

Project 3.2.4: Investigating Enzyme Action

Introduction

In the previous activity, you investigated the basic structure of the digestive system as well as the importance of enzymes in the chemical breakdown of food. Our diet supplies us with the raw materials needed to synthesize the energy compound adenosine triphosphate (ATP), an amazing molecule that provides power to the human machine. However, just as raw petroleum out of the ground must be processed before it can be used in automobiles, food must be broken down into much smaller molecules before it can be used efficiently by the body.

As part of the digestive process, chemical reactions break complex polymers in our food into the simple monomers that can be used by the body for energy production and for growth and repair. These chemical reactions are catalyzed by enzymes, proteins that increase the rate of reaction without being changed or used up. In Activity 3.2.1, you built a model to explore the structure, function, and action of enzymes. In this activity you will look closer at factors that have an impact on how these important proteins operate. Even though all enzymes are specific to a given substrate, many behave in similar ways under extreme environmental conditions.

Hydrogen peroxide, H2O2, is toxic to most living organisms. Many organisms are capable of enzymatically destroying the H2O2 before it can do much damage. Although this reaction occurs spontaneously, enzymes increase the rate considerably. At least two different enzymes are known to catalyze this reaction: *catalase,* found in animals and protists, and *peroxidase*, found in plants. A great deal can be learned about enzymes by studying the rates of enzyme-catalyzed reactions. In this project you and a partner will design and carry out experiments to investigate the way in which factors such as temperature and pH can affect the action of the enzyme catalase. Enzymes are specific to the reaction they catalyze, and each one functions under unique environmental conditions.

Equipment

* Laboratory journal
* Catalase solution (potato extract)
* 50mL graduated cylinder
* Test tubes and test tube rack
* Forceps
* Glass stirring rod
* Filter paper
* Paper hole punch
* Distilled water
* 1.5% H2O2 solution
* Thermometer (optional)
* pH meter or pH paper (optional)
* transfer pipettes
* grease pencil
* Catalase and H2O2 solutions at varying concentrations/pH (optional)

Note: The list of equipment is meant to be a guide for ideas. If your design requires something not listed, check with the teacher to see if it is available.

Procedure

**Part I: Standard Reaction**

In this part of the project, you will run a standard reaction to investigate the action of catalase as it breaks down hydrogen peroxide. As H2O2 isdecomposed, it produces oxygen gas. You will determine the rate of catalase activity by measuring the time it takes for a filter paper disk to rise to the top of the liquid by the oxygen gas that is produced.

1. Remember that as an enzyme works, it interacts with its substrate(s) and converts the substrate(s) to product(s).

**Enzyme**

Substrate(s) ------------🡪 Product(s)

1. Research the action of the enzyme catalase.
2. In your laboratory journal, write the simple equation that describes the action of the enzyme catalase. What is/are the substrate(s)? What is/are the product(s)?
3. Put on safety glasses.
4. Obtain a box of lab materials
5. Read the procedure steps for the lab procedure in part 1.
6. Design a data table in your lab notebook.
7. Use a clean 50 mL beaker to obtain approximately 10 mL of catalase extract.
8. Select 3 test tubes and label them A, B, C
9. Measure up 5cm from the bottom of each test tube and mark the height on the test tube.
10. Fill each test tube to the 5 cm mark with 3% hydrogen peroxide.
11. Cut 3 disks of filter paper using a paper hole punch.
12. Soak each filter paper disk in catalase extract then dry the disks for 5 seconds to remove excess moisture.
13. Use clean forceps or glass stirring rod to place each disk at the bottom of its own test tube.
14. Measure the time that it takes for the disc to reach the surface of the solution in the test tube. Record this in your data table.
15. Calculate the average time for the disc to travel to the surface. Show your work in your lab journal.
16. Calculate the rate of enzyme activity using the equation: Distance = Rate x Time. Show your work in your lab journal.
17. Answer Conclusion questions 1 and 2.

Part II: Experimental Design

In this project you and a partner will investigate how a specific environmental factor influences enzyme function. You will design and carry out your own investigation.

1. Work with a partner to generate a researchable question dealing with catalase activity. Think about some of the factors that may impact how enzymes function in the human body. Record your ideas in your laboratory journal.
2. Discuss with your partner an experimental design. Follow the steps outlined in the PLTW Biomedical Sciences Experimental Design handout.
3. Keep in mind all aspects of valid experimental design, including controls.
4. Use the following guidelines to help you with your design:
   * Do not put a test tube directly on the hot plate or on ice. Place the test tube in a beaker with ice or in a beaker with water on the hot plate/stirrer.
   * Make sure all connections are tight to ensure proper readings.
5. Write a draft of your procedure in your laboratory journal. Include experimental design, as well as possible data tables and graphs that will be used to summarize the data. Explain safety precautions that must be taken when carrying out the procedure. When the draft is completed, meet with the teacher for approval.
6. Make any additions or corrections suggested by the teacher.
7. Create the data table you will use for your experiment.
8. Proceed with the actual experiment when given approval.
9. Once data collection is complete, clean all tools and equipment and return supplies to the designated area.
10. Share your findings with the class. Discuss the factors that may impact enzyme action in the body.
11. Show your laboratory journal with the completed project to the teacher before proceeding.
12. Obtain the *How to Write a Science Lab Report* handout and the Science Laboratory rubric from your teacher.
13. Using the handout, create a written report which will be submitted to the teacher for evaluation. This report should follow the structure outlined on the document and will be scored according to the Science Laboratory Report rubric. Write the report for one of your experiments (not both).
14. Answer the remaining Conclusion questions.

Conclusion

1. List and describe three factors that could possibly affect catalase activity.
2. Why is it important that cells contain catalase?
3. Based upon your experimental results, write a paragraph discussing the relationship between environmental conditions and enzyme function.
4. High fever can be a very dangerous condition for anyone, as it is an indicator of a serious infection. Based on this project, suggest a possible explanation for this medical concern.
5. Amylase is an enzyme that has the ability to break down starch, a polysaccharide, into smaller disaccharides. In the last project, you saw that two types of amylase function in the human digestive system, salivary amylase and pancreatic amylase. Salivary amylase and pancreatic amylase are released by two accessory organs of the digestive system. In what structures do the enzymes actually chemically digest food?
6. Each enzyme functions in a different area of the body, but both work to harness the power in carbohydrates and break these complex molecules into simple sugars. Based on the information you have learned about the digestive system, what do you expect to be the optimal pH for the enzymatic action of pancreatic amylase?