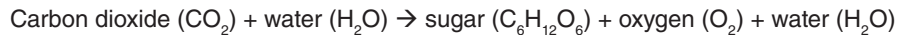


# Lab 5. Photosynthesis: Why Do Temperature and Light Intensity Affect the Rate of Photosynthesis in Plants?

## Introduction

You have learned that green plants have the ability to produce their own supply of sugar through the process of photosynthesis. Photosynthesis is a complex chemical process in which green plants produce sugar and oxygen for themselves. The equation for photosynthesis is as follows:



The plant uses the sugar it produces through photosynthesis to grow and produce more leaves, stems, and roots—the biomass of the plant. Plants therefore get their mass from air. The process of photosynthesis, however, does not happen all the time, and when it happens depends on a number of environmental factors. For example, plants need a supply of water, carbon dioxide, and light energy for photosynthesis to work. Plants must get these resources from the surrounding environment. The process of photosynthesis can also slow down or speed up depending on environmental conditions. In this lab investigation, you will explore how two different environmental conditions affect how quickly photosynthesis takes place within a plant. You will then develop a conceptual model that explains why.

## Your Task

Design a series of experiments to determine how temperature and light intensity affect the rate of photosynthesis in spinach. Then develop a conceptual model that explains why these environmental factors affect the rate of photosynthesis in the way that they do.

The guiding question of this investigation is, **Why do temperature and light intensity affect the rate of photosynthesis in plants?**

## Materials

You may use any of the following materials during your investigation:

- Spinach leaves
- Erlenmeyer flask (250 ml)
- CO<sub>2</sub> or O<sub>2</sub> gas sensor
- Sensor interface
- Beaker (600 ml or larger)
- Thermometer or temperature probe
- Hot plate
- Ring stand and clamps
- Floodlight
- Ice
- 40-W bulb
- 60-W bulb
- 100-W bulb
- Goggles and aprons

## Safety Precautions

1. Safety goggles and aprons are required for this activity.
2. Use caution when working with electrical equipment. Keep away from water sources in that they can cause shorts, fires, and shock hazards. Use only GFI-protected circuits.
3. Lightbulbs and hot plates can become hot and burn skin. Handle with care!
4. Wash hands with soap and water after completing this lab.
5. Follow all normal lab safety rules.

## Getting Started

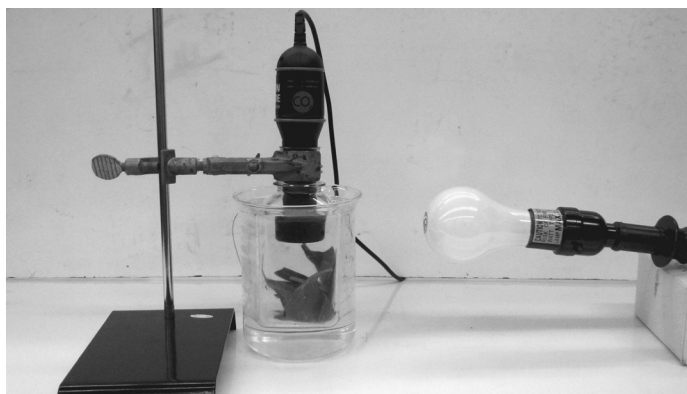
The first step in developing your model is to design and carry out a series of experiments to determine how temperature and light intensity affect the rate of photosynthesis. You will therefore need a way to calculate a rate of photosynthesis. A photosynthesis rate can be calculated by measuring how much CO<sub>2</sub> a plant consumes or how much O<sub>2</sub> a plant produces over time using the following equation:

$$\text{Photosynthesis rate} = \frac{\text{change in CO}_2 \text{ or O}_2 \text{ level}}{\text{time}}$$

To measure how much CO<sub>2</sub> spinach consumes (or O<sub>2</sub> it produces) over time, simply put five spinach leaves inside a 250 ml flask and seal the flask with a CO<sub>2</sub> gas sensor or O<sub>2</sub> gas sensor. Next, fill a 600 ml (or larger) beaker with water to create a water bath in order to keep the spinach leaves

at a constant temperature. You can place the flask in the water bath (see the “Equipment setup” figure below) or place the water bath between the flask and the light source.

#### Equipment setup



The next step is to think about how you will collect the data and how you will analyze it. To determine how you will collect your data, think about the following questions:

- What will serve as a control (or comparison) condition?
- What will serve as the treatment condition(s)? (Hint: To investigate the effect of temperature on photosynthesis rate, you will need to determine how to vary the temperature inside the flask. To investigate the effect of light intensity on photosynthesis rate, you can use lightbulbs with different wattages.)
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect and how will you organize the data?

To determine how you will analyze your data, think about the following questions:

- How will you determine if there is a difference between the treatment and the control conditions?
- What type of calculations will you need to make?
- What type of graph could you create to help make sense of your data?

Once you have carried out your series of experiments, your group will need to develop a conceptual model. Your model needs to explain why these two environmental factors affect the rate of photosynthesis in the way that they do. The model should also explain what is happening at the submicroscopic level during the process of photosynthesis.

**Investigation Proposal Required?**    Yes         No

#### Connections to Crosscutting Concepts and to the Nature of Science and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- the importance of identifying the underlying cause for observations,
- how models are used to study natural phenomena,
- how energy and matter move within or through a system,
- the difference between observations and inferences in science, and the nature and role of experiments in science.

#### Argumentation Session

Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure on the following page.

To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see.

In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

## Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!

### Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence: