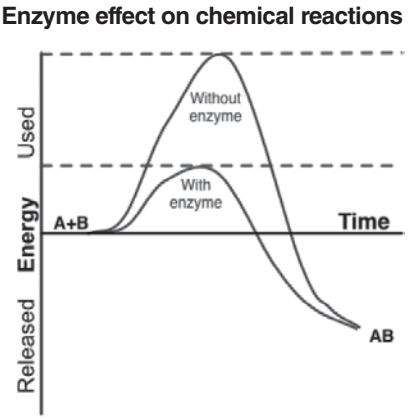
Lab 8. Enzymes: How Do Changes in Temperature and pH Levels Affect Enzyme Activity?

Lab Handout

Introduction



Sugars are vital to all living organisms and are used to produce the energy (in the form of adenosine triphosphate, or ATP) an organism needs for survival. All sugars are carbohydrates, which are molecules that contain the elements carbon, hydrogen, and oxygen with the general chemical formula of $(CH_2O)n$, where n is 3 or more. Living organisms use carbohydrates as sources of energy. Different types of sugars are found in different kinds of foods, but not all of these sugars can be used as energy sources by every type of organism. In order for an organism to make use of a sugar as an energy source, it must be capable of transporting the sugar into its cells and it must have the proper enzymes to break down the chemical bonds of the sugar to release the energy stored inside the molecule.

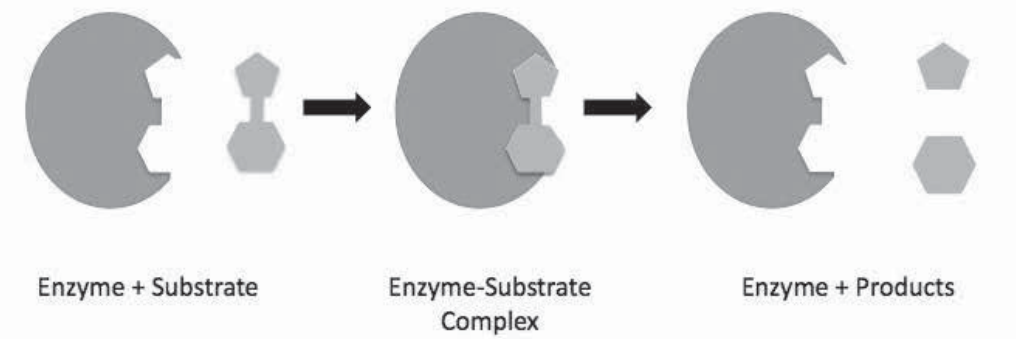
Enzymes are proteins that are involved in almost every chemical reaction that take place within an organism. They act as catalysts, substances that speed up chemical reactions without being destroyed or altered during the process. The figure above illustrates how an enzyme lowers the amount of energy needed for a reaction to take place, and the figure on the next page illustrates how an enzyme interacts with a substrate. Although most reactions can occur without enzymes, the rate of the reaction would be far too slow to be useful.

An example of an important enzyme in animals is catalase, which is produced in the liver and is used to catalyze the breakdown of hydrogen peroxide (H_2O_2). H_2O_2 is a toxic chemical that is produced as a natural by-product of many reactions that take place within your cells. Because it is toxic, it must be destroyed before it can do too much damage. To destroy H_2O_2, cells convert it into oxygen gas and water based on the following reaction:

$$H_2O_2\ (\text{liquid}) \xrightarrow{\text{catalase}} H_2O\ (\text{liquid}) + O_2\ (\text{gas})$$

Environmental conditions, such as temperature or pH level, can affect the function of enzymes. In this investigation, you will explore how these two environmental conditions affect enzyme activity by measuring the rate at which O_2 is produced when H_2O_2 is exposed to catalase at different pH levels and temperatures.

How an enzyme interacts with a substrate



Your Task

Design two controlled experiments to determine how changes in temperature and pH levels affect the activity of the enzyme catalase.

The guiding question of this investigation is, **How do changes in temperature and pH levels affect enzyme activity?**

Materials

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

- Catalase solution
- 3% H_2O_2 solution
- 0.1 M hydrochloride (HCl) solution
- 0.1 M sodium hydroxide (NaOH) solution
- Graduated cylinder (25 ml)
- 2 Erlenmeyer flasks (each 250 ml)
- 2 Beakers (each 600 ml)
- Hot plate
- Ice
- O_2 gas sensor
- Sensor interface
- Temperature probe or thermometer
- pH probe or pH paper
- Ring stand and clamps
- Safety goggles, vinyl gloves, and aprons

LAB 8

Safety Precautions

1. Safety goggles, vinyl gloves, 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. Hot plates can get hot and burn skin. Use caution and handle with care!
4. Wash hands with soap and water upon completing this lab.
5. Follow all normal lab safety rules.

Getting Started

To answer the guiding question, you will need to design and conduct two experiments. For each experiment, you must determine what type of data you will need to collect, how you will collect it, and how you will analyze it. To determine *what type of data you will need to collect,* think about the following questions:

- What will serve as your independent variable during each of your experiments?
- What will serve as your dependent variable during each of your experiments?
- What type of measurements or observations will you need to record during each of your experiments? (Hint: What information will you need to calculate a rate?)

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

- What will serve as a control condition?
- What types of treatment conditions will you need to set up and how will you do it?
- How many trials will you need to conduct?
- 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 measurement 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 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?

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 energy and matter move within or through a system;
- how structure is related to function in living things;
- the nature and role of experiments in science; and
- how science, as a body of knowledge, develops over time.

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 to the right.

Argument presentation on a whiteboard

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

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 you 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!