Lactase enzyme lab

This lab will examine the specificity of an enzyme (lactase) to a specific substrate (lactose). Students will observe the actions of the enzyme and how shape is important to enzyme reactions.

A lesson plan for grades 9–12 English Language Arts and Science

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Learning outcomes

This lab will examine the specificity of an enzyme to a specific substrate. Students will also observe what will happen when the enzyme is denatured.

Teacher planning

TIME REQUIRED FOR LESSON

50 minutes

MATERIALS/RESOURCES

- Lactase tablets: these can be bought in any drug store or grocery store.
- Fifteen milliliters of milk: any milk will work.
- Water: used for dissolving the lactase tablet, dissolving the sucrose and boiling the lactase.
- Sucrose: five grams per group.
- One hundred milliliter graduated cylinder/ten milliliter graduated cylinder: measuring water and enzyme amounts.
- Three four hundred milliliter beakers: used for dissolving the lactase tablet, dissolving the sucrose and boiling the lactase.
- Five test tubes: these tubes hold the different solution mixtures.
- Test tube rack: hold the test tubes.
- Marking pencil: mark the test tubes so that confusion does not occur.
- Clock
- Hot plate with a Pyrex test tube for denaturing the enzyme.
- Glucose test strips: these strips can be found in any drugstore
- Stirring rod: helps to mix up the lactase tablet in the water.

The complete list is on the attached Lactase Enzyme Lab.

Pre-activities

Students should understand enzymes.

Learn more

- Lactose Intolerance Describes the effects on the body of lacking lactose, and differentiates the condition from milk allergies
- Teens Health Discussion of lactose intolerance with particular attention to how teenagers can maintain a nutritious diet in spite of lactose intolerance

RELATED PAGES

- Morehead Planetarium and Science Center: Located on the campus of the University of North Carolina at Chapel Hill, the *Morehead Planetarium and Science Center* is a fascinating place to visit to learn more about astronomy.
- Chem-speak (introduction to chemical equations): Students will understand what constitutes a chemical reaction and how chemical equations represent chemical reactions by means of discussion and demonstrations.
- Port Discover: Students will enjoy visiting this

Activities

PURPOSE

This lab will examine the specificity of an enzyme to a specific substrate. Students will observe what happens when the enzyme is denatured.

INTRODUCTION

Student information

Lactose, the sugar found in milk, is a disaccharide composed of glucose and galactose (both six-sided sugars). Sucrose, ordinary table sugar, is also a disaccharide composed of fructose and glucose. Glucose is a six-sided sugar and fructose is a five-sided sugar.

Lactase is an enzyme that breaks lactose down into galactose and glucose. Lactase can be purchased in pill form by people who are lactose intolerant. These people lack the enzyme, lactase, and cannot break down the sugar lactose into its component parts.

Although lactose is similar to sucrose, lactase will break down only lactose because of the shape of the sugar.

In this lab, you will see lactase break lactose down into galactose and glucose. You will also observe what happens if the shape of lactase is changed due to heating.

PROCEDURES

Solution preparation

1. Enzyme solution: Add one lactase tablet to two hundred milliliters of water. Stir until the tablet has dissolved.
2. Skim milk: this solution contains the lactose.
3. Sucrose solution: Add five grams of sugar to one hundred milliliters of water. Stir until the sugar has dissolved.
4. Denatured enzyme solution:
    - Place twenty milliliters of enzyme solution into a Pyrex test tube.
    - Add two hundred milliliters of water to a four hundred milliliters Pyrex beaker.
    - Place the test tube in the beaker (gently laying the test tube so it rests on the side of the beaker.)
    - Place the beaker and test tube on the hot plate.
    - Boil the water in the beaker for thirty minutes.
    - Let the solution cool to room temperature.

Lab procedures

1. Gather the materials.
2. Label the test tubes with the following labels:
    1. Test tube with skim milk and enzyme solution.
    2. Test tube with skim milk and water.
    3. Test tube with skim milk and denatured enzyme solution.
    4. Test tube with sucrose solution and enzyme solution.

new hands-on science and health center which is geared to the pre-k to fifth grade curriculum.

RELATED TOPICS

- Learn more about biology, chemical reactions, chemistry, enzymes, labs, lactase, and science.

Help

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5. Test tube with sucrose solution and water.

3. In test tube A add two milliliters of skim milk and one milliliter of enzyme solution.
4. Time for two minutes and test for glucose with the glucose test tape. Record this data in table 1. If there was glucose present mark a '+' in the table. If glucose was absent, mark a '-' in the table.
5. In test tube B add two milliliters of skim milk and one milliliter of water.
6. Repeat step 4.
7. In test tube C add two milliliters of skim milk and one milliliter of denatured enzyme solution.
8. Repeat step 4.
9. In test tube D add two milliliters of the sucrose solution and one milliliter of enzyme solution.
10. Repeat step 4.
11. In test tube E add two milliliters of the sucrose solution and one milliliter of water.
12. Repeat steps 4.

RESULTS

You can make this into a table with six rows by two columns. In the second column, record if the glucose test is positive or negative.

Glucose Presence in the Following Solutions

Type of Solution	Positive or Negative Glucose Result
Test tube A: milk and enzyme solution	
Test tube B: milk and water	
Test tube C: milk and denatured enzyme solution	
Test Tube D: sucrose solution and enzyme solution	
Test Tube E: sucrose solution and water	

Any students having difficulty will work in a small group with the teacher and/or assistant for further teaching and remediation.

CONCLUSION AND QUESTIONS

1. Diagram and describe the lactose and lactase reaction.
2. Why did the enzyme react to lactose but not to sucrose?
3. What happened when the enzyme was boiled?
4. Another way to affect the enzyme is by lowering the pH of the solution. However, lactase is supposed to be able to work in the stomach. Would lowering the pH of the enzyme solution affect the enzyme? Why or why not?
5. What type of reaction is this? Dehydration or hydrolysis?

The complete activity can also be found on the attached Lactase Enzyme Lab.

Assessment

Teachers will be able to assess the result table (the only positive reaction should be test tube A) and the teacher will be able to correct the conclusion questions.

1. The students should draw a hydrolysis-induced fit model.
2. The shape of sucrose (glucose and fructose) is different from lactose (glucose and galactose). The sucrose will not fit into the active site of lactase.
3. The enzyme denatured. The hydrogen atoms vibrated so much due to the energy added to the system that the hydrogen bonds broke changing the secondary, tertiary, and quaternary structure of the enzyme. Note: as long as the students understand that the bonds broke changing the enzyme shape, they are ok.
4. The enzyme will denature (eventually). The H+ will interfere with the hydrogen bonds, and denature the enzyme.
5. This reaction is a hydrolysis reaction.

Supplemental information

Denaturing the enzyme was very difficult. We had to boil the enzyme (placing a test tube with the enzyme in a beaker of boiling water) for thirty minutes.

We thought about lowering the pH of the enzyme solution, but commercial lactase is swallowed and works in the stomach—so lowering the pH was not really an option.

We experimented by boiling the lactase for five, ten, and fifteen minutes. Thirty minutes worked for us. We suggest that you try boiling the enzyme before the lab, adding some milk (source of lactose) and test for glucose. If glucose is present, boil the lactase for a longer period of time.

You can approach the enzyme specificity in two different ways:

1. Why didn't the sucrose break down in the presence of lactase?
2. Why didn't the lactose break down in the presence of boiled lactose?

This lab is an uncomplicated introduction to enzyme reactions.

COMMENTS

This lab is a relatively simple lab which shows the specificity of enzymes based on shape. You will need to purchase lactaid and glucose test strips. I suggest the glucose test strips from Science Kits and Boreal Labs, which are easy to use.

You might want to set up the solutions before the lab (if you are pressed for time). This will simplify the lab for the students.

Common Core State Standards

- **ENGLISH LANGUAGE ARTS (2010)**
  - **Science & Technical Subjects**

- Grades 11-12
  - 11-12.LS.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
- Grades 9-10
  - 9-10.LS.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

- North Carolina Essential Standards
  - **SCIENCE (2010)**
    - **Biology**
      - Bio.4.1 Understand how biological molecules are essential to the survival of living organisms Bio.4.1.1 Compare the structures and functions of the major biological molecules (carbohydrates, proteins, lipids, and nucleic acids) as related to the survival of...

North Carolina curriculum alignment

SCIENCE (2005)

Grade 9–12 — AP Biology

- **Goal 3**: The learner will develop an understanding that cellular processes are based on physical and chemical changes.
  - **Objective 3.04**: Describe the structure and function of enzymes.
    - Regulation by enzymes of chemical reactions.
    - Dependence of specificity to structure.
    - Regulation of enzymes.
    - Recommended laboratory - *Enzyme Catalysts*

Grade 9–12 — Biology

- **Goal 2**: The learner will develop an understanding of the physical, chemical and cellular basis of life.
  - **Objective 2.04**: Investigate and describe the structure and function of enzymes and explain their importance in biological systems.