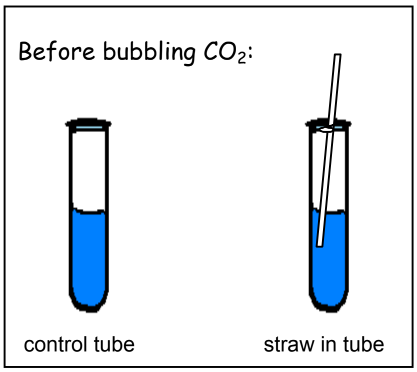
**Materials** (details p. 25 )

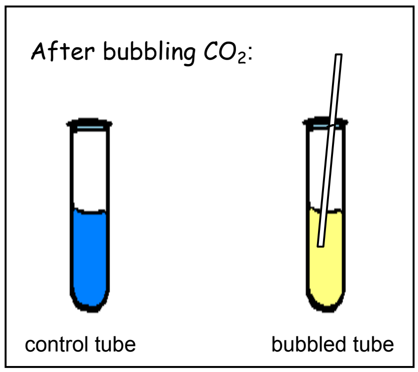
**For the class:**
- ☐ 4 test tubes of water
- ☐ straws
- ☐ white paper
- ☐ bromthymol blue solution
- ☐ dropper

ENGAGE

1. Fill 2 test tubes or tall vials with 100 ml of water. Add 15-20 drops of bromthymol blue indicator to the water of each test tube. Explain that an indicator is a chemical that changes colors when it comes in contact with certain substances.

2. After stirring gently with a straw, place a sheet of white paper behind each test tube and ask students to observe the color of the solutions. *(light blue)*




**SAFETY FIRST ALERT**

3. Select two student volunteers from each group. Remind them that a chemical named bromthymol blue is being used so safety goggles must be worn. Each student volunteer prepares a test tube by blowing $CO_2$ bubbles into the solution with the straw **without pulling any of the solution up the straw toward their mouth.** (The teacher can also do this as a demonstration to model the bubbling procedure.) The bubbling should continue until the solution begins to turn a different color and stop as soon as the color changes. The two prepared vials or test tubes should be labeled with the group member's name and placed into a test tube rack for use in the first Explore experience.

4. Place the paper behind the bubbled test tubes again. Ask students to compare the color of the solution in their test tubes to the control test tube solution which did not have carbon dioxide bubbled into it.

**ENGAGE**

**Questioning Strategies**

- What color changes did you observe? *(The solution in the bubbled test tube turned from blue to green, and then yellow. The solution in the test-tube that was not bubbled remained a light blue color.)*
- What is an indicator? *(A substance that changes color to show that it is in contact with certain substances.)*
- What indicator did we use? *(bromthymol blue)*
- When did the color change in the indicator occur? *(When someone blew bubbles into the solution it turned from blue to green to yellow.)*
- What gas do we breathe in? *(oxygen)*
- What gas do we breathe out? *(carbon dioxide)*
- What substance was bubbled into the water? *(carbon dioxide from the bubbler's breath)*
- Why did we prepare a test tube that did not have carbon dioxide bubbled into it? *(It serves as a control that remains the same color, so the resulting color in the bubbled test tube can be compared to it.)*
- What is the independent variable, or the factor in the experiment that was purposely changed? *(Adding carbon dioxide bubbles to the solution.)*
- What substance causes bromthymol blue to change from blue to a greenish-yellow color, based on the evidence from our test? *(Bubbling carbon dioxide into water forms weak carbonic acid which is indicated by bromthymol blue)*

# EXPLORE

**A. Students explore to discover if plants use carbon dioxide gas when they are in light:**

1. Show materials to students and review the results of the previous experience of bubbling $CO_2$ into the bromthymol solution.

**SAFETY FIRST ALERT**

2. Stress that safety and responsible behavior are an important part of every lab.
Distribute materials and student data sheets. Demonstrate to students the proper procedure for filling the vials and bubbling the carbon dioxide into the solution. Teachers who are concerned about unsafe bubblers may opt to have students blow up balloons with their exhaled air and slowly release the air into the solution by placing the straw into the neck of the balloon. Only one person should use each straw.

3. Have students read and follow the procedures listed on the student data sheet. Students need to wait until the next day before completing observations. Therefore, they may continue with section B after setting up section A.

**B. Students explore to see if plants produce gas bubbles in light.**

Demonstrate how to set up the materials as described in Part B on the student data sheet. Have students set up their own materials and make and record observations.

**Materials** (details p. 25)

**Explore A. and B.**
**For each group of students:**
- ☐ 2 prepared test tubes from Engage activity
- ☐ bromthymol blue
- ☐ labels
- ☐ spring water
- ☐ *Elodea* sprigs
- ☐ white paper
- ☐ strong light source
- ☐ test tubes
- ☐ vials
- ☐ safety goggles
- ☐ straight pins
- ☐ clear funnel
- ☐ large beakers

**For each student:**
- ☐ *Sunny Synthesis data sheet*, Masters A-B

EXPLORE

**C. Students explore plant cells under the microscope to discover which cell parts contain green chlorophyll to capture sunlight energy for photosynthesis.**

Review how to make a wet mount slide and demonstrate using Elodea leaves. Review microscope focusing procedures used in sixth grade lesson.

Ask students to focus the microscope on low power to observe the *Elodea* leaves. Remind them that they are looking for Elodea cell parts that give evidence of green chlorophyll pigment that traps light energy for photosynthesis.

**D. Students explore to find out if plant leaves that are deprived of light can produce glucose and store it as starch.**

Demonstrate the importance of light for food production in plants by comparing the effects on geranium leaves that are left in sunlight, darkness, and partial darkness. One leaf should be left alone as a control, one leaf half covered with a piece of foil it to keep out sunlight, and one leaf should be completely covered with foil. Place the plant in a sunny window. The leaves should remain attached to the plant with the covers in place for four days. At the end of fourth day, remove the leaves from the plant. After class, remove the chlorophyll from the leaves with alcohol in a hot water bath that is heated on a hot plate. Reserve the "green alcohol" as evidence of chlorophyll in the leaves.

**SAFETY FIRST ALERT**

Stress the importance of keeping alcohol away from any type of flame because it is extremely flammable. Model safe lab behavior by wearing goggles while using heat and or a chemical. *Each student must wear safety goggles while using iodine solution*

**EXPLORE**

**Materials** (details p. 25

**Explore C, D, and E**
**For each group of students:**

- ☐ *Elodea* leaves
- ☐ slides
- ☐ cover slips
- ☐ water droppers
- ☐ microscopes
- ☐ petri dish
- ☐ Lugol's iodine
- ☐ slices of potato
- ☐ celery sticks with leaves
- ☐ beakers
- ☐ red ink
- ☐ hand lens or loupe
- ☐ Geranium leaves
- ☐ foil
- ☐ alcohol
- ☐ hot plate

EXPLAIN

1. Have students observe the leaf in a petri dish and the green alcohol in the beaker. Explain that the chlorophyll from the leaf was removed so it won't interfere with the test for stored glucose in the form of starch. Plants often store glucose as starch. A potato is a good example of stored starch in a plant that we use as food.
2. We can use an indictor called Lugol's iodine to test for the presence of starch in a substance. Hold up the iodine bottle so students can observe it.
3. Allow students to test slices of potato to see a positive test for starch, and record in their journal.
4. Cover the demonstration geranium leaf with iodine and put the lid on the petri dish so students can observe it without coming in contact with the iodine.

**E. Students explore to find out how plants get the water needed for photosynthesis.**

Ask students to use a hand lens to observe and draw the cut ends of celery sticks. Place the celery into a clear beaker or glass that contains 6-8 drops of red ink in about 100 ml of water for at least one hour, or overnight, if possible.

**F. Students explore to find out how gases enter and exit leaves.**

Students may observe stomata and guard cells in the leaves of indoor or outdoor plants by painting the underside of the leaf with 5 to 6 layers of clear fingernail polish and allowing it to dry before carefully peeling it off. The clear polish will have the imprint of the stomata, which can be observed under the microscope on low power. Students should draw a microscopic view of the stomata in their journals.

*Grades 6-8*

*Students should know that almost all food energy comes originally from sunlight.*

*Benchmarks for Science Literacy, p. 120*

EXPLORE

## Sunny Synthesis (See Master A-B)

Data Sheet

Question: Do plants take in and release gas?

Materials: straws, bromthymol blue, labels, spring water, white paper, *Elodea* sprigs, vials with lids, safety goggles

**Procedure A:**

1. Label two vials "In Dark" and two vials "In Light". Write the name of the Material Manager on the labels so he/she can locate them after the test.
2. Put on safety goggles. This activity uses a chemical indicator called bromthymol blue.
3. Fill the vials ½ full of water and add 15 drops of bromthymol blue. Place a white sheet of paper behind each vial, observe, and record the color of the solution below.
4. Bubble carbon dioxide into the solution slowly and carefully, so splashing and spilling do not occur. **Exhale** only while bubbling and take the straw away from your mouth if you need to take a breath.
5. Place a white sheet of paper behind each vial, observe, and record the color of the solution below.
6. Place a sprig of *Elodea* in one "In Dark" vial and in one "In Light" vial.
7. The other "In Dark" and "In Light" vials will serve as controls so they will only contain water, bromthymol blue, and $CO_2$.
8. Place "In Light" vials in bright light, and "In Dark" vials in a dark area.

**Uptake of Carbon Dioxide by *Elodea***

| Light conditions and contents of vial | Color of solution when bromthymol blue indicator is added | Color of solution when carbon dioxide is added by bubbling | Color of solution after waiting one or two days |
|---|---|---|---|
| "In Dark" – water, bromthymol blue, and $CO_2$ | | | |
| "In Dark" - *Elodea*, water, bromthymol blue, and $CO_2$ | | | |
| "In Light" – water, bromthymol blue, and $CO_2$ | | | |
| "In Light" – *Elodea*, water, bromthymol blue, and $CO_2$ | | | |

EXPLORE

Based on your observations of the vials, summarize ALL changes that occurred and their causes.

**Procedure B.**

Materials: spring water, *Elodea* sprigs, test tubes, large beaker, clear funnel, light, pin

1. Snip off the ends of two *Elodea* sprigs, and use a pin to poke two holes in the end of the stem. Push the cut ends up into the pointed area of the funnel. Prepare a second funnel in the same manner.
2. Fill two beakers almost full of spring water. Immerse a funnel in each beaker, with the pointed end sticking up.
3. Fill two test tubes with spring water. Keeping your finger over the open end of the test tube, turn each test tube upside down over a prepared funnel. Make sure the open end of the test tube is underwater before removing your finger from the end of the test tube to prevent the water from running out.
4. Place one beaker under a light source, and the other in dark. Wait at least 45 minutes before making observations.
5. Draw a labeled diagram in the box below to record your observations of both beakers and any changes that occur.

| Light | Dark |
| --- | --- |
| | |

EXPLAIN

# EXPLAIN

Allow students in each group to share and discuss their results from Part A of the Explore activity.

**Materials** (details p. 26)

**For the class:**
- ☐ student setups of Explore activities
- ☐ transparency of Photosynthesis diagram, Master C
- ☐ Geranium leaves
- ☐ foil
- ☐ alcohol
- ☐ hot plate

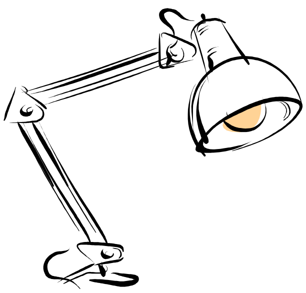
Questioning Strategies

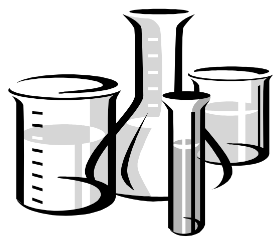
- What was the color of all four vials when bromthymol blue was first added to the water in the vials? *(light blue)*
- What was the color of the solutions after students bubbled into them? *(green, then yellow)*
- What color is the vial that was not bubbled in? *(still blue)*
- Why did you set up a bubbled vial without *Elodea* plants? *(To compare with the vials containing plants, and to make sure that the plants were causing any changes seen)*
- Describe your vials that were in the light. What color is the solution of the vial containing the Elodea? *(It changed from green back to blue)*
- What color is the vial that did not contain a plant? *(It is still green)*
- What substance causes the bromthymol blue indicator to turn yellow? *(Carbon dioxide, so the solution in the vial without a plant still has carbon dioxide in it)*
- Describe the vials that were labeled "In Light". What color is the solution of the vial containing the *Elodea*? Record on the student data sheet. *(It changed from green to blue)*
- What color is the solution of the vial in light without the *Elodea*? *(green.)*
- Describe the color changes that occurred in the "In Dark" vials. *(The vial with the plant and without the plant remained green, showing that they both still contain carbon dioxide.)*

EXPLAIN

Questioning Strategies

- Why do you think the plant in the dark was unable to use up the carbon dioxide? *(It must need light to take up carbon dioxide)*
- What do these changes indicate? *(Bromthymol blue indicates when carbon dioxide is present by turning green and yellow.)*
- What process could cause plants to use carbon dioxide only when exposed to light*? (photosynthesis)*





B. Allow students in each group to share their results from Part B of the Explore activity. Be prepared to bring into the discussion the following information if students do not.

Questioning Strategies

- Did you observe anything near the Elodea? *(bubbles)*
- Where are the bubbles coming from? *(the Elodea stem and leaves)*
- Where are the bubbles going? *(towards the top of the container)*
- What are the bubbles? *(gas)*
- Did you see bubbles rising in the test tubes that were in light and dark? (*the test tube in the light had the most bubbles*)
- Can you see any bubbles rising in the test tube of the container that was in the dark? (*There are no/few bubbles in that test tube)*
- What process could cause plants to produce bubbles of gas only when in light? *(photosynthesis)*

EXPLAIN

Ask students to look at the Elodea demonstration prepared the day before class to allow gas to collect in the top of the tube.

Questioning Strategies

- Discuss the changes in the large beaker with Elodea under the funnel and test tube.
- Do they agree with student results?
- Why was a test tube filled with water placed on each funnel?
- Do both funnels look the same after sitting overnight?
- Why are the water levels in the test tubes different?
- What could be taking up the space at the end of the test tube? (a gas)
- What gas enters the leaf? *(carbon dioxide)*
- What gas exits the leaf? *(oxygen)*
- What is supplying energy for photosynthesis? *(sunlight)*
- What is absorbing the sunlight? *(chlorophyll in the leaf)*
- What other substance is entering the leaf? *(water from the roots)*
- What substance is produced in the leaf during photosynthesis? *(sugar called glucose)*

Look at the summary of what is occurring at the bottom of the page under the diagram in words and chemical formulas. What is the process of plants using carbon dioxide gas and water, in the presence of light and chlorophyll, to produce glucose sugar and oxygen gas? (*photosynthesis*)

*Organisms are linked to one another and to their physical setting by the transfer and transformation of matter and energy. This fundamental concept brings together insights from the physical and biological sciences.*

*Benchmarks for Science Literacy, p. 118*

* Note – it is not necessary to teach students how to balance the equation at this point.

Relate the Photosynthesis diagram (Master C) to the Explore experiences as you discuss the following:

EXPLAIN

Questioning Strategies

- What gas did the Elodea remove from the yellow bromthymol solution to make it turn blue again? *(carbon dioxide)*
- What were the bubbles of gas that were rising in the test tube of the beaker that was placed in sunlight? *(oxygen gas that was released from the Elodea during photosynthesis)*
- What had to be present for either of these reactions to occur? *(sunlight or light energy)*
- What else must be present to absorb sunlight? *(chlorophyll in the leaves)*
- What evidence do we have that Elodea leaves contain chlorophyll? *(they are green)*
- What could we do to try to find out what causes their green color? (observe them under the microscope, and look for chloroplasts
- Do you see any green cell parts? (Bright green chloroplasts are floating around in the Elodea cells. The chloroplasts' bright green color is evidence that they contain the green pigment chlorophyll, which allows the Elodea to convert light energy into chemical energy during photosynthesis.) Explain that the chloroplasts move around the cell because the cytoplasm in the cell is flowing around the cell.

Ask students to observe the Photosynthesis diagram (Master C) and compare their experiences with it.

Questioning Strategies

What do the "stacks" of Elodea cells remind you of? *(They look like stacks of bricks. The cell walls of the Elodea provide rigid support for the plant cells, like bricks in a wall.)*

- What is produced during photosynthesis? (*glucose or sugar)*
- How can we provide evidence of glucose being produced in plants that are in light?

*In popular language, food is whatever nutrients plants and animals must take in if they are to grow and survive (solutions of minerals that plants need traces of frequently bear the label "plant food"); in scientific usage, food refers only to those substances, such as carbohydrates, proteins, and fats, from which organisms derive the energy they need to grow and operate and the material of which they are made. It's important to emphasize that the sugars that plants make out of water and carbon dioxide are their only source of food. Water and minerals dissolved in it are not sources of energy for plants or for animals.*

Benchmarks for Science Literacy, p. 120

EXPLAIN

Hold up a green leaf that is shielded from light by foil, then pass a similar leaf that was treated with alcohol and iodine around in a covered petri dish so students can see the results of deprivation of light.

Questioning Strategies

- What did the alcohol remove from the leaf? *(green chlorophyll)*
- What color is iodine? (*reddish-brown)*
- What color does iodine turn when it comes in contact with starch*?( bluish-black)*
- How will we know if the leaf contains stored starch? *(It will turn blue-black)*
- Do you expect the whole leaf to change color?
- Did the whole leaf change to a blue-black color*? (No, the part that was covered with foil didn't change because it had no light to provide energy for photosynthesis)*
- What is a product of photosynthesis? *(glucose, which later can be stored as starch)*
- Photosynthesis only happens if light energy is present. What are the other parts of the photosynthesis system that must be present for the process to begin? *(carbon dioxide, chlorophyll, water)*

How does water get to the leaves ?

<u>*Grades 6-8*</u>

*Students should know that plants use the energy in light to make sugars out of carbon dioxide and water. This food can be used immediately for fuel or materials or it may be stored for later use.*

*Benchmarks for Science Literacy, p. 120*

7. Ask students to use a hand lens to observe and draw the ends of the celery again after it has been in the dye solution.

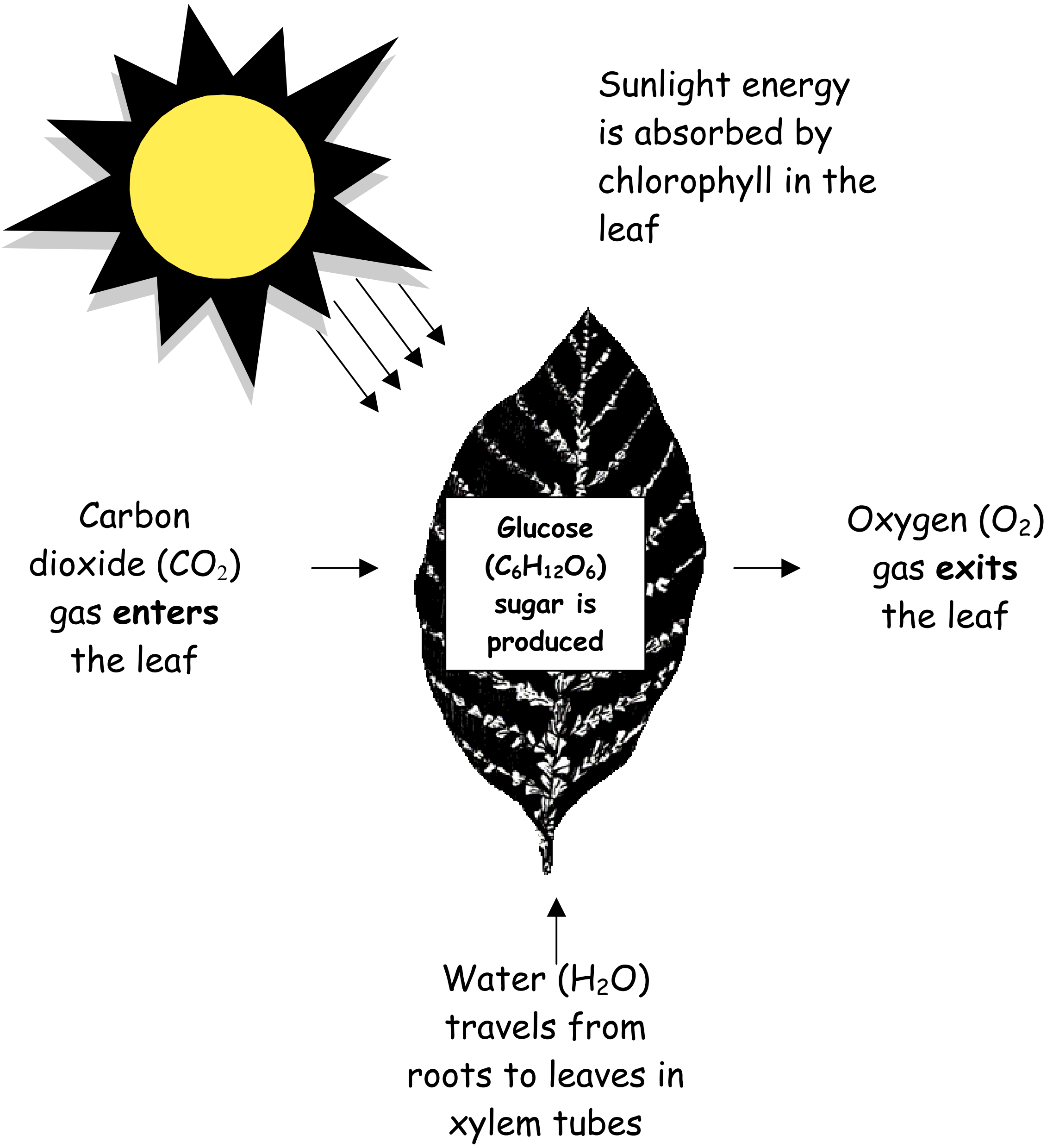
EXPLAIN

Questioning Strategies

- Describe the appearance of the celery sticks before they were placed in the red ink solution. *(The stem looked like it had tiny bundles of straws or tubes arranged in a circular pattern.)*
- Describe the appearance of the celery sticks after they were placed in the red ink solution. *(All of the tiny bundles of tubes were stained red on ends of the celery stick.)*
- Why were the veins in the leaves at the tops of the celery sticks stained red if they were not setting in the dye? *(The dyed water traveled up the tubes and into the veins of the leaves)*
- Predict what would happen if plants with white flowers, like *Impatiens,* were removed from soil, and placed in the dye solution. *(The dye would travel into the plants through the roots, up the stem in tubes called xylem, and into the veins of the leaves, where water is needed for photosynthesis.)*
- Does all of the water stay in the leaf? *(A portion of the water is used for photosynthesis, but some of the water exits the leaf through transpiration, which is like the leaf "sweating." Water continually evaporating from the leaf ensures a steady pull of water up the tubes, into the veins of the leaves, and out through the openings in the leaves called stomata.)*

9. Transpiration can be demonstrated by placing a plant in a sealed plastic bag and placing it in a sunny location. Moisture will collect inside the bag from the process of transpiration.

## **Photosynthesis** (See Master C)




$$\underset{(H_2O)}{\text{Water}} + \underset{(CO_2)}{\text{Carbon dioxide}} \xrightarrow[\text{chlorophyll}]{\text{light}} \underset{(C_6H_{12}O_6)}{\text{Glucose}} + \underset{(O_2)}{\text{Oxygen}}$$

# ELABORATE

Students use their knowledge of photosynthesis from the Explore and Explain experiences to design an experiment that will test the effects of the amount of light or the amount of carbon dioxide on the process of photosynthesis.

Students will be provided with the materials listed on the right.

*Review that the release of oxygen gas bubbles formed during photosynthesis can be observed when broken *Elodea* sprigs are placed in a test tube of water. An increase in the number of released oxygen bubbles indicates an increase in the rate of photosynthesis.

*Explain that adding a pinch of baking soda ($NaHCO_3$) to the water in the test tube increases the carbon dioxide in the Elodea's water. Bubbling is not needed.

Review the format for experimental design before students begin planning. Working in a group, students should discuss and plan the experiment on the Photosynthesis Investigation Planning Guide before beginning the experiment. The procedure steps must have teacher approval before the students begin testing, including any safety measures that must be followed.

**Materials** (details p. 26-27)

**For each group of students:**
- ☐ Elodea sprigs
- ☐ glassware ( beakers, funnels, test tubes, flasks, petri dishes)
- ☐ light sources with 75 or 100-watt bulbs
- ☐ grow lights, if available
- ☐ baking soda

**For each student:**
- ☐ *Photosynthesis Performance Task*, Master D
- ☐ *Investigation Planning Guide*, Master E
- ☐ *Photosynthesis Scoring Rubric*, Master F

ELABORATE

ELABORATE

## **Photosynthesis Performance Task** (See Master D)

Design an experiment that will test the effects of changing either the amount of light or the amount of carbon dioxide during plant photosynthesis. Working with your group, discuss and plan the experiment on the Photosynthesis Investigation Planning Guide before beginning the experiment. Deciding how you will measure the effect of the light or carbon dioxide on photosynthesis is an important topic to decide upon before planning the experiment. The procedure must be approved and initialed by the teacher before you begin testing. **Be sure to include any safety measures that must be followed.**

You will be provided with the following materials to choose from:

Elodea sprigs
Glassware ( beakers, funnels, test tubes, flasks, petri dishes)
Light sources with 75 or 100-watt bulbs
Grow lights, if available
Baking soda

Helpful Hints !

*Remember that the release of oxygen gas bubbles formed during photosynthesis can be observed when broken *Elodea* sprigs are placed in a test tube of water. An increase in the number of released oxygen bubbles indicates an increase in the rate of photosynthesis.

* Adding a pinch of baking soda ($NaHCO_3$) to the water in a test tube increases the carbon dioxide in the Elodea's water. Therefore, bubbling into the tube is not needed.

ELABORATE

## Investigation Planning Guide (See Master E)

**PROBLEM** (Ask a clear question that can be tested.)

**HYPOTHESIS** (Make a prediction about what may be the answer to the question.)

**MATERIALS** (List the materials needed to perform the experiment.)

**PROCEDURES** (State exactly what must be done during the experiment in step-by-step order. Begin each step with a verb and end each step with a period. Avoid using " I" or "you" in the steps. Repeat trials whenever possible.)

**RESULTS** ( The observations of what happened during the experiment should be recorded in words, pictures, charts, or graphs.)

**CONCLUSION** (A statement that interprets the results of the experiment and states whether or not the hypothesis was supported.)

ELABORATE

## Photosynthesis Scoring Rubric (See Master F-G)

| | | |
|---|---|---|
| A. Experimental Design | The problem is clear and testable. A valid, practical procedure is presented in a logical sequence to allow gathering of accurate data suitable for analysis to accomplish the task. | 4 |
| | The problem is clear and testable. Valid, practical procedure is presented that contains errors or omissions that may hinder the gathering of accurate data suitable for analysis to accomplish the task. | 3 |
| | The problem is testable. A practical procedure with many steps insufficiently described or missing prevents the gathering of accurate data for the task. | 2 |
| | The problem is partially testable. The procedure is highly incomplete, and the method used to gather data is inappropriate for the task. | 1 |
| | The problem is not testable. The procedure is missing, or cannot generate useful data. | 0 |
| | | |
| B. Data collection | The collected data and observations are complete, clearly and logically recorded, and consistent with the procedure. Measurements are precise. Technology used to develop a clear and attractive display of data in charts and graphs. | 4 |
| | The collected data and observations are fairly complete, clearly recorded, and fairly consistent with the procedure. Data is clearly displayed in chart or graph form. | 3 |
| | The collected data and observations have several omissions, recorded in a way that is difficult to interpret, and relate somewhat to the procedure. Data display is unclear. | 2 |
| | The data gathered is very incomplete, and is not related to the procedure. No charts or graphs of the data are included. | 1 |
| | No data or observations are recorded | 0 |
| | | |

ELABORATE

| | | |
|---|---|---|
| C. Evaluation of Data and Conclusion | Clear communication of complete and accurate analysis of data and observations. Accurate conclusion is reached, which is supported by the analysis. | 4 |
| | Communication of complete but slightly flawed analysis of data and observations, which leads to a slightly inaccurate conclusion. | 3 |
| | Unclear communication of accurate conclusion with no analysis, or the analysis does not support the conclusion. | 2 |
| | Unclear communication of inaccurate conclusion with no analysis. | 1 |
| | No conclusion or analysis is present. | 0 |
| | | |
| D. Lab Skills, Safety, and Participation | Selects and uses appropriate equipment with care and proficiency. Listens attentively, and stays actively involved in an organized approach. | 4 |
| | Uncertain about equipment selection, but uses equipment carefully. Listens to instructions and stays involved, but may wait for others to lead. | 3 |
| | Is not familiar with use of equipment, so chooses inappropriate equipment, but does not abuse equipment. Distracted during instructions, so must rely on others for directions. | 2 |
| | Uses equipment improperly, and is haphazard and disorganized. Is distracted during instructions, and needs constant reminders to stay on task | 1 |
| | Does not use equipment or abuses equipment. Is disruptive during instructions and activity. | 0 |
| | Total points | |

# EVALUATE

Have students complete the performance task by sequencing a set of photosynthesis process cards and making a labeled diagram of the events that occur during photosynthesis.

**Materials** (details p. 27)

- ☐ *Sunny Synthesis Assessment*, Master H
- ☐ *Sequencing Photosynthesis* cards, Master I
- ☐ *Sunny Synthesis Scoring Rubric,* Master J

EVALUATE

EVALUATE

## Sunny Synthesis Assessment (See Master H)

**TASK 1**
Materials: 1 bag of photosynthesis cards

1. Remove the cards from the bag and determine which cards should be used to illustrate the process of photosynthesis. (Place any cards that are not needed back into the bag.)
2. Sequence the cards to show the substances needed for photosynthesis on the left side of the arrow and the substances produced by photosynthesis on the right side of the arrow.

Record the sequence of the cards in the blanks below.

__________

__________ + __________ → __________ + __________

__________

**TASK 2.**
Draw a diagram of a plant leaf below. Show the substances that must be present to begin photosynthesis on the left side of the leaf and the substances that are produced by photosynthesis on the right side of the leaf. Include any energy sources that are needed.

## Sunny Synthesis Assessment (See Master J)

Scoring Rubric

| Task | Criteria | Pts. |
|---|---|---|
| **Task 1** Selects correct photosynthesis cards and sequences on appropriate sides of the arrow | Correct materials needed and materials produced on appropriate sides of the arrow, no omissions | 4 |
| | Omitted or misplaced one card | 3 |
| | Omitted or misplaced two cards | 2 |
| | Omitted or misplaced three cards | 1 |
| | Omitted or misplaced four cards | 0 |
| | | |
| **Task 2** Draws and labels leaf diagram, showing the correct materials needed and materials produced in photosynthesis | Detailed, labeled drawing, no omissions | 4 |
| | Fairly detailed drawing, 1 omission | 3 |
| | Fairly detailed drawing, 2 omissions | 2 |
| | Few details in drawing, 3 omissions | 1 |
| | No drawing | 0 |
| | POINTS | |

# Materials Detail Sheet

ENGAGE

**For the class:**

- ☐ bromthymol blue solution; available from vendors of science teaching supplies
- ☐ 4 test tubes filled with water
- ☐ 4 sheets of white paper
- ☐ 4 drinking straws
- ☐ 1 dropper

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EXPLORE

**For each group of students:**

- ☐ 2 prepared test tubes from Engage activity
- ☐ bromthymol blue
- ☐ labels
- ☐ 5 vials
- ☐ spring water
- ☐ *Elodea* sprigs; available from pet stores
- ☐ white paper
- ☐ strong light source
- ☐ test tubes
- ☐ safety goggles
- ☐ straight pins
- ☐ clear funnels
- ☐ large beakers

**For each student:**

- ☐ *Sunny Synthesis data sheet*, Masters A-B

# Materials Detail Sheet

EXPLAIN

**For the class:**

- ☐ student setups of Explore activities
- ☐ Photosynthesis transparency, Master C
- ☐ leaves from a living geranium plant
- ☐ foil
- ☐ alcohol; rubbing alcohol from drugstore will work
- ☐ hot plate

**For each group of students:**

- ☐ Elodea leaves
- ☐ microscope slides
- ☐ cover slips
- ☐ water droppers
- ☐ microscopes
- ☐ petri dish
- ☐ Lugol's iodine; iodine tincture from drugstore will work
- ☐ slices of potato
- ☐ celery sticks with leaves
- ☐ beakers
- ☐ red ink
- ☐ hand lens or loupe
- ☐ journals

ELABORATE

**For each group of students:**

- ☐ journals
- ☐ Elodea sprigs
- ☐ glassware ( beakers, funnels, test tubes, flasks, petri dishes)
- ☐ light sources with 75 or 100-watt bulbs
- ☐ grow lights, if available
- ☐ baking soda

# Materials Detail Sheet

**For each student:**

- ☐ *Photosynthesis Performance Task*, Master D
- ☐ *Investigation Planning Guide*, Master E
- ☐ *Photosynthesis Scoring Rubric*, Master F

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EVALUATE

**For each student:**

- ☐ *Sunny Synthesis Assessment*, Master H
- ☐ *Sequencing Photosynthesis Cards*, Master I
  Copy on cardstock, laminate, and bag.
- ☐ *Sunny Synthesis Scoring Rubric*, Master J

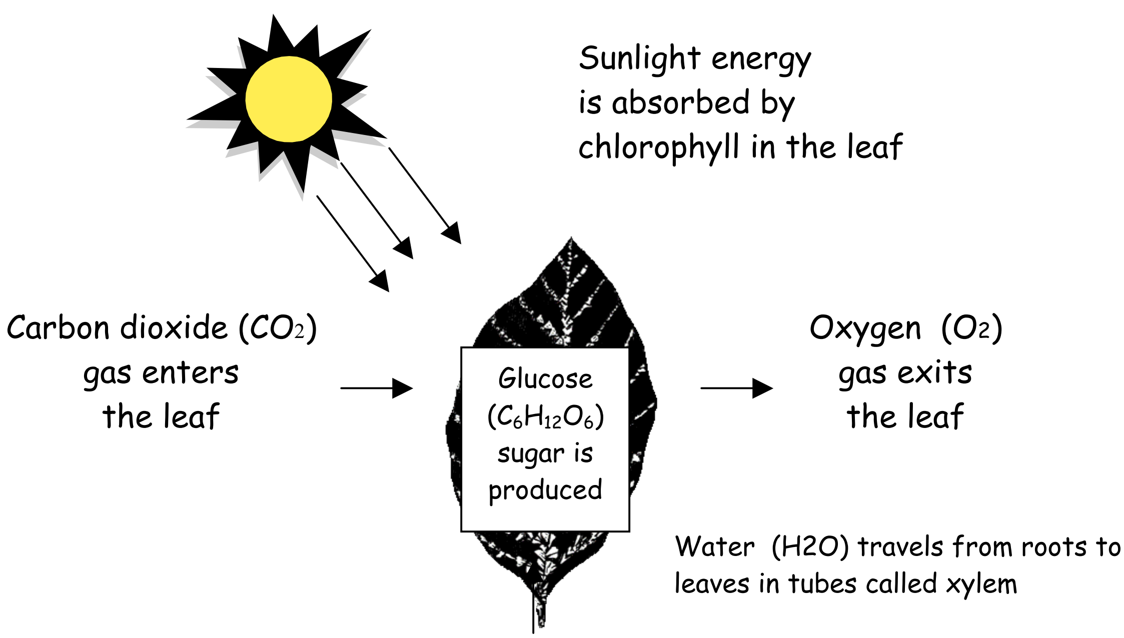
## Background Information for Teachers

In the middle school years, students should progress from studying life science from the point of view of individual organisms to recognizing patterns in ecosystems and developing understandings about the cellular dimensions of living systems. (*National Science Education Standards*, p. 155) For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs. (*National Science Education Standards*, p. 158)

Green plants feed most living things on Earth by transforming light energy from the Sun into the chemical energy of glucose through a process called photosynthesis. A green pigment in plants, called chlorophyll, absorbs light energy from the sun to fuel the process of building the glucose sugars through a series of chemical reactions. The overall chemical reaction for photosynthesis is:

$$\text{Water} + \text{Carbon dioxide} \xrightarrow[\text{Chlorophyll}]{\text{light}} \text{Glucose} + \text{Oxygen}$$

In other words, plants are able to take water in through their roots, carbon dioxide from the air, and light energy from the sun into their cells to produce food and oxygen. The carbon dioxide gas needed for photosynthesis enters the leaves of plants through tiny holes in their leaves called stomata, and oxygen exits the leaves through the same holes.



Other living things use the oxygen gas that is released by plants to break down the energy in glucose during respiration. The overall chemical reaction for respiration is:

**Respiration**

| Glucose | + | Oxygen | → | Water | + | Carbon dioxide | + | ENERGY |
|---|---|---|---|---|---|---|---|---|
| **($C_6H_{12}O_6$)** | | **($O_2$)** | | **($H_2O$)** | | **($CO_2$)** | | **ATP** |

Respiration breaks down glucose into an energy form that cells can use called ATP. The carbon dioxide gas that is given off by living things during respiration is needed by plants to photosynthesize. This beneficial gas exchange between plants and other living things is a arge part of the carbon dioxide-oxygen cycle. This cycle can easily be demonstrated using aquatic plants such as *Elodea*, and a narrow range pH indicator like bromthymol blue.

Carbon dioxide is easily detected in solution by using an indicator called bromthymol blue. It is an indicator with a very narrow pH range, so it will change from blue to yellow in a slightly acidic solution. In neutral or slightly alkaline solutions above a pH of 7.6, bromthymol blue is a light blue color. A solution with a slightly acidic pH of 6 will turn bromthymol blue to a yellow color. Exhaling carbon dioxide into a bromthymol blue-water solution with a straw creates a weak carbonic acid solution with a pH of 6, which causes the indicator to turn green, then yellow. If an aquatic plant, like *Elodea*, is placed in a yellow carbonic acid and bromthymol blue solution, it will take up the carbon dioxide as long as it has sunlight energy to photosynthesize. As the *Elodea* pulls out carbon dioxide during photosynthesis, the solution will turn from yellow to blue in about 45 minutes. If *Elodea* is placed in a yellow carbonic acid and bromthymol blue solution that is in darkness, photosynthesis will not occur. The solution will remain yellow.

The release of oxygen gas bubbles formed during photosynthesis can be observed when broken *Elodea* sprigs are placed in a test tube of water. The number of released oxygen bubbles increases as the rate of photosynthesis increases. There are several factors or variables that can affect the rate of photosynthesis in *Elodea*. For example, adding a pinch of baking soda (NAHCO3) to the water in the test tube increases the carbon dioxide that is available to the *Elodea* for photosynthesis. Placing the test tube containing the Elodea in bright sunlight or near a strong light source can also increase the number of oxygen bubbles that are released.

*Elodea* leaves can be examined under the microscope to observe the parts of plant cells. Chloroplasts are very easy to see in *Elodea* specimens because of their bright green color, and their movement around the cell by cytoplasmic streaming. The chloroplasts bright green color is evidence that they contain the green pigment chlorophyll, which allows the *Elodea* to convert light energy into chemical energy during photosynthesis.

# Targeted Texas Essential Knowledge & Skills

## Science TEKS

**7.1** The student conducts field and laboratory investigations using safe, environmentally appropriate and ethical practices. The student is expected to:

(A) demonstrate safe practices during field and laboratory investigations

**7.2** The student uses scientific inquiry methods during field and laboratory investigations. The student is expected to:

(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting and using equipment and technology
(B) collect data by observing and measuring
(C) organize, analyze, make inferences, and predict trends form direct and indirect evidence
(D) communicate valid conclusions
(E) construct simple graphs, tables, maps, and charts using tools including computers to organize, examine, and evaluate information

**7.3** The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information
(C) represent the natural world using models and identify their limitations

**7.4** The student knows how to use a variety of tools and methods to conduct science inquiry. The student is expected to:

(A) collect, analyze, and record information to explain a phenomenon using tools including beakers, petri dishes, meter sticks, graduated cylinders, weather instruments, hot plates, dissecting equipment, test tubes, safety goggles, spring scales, balances, microscopes, telescopes, thermometers, calculators, field equipment, computers, computer probes, timing devices, magnets, and compasses
(B) collect and analyze information to recognize patterns such as rates of change

**7.8** The student knows that complex interactions occur between matter and energy. The student is expected to:

(B) identify that radiant energy from the Sun is transferred into chemical energy through the process of photosynthesis

**7.11** The student knows that the responses of organisms are caused by internal or external stimuli. The student is expected to:

(B) identify responses in organisms to external stimuli found in the environment such as the presence or absence of light.

## References

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Pentz, Lundy. *The Biolab Book*. John Hopkins University Press. 1983.

## Websites

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http://www.funsci.com/

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http://gened.emc.maricopa.edu/bio/bio181/BIOBK/BioBookPS.html

Photosynthesis
http://www.botany.uwc.ac.za/ecotree/photosynthesis/spectrum.htm

Plants and Our environment
http://tqjunior.advanced.org/3715