Plants in a Bottle: Photosynthesis and Respiration

science take-out
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My grandfather has a large bottle filled with water, soil, and plants. For the last 50 years, the plants have been completely sealed from the outside world.

It is really low maintenance! My grandfather does not need to add more water to the sealed bottle. He keeps the bottle about six feet from a sunny window. The plants grow toward the light, so he turns the bottle around occasionally so that the plants grow evenly.

Part 1: Photosynthesis and Cellular Respiration

1. Use the **Photosynthesis and Respiration Diagram Sheet** in the kit. For each of the following statements, circle the word on the right to indicate whether the statement is true for photosynthesis, respiration, or both.

• Uses food (sugar)	**Photosynthesis**	**Respiration**	**Both**
• Makes food (sugar)	**Photosynthesis**	**Respiration**	**Both**
• Uses oxygen	**Photosynthesis**	**Respiration**	**Both**
• Makes oxygen	**Photosynthesis**	**Respiration**	**Both**
• Uses carbon dioxide	**Photosynthesis**	**Respiration**	**Both**
• Makes carbon dioxide	**Photosynthesis**	**Respiration**	**Both**
• Occurs during the day	**Photosynthesis**	**Respiration**	**Both**
• Occurs at night	**Photosynthesis**	**Respiration**	**Both**
• Makes ATP for life activities	**Photosynthesis**	**Respiration**	**Both**
• Occurs in plants	**Photosynthesis**	**Respiration**	**Both**
• Occurs in mitochondria	**Photosynthesis**	**Respiration**	**Both**
• Occurs in chloroplasts	**Photosynthesis**	**Respiration**	**Both**

2. For the plants to survive, what must enter the bottle?

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3. In your own words, explain **why** a plant carries out the process of photosynthesis.

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4. In your own words, explain **why** a plant carries out the process of cellular respiration.

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Part 2: Photosynthesis and Respiration Affect the Oxygen Concentration

In Part 2, you will collect and analyze data from an experiment to investigate how photosynthesis and cellular respiration affect the oxygen concentration.

A student set up 4 clear, sealed bottles. Each bottle was filled with 5 grams of aquatic plants and 500 mL of water. The student determined that the initial (beginning) concentration of oxygen in each of the bottles was 6 parts per million (ppm). The bottles were then placed in environments that had the same temperatures but different light intensities. After 24 hours, water samples were removed from each of the 4 bottles.

You will measure the concentration of oxygen in each of the bottles after 24 hours.

1. The **independent variable** in an experiment is the variable that is changed by the scientist. To ensure a fair test, a good experiment has only one independent variable. What is the independent variable in the experiment described in the box above?

   _____

2. As the scientist changes the independent variable, he or she observes or measures the **dependent variable**. This will measure how the dependent variable responds when change is made to the independent variable. What is the dependent variable in the experiment described in the box above?

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3. A well-designed experiment also has **controlled** or **constant variables**. These are things, other than the independent variable, that could affect the results of an experiment. An experiment would not be a fair test unless these controlled variables were kept the same in all four bottles. List at least <u>three</u> controlled variables that were kept constant to ensure that there was only one variable (the independent variable) in the experiment.

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   - _____
   - _____

4. Photosynthesis converts light energy into energy stored in food. In which bottles do you think that photosynthesis is occurring? Explain in detail why you think photosynthesis is occurring in these bottles.

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5. Respiration converts energy stored in food into ATP energy used for carrying out life activities. In which bottles do you think respiration is occurring? Explain in detail why you think respiration is occurring in these bottles.

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6. Use the tube of Oxygen Indicator and the instructions below to determine the FINAL oxygen concentration in each of the water samples (Bottles 1–4). *Be careful to use the droppers with labels that match the labels on the tubes.*

- Place 1 drop of Oxygen Indicator in each of the circles in the Oxygen Test Column on the plastic Test Sheet.
- Place 2 drops of water samples from each bottle in the appropriate circles in the left column of the Test Sheet.
- Wait for 15 seconds and then compare the colors of the liquid in each circle of the test sheet with the Oxygen Concentration Color Chart.
- Record the FINAL oxygen concentration (ppm) for each sample in the data table below.

ppm
parts per million

A measure of the number of oxygen molecules in 1 million molecules of air

Be sure to include a + or – sign in your answer!

Bottle	FINAL Oxygen Concentration (ppm)	INITIAL Oxygen Concentration (ppm)	NET CHANGE in Oxygen Concentration (ppm) Final - Initial = Net Change
1 Bright Light		6	
2 Medium Light		6	
3 Low Light		6	
4 Dark		6	

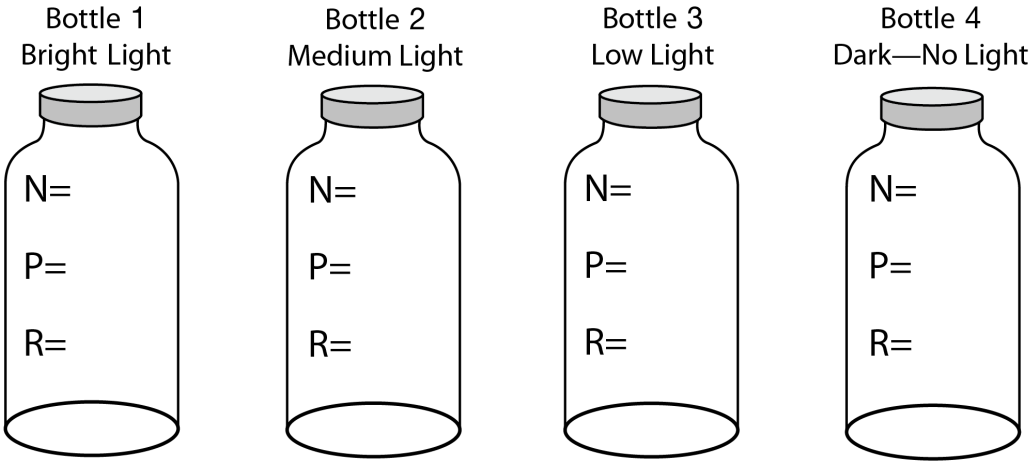
7. Complete the "NET CHANGE in Oxygen Concentration" column in the data table. Be sure to include the + or – sign in your answer.

FINAL oxygen concentration – INITIAL oxygen concentration = NET CHANGE in oxygen concentration

- A "+" sign in your answer indicates that more oxygen is produced than used.
- A "−" sign in your answer indicates that more oxygen is used than made.
- A "0" for your answer indicates that the oxygen used equals the oxygen produced.

All plants need to carry out respiration to change stored food energy into ATP energy needed for their life activities.

- **Respiration is occurring in ALL four bottles.**
- **The amount of oxygen used for respiration in Bottle 4 is the same as the amount of oxygen used for respiration in the other three bottles (1, 2, and 3).**



8. Represent the amount of oxygen used for respiration in all four bottles by writing **R = 4** in each of the bottles above (1, 2, 3, and 4) to represent the amount of oxygen used for respiration (4 ppm).

9. Use the information from the last column on your data table to write the NET CHANGE in oxygen after the "**N =**" for each bottle above. *Note: See your data table on the previous page.*

10. Use the equation shown below to calculate **P** (the oxygen produced by photosynthesis in the plants). Record your answer after the "**P =**" on the diagrams of bottles above.

N	**=**	**P**	**-**	**R**
Net change in oxygen		Oxygen produced by photosynthesis		Oxygen used for respiration

Show your work for each of the bottles.

Bottle 1	**Bottle 2**	**Bottle 3**	**Bottle 4**

11. In which bottle or bottles is the amount of oxygen produced by photosynthesis **greater than** the amount of oxygen used for respiration? Support your answer with information from the diagrams on the previous page.

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12. In which bottle or bottles is the amount of oxygen produced by photosynthesis **equal** to the amount of oxygen used in cellular respiration? Support your answer with information from the diagrams on the previous page.

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13. In which bottle or bottles is the amount of oxygen produced by photosynthesis **less than** the amount of oxygen used in cellular respiration? Support your answer with information from the diagrams on the previous page.

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14. In which bottle would you expect the most plant growth? Explain why you chose your answer in detail.

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15. **PREDICT** – In which bottle would you expect to find the lowest concentration of carbon dioxide? Explain why you chose your answer.

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16. Test your prediction. Use the tube of Carbon Dioxide Indicator and the instructions below to determine the carbon dioxide concentration in each of the water samples (Bottles 1-4).

- Place 1 drop of Carbon Dioxide Indicator in each of the circles in the Carbon Dioxide Test Column on the plastic Test Sheet.
- Place 2 drops of water samples from each bottle in the appropriate circles as indicated in left column.
- Wait for 10 seconds and then compare the colors of the liquid in each circle with the Carbon Dioxide Concentration Color Chart.
- According to the test results, which bottle had the lowest concentration of carbon dioxide?

17. Was your prediction in question 15 correct? If not, how would you modify your prediction and explanation to be supported by the carbon dioxide testing results?

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18. Scientists believe that the concentration of carbon dioxide in the atmosphere is increasing. Describe two human activities which may lead to an increase in carbon dioxide in the atmosphere.

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