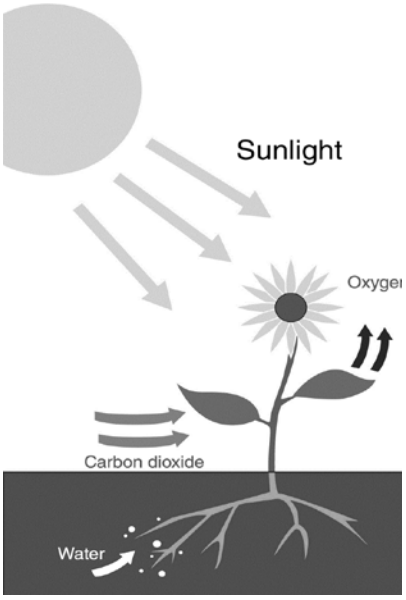
Lab 5. Temperature and Photosynthesis: How Does Temperature Affect the Rate of Photosynthesis in Plants?

Introduction

All the colors that our eyes can see can be found in plants that live in the world. They include deep, bright reds to rich blues and purples. Interestingly, one common color that most plants share is green. This common characteristic is not simply due to chance. The green found in most plants actually serves an important survival need. The green comes from special organelles found in plants known as *chloroplasts*. Chloroplasts are the location where certain chemical reactions take place that help plants live. Chloroplasts are responsible for giving plants their green color; this color comes from a chemical called chlorophyll, which provides green plants with a special chemical ability to absorb energy from light. Green plants have the ability to produce their own supply of sugar through the process of *photosynthesis*.

FIGURE L5.1
Elements of photosynthesis



Photosynthesis is a complex chemical process in which green plants produce sugar and oxygen gas (O_2) for themselves. The sugar produced is used by a plant as food to provide energy for other activities. Animals can also eat plants to get sugar for their own energy needs. The O_2 is released into the atmosphere (see Figure L5.1) and is used for other chemical reactions inside plants for producing energy. Animals also use O_2 to produce energy. This common process for producing energy in living things is known as *respiration*, which refers to a series of chemical reactions that use O_2 to break bonds in the sugar molecules, releasing the energy stored there. The products of respiration include carbon dioxide gas (CO_2), which is released into the atmosphere and can then be used in photosynthesis.

Photosynthesis requires two chemicals to react: CO_2 from the atmosphere and water that can come from the ground. However, photosynthesis also requires light energy to make sugar and O_2. The chemical equation for photosynthesis is

$$\text{Carbon dioxide } (CO_2) + \text{water } (H_2O) + \text{light energy} \rightarrow \text{sugar } (C_6H_{12}O_6) + \text{oxygen } (O_2) + \text{water } (H_2O)$$

This sugar is then used to produce the flowers, leaves, stems, and roots—the *biomass* of the plant. In other words, plants get their building blocks from air!

Plants rely on gases in the air and sunlight to create the food and energy they need. The amount of sunlight in a plant's environment will influence how much photosynthesis can occur. The amount of water present (dry desert vs. moist rainforest) also influences plants' activities and affects their growth. Obviously, plant growth and survival depend in part on conditions in the environment. A common example of this is the difference between the seasons. Most plants do not show a lot of activity during the winter, although they remain alive. In the spring, they become colorful and grow a lot. That growth continues over the summer, with some plants producing fruits and vegetables, and then their growth slows down during the fall. We also know that the temperature in the environment is very different across the seasons. So if overall plant growth and behavior are affected by seasonal changes in temperature, how do different temperatures affect the process of photosynthesis?

Your Task

Design a scientific investigation to determine how temperature influences the rate of photosynthesis in plants.

The guiding question of this investigation is, **How does temperature affect the rate of photosynthesis in plants?**

Materials

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

Consumables	Equipment
• Fresh geranium plant	• Scissors • O_2 gas sensor • CO_2 gas sensor • Temperature probe • Go!Link adaptor and laptop computer • Biochamber or sealed container with opening for sensors • Hot plate or incubator • Ice packs or ice bath • Sanitized indirectly vented chemical-splash goggles • Chemical-resistant apron • Gloves

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

1. Put on sanitized indirectly vented chemical-splash goggles and laboratory apron and gloves before starting the lab activity.
2. Be careful handling hot plates and incubators set at high temperatures because they may be hot enough to burn you.
3. Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

Figure L5.2 shows how CO_2 and O_2 gas sensors can be inserted into a biochamber. The sensors can then be connected to a laptop to collect data about CO_2 and O_2 gas concentration over periods of time. Ask your teacher for help if you do not understand how to set up the sensors and computer to collect data.

FIGURE L5.2

O_2 or CO_2 gas sensor

To answer the guiding question, you will need to design and conduct an investigation that explores rates of photosynthesis in different temperatures. To accomplish this task, you must determine what type of data you need to collect, how you will collect it, and how you will analyze it. To determine *what type of data you need to collect*, think about the following questions:

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- How will you test the effect of temperature on the photosynthesis rate?
- How will you change the temperature inside the chamber?
- What type of measurements or observations will you need to record during your investigation?

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

- What will serve as a control (or comparison) condition?
- What types of treatment conditions will you need to set up and how will you do it?

- How often will you collect data and when will you do it?
- 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 it?

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 conditions and the control condition?
- What type of calculations will you need to make?
- What type of graph could you create to help make sense of your data?

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

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

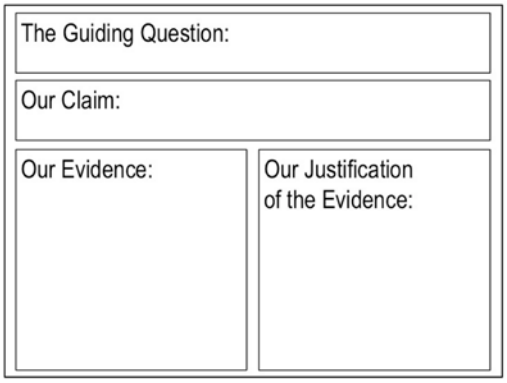
- how scientists try to figure out cause-and-effect relationships that explain why something happens,
- how energy and matter flow through living things while being totally conserved,
- the different roles theories and laws play in science, and
- the difference between data collected and evidence created in an investigation.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, evidence to support your claim, and a justification of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L5.3.

FIGURE L5.3

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- What did your group do to collect the data? Why do you think that way is the best way to do it?
- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What other ways of analyzing and interpreting the data did your group talk about?
- What did your group do to make sure that these calculations are correct?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those other ideas?
- How sure are you that your group's claim is accurate? What could you do to be more certain?

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. The 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!