Enzymes – The Catalysts of Life

Introduction

Living systems are a sea of chemical reactions. At moderate temperatures (like the temperature of most living systems) chemical reactions occur rather slowly. How can chemical reactions be made to go fast enough to keep something alive? The answer lies in understanding enzymes, the catalysts of life.

Background

A living organism is teeming with many interrelated chemical reactions, many occurring simultaneously. Like all chemical reactions, those in living organisms are affected by changes in conditions such as temperature or pH. The same things that might speed up a chemical reaction in a test tube (such as intense heat or cold) might be deadly to a living organism! How can chemical reactions occur in a living organism without killing it? The answer lies in an understanding of catalysts. Catalysts are chemicals that affect the rate of a chemical reaction without itself changing during the reaction. Biological catalysts are called enzymes. Enzymes speed up most of the chemical reactions in living things. In this laboratory you can discover what influences the activity of the digestive enzyme, amylase.

Molecules are digested in living cells and in complex processes energy is released for use by the cell. Starch molecules are a common food source but must be digested into a more soluble form (sugar) before it can be used effectively by cells. In cells, one enzyme that catalyzes the breakdown of starch into sugar is amylase. A generalized formula for the digestion process is

$$(C_6H_{12}O_5)x + XH_2O \rightarrow C_6H_{12}O_6$$

Materials:

- Amylase solution, 0.5%
- Benedict's solution
- Distilled water
- Hydrochloric acid solution, 0.1M
- Iodine solution
- Sodium hydroxide solution, 0.1M
- Starch solution, 1%
- Table cracker
- Pipet
- Graduated cylinder
- Hot water
- Ice water
- pH paper
- Reaction plate, 12-well
- Stopwatch
- Test tubes
- Test tube racks

Observation note:

Starch + Iodine = purple color
Sugar + Benedict's + heat = orange color

Part 1: **Salivary amylase digestion of a matzo cracker**

1. Obtain a piece of cracker from the teacher and break it up into 4 equal pieces
2. Grind a 2 of the 4 pieces of Table cracker into powder (crush in paper towel).
3. Put 1 of the powdered cracker in test tube A and the other of the powdered cracker in test tube B.
4. Add enough drops of water to each test tube to make it liquid.
5. Add 3-4 drops of Iodine to test tube A, mix and record observation and color on table 1.
6. Add 3-4 drops of Benedict's to test tube B. Place in hot water bath for 1-2 minutes. Record observation and color on table 1.
7. Chew the other 1/2 piece of Table cracker until your mouth is full of saliva.

8. Spit 1/4 of the Table cracker – saliva mixture into test tube C
9. Spit 1/4 of the Table cracker – saliva mixture into test tube D
10. Add enough drops of water to each test tube to make it liquid.
11. Add 3-4 drops of Iodine to test tube C, mix and record observation color on table 1
12. Add 3-4 drops of Benedict's to test tube D. Place in hot water bath for 1-2 minutes. Record observation and color on table 1.

Part 2: <u>pH influence on enzyme activity</u>

1. Using a clean reaction plate, add 2 drops of starch solution to each of four successive wells.
2. To well #1 add 1 drop of iodine. (DO NOT ADD AMYLASE TO THIS WELL. THIS WILL BE USED TO COMPARE TO THE OTHER WELLS.)
   To well #2 add 2 drop of 0.1 M hydrochloric acid solution.
   To well #3 add 2 drop of distilled water.
   To well #4 add 2 drop of 0.1 M sodium hydroxide solution.
3. Add 4 drops of distilled water to each of the four wells.
4. Use small strips of pH paper to determine the pH of the solution in each well.
5. Remove the pH strips from the wells and add 2 drops of amylase solution to wells #2-4.
6. Wait three minutes and add 1 drop of iodine to wells #2-4.
7. Record the results on table 2. (Do not record the observations of the pH paper)

Part 3: <u>Temperature influence on enzyme activity</u>

1. Using the clean wells of a reaction plate, add 2 drops of starch solution to each of four successive wells.
2. To well #1 add 1 drop of iodine. (DO NOT ADD AMYLASE TO THIS WELL. THIS WILL BE USED TO COMPARE TO THE OTHER WELLS.)
   To well #2 add 8 drops of hot water.
   To well #3 add 8 drops of room temperature water.
   To well #4 add 8 drops of ice water.
3. Quickly add 2 drops of amylase to wells #2-4.
4. After 3 minutes test for the presence of starch by adding one drop of iodine to wells #2-4.
5. Record the results on table 3.

Table 1

Test Tube	Observation color	Sugar or starch
A		
B		
C		
D		

Table 2

Well #	pH	Observations of Wells
1		
2		
3		
4		

Table 3

Well #	Water Temperature	Observations of Wells
1		
2		
3		
4		

Analysis Questions

General questions about enzymes.

1. Compare and contrast a catalyst and an enzyme. How are they the same? How are they different?

2. What is the function of an enzyme?

Part 1

3. Which test tubes served as the controls in the experiment?

4. Which test tubes served as the experimental test group

5. Using your results, explain how you know that amylase, an enzyme found in saliva, digests starch into sugar.

6. What was the purpose of chewing the matzo cracker?

Part 2

7. Explain how pH can affect the function of an enzyme?

8. What should be the outcome (color) when starch is added to a base, water, amylase, and iodine? Explain why?

Part 3

9. Explain how temperature can affect the function of an enzyme?

10. What should be the outcome (color) when starch is added to hot water, amylase, and iodine? Explain why.