

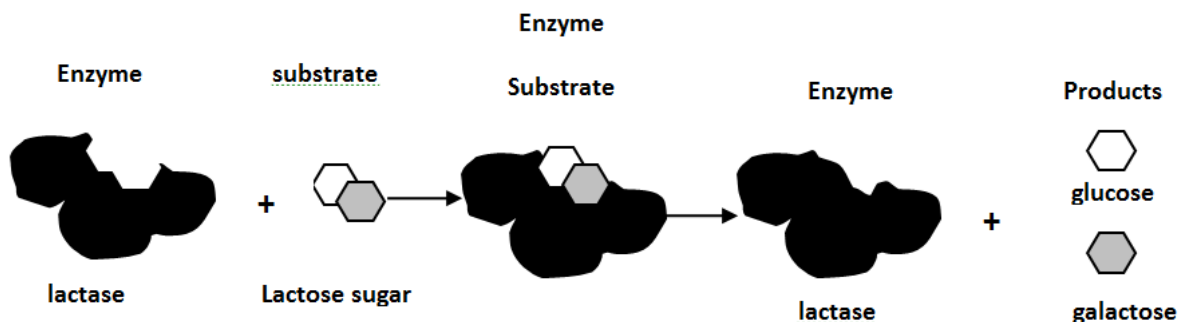
# Lab: A Study of Lactose Intolerance

## HONORS BIOLOGY: UNIT 5

**BACKGROUND:** If you have problems digesting milk, ice cream, yogurt, cheese or other dairy foods, chances are you're one of the 75% of the world's population who are "lactose intolerant". Lactose intolerance is an inability to digest **lactose**—the sugar found in milk and milk products and it troubles about 50 million Americans. Interestingly, most people are born with the ability to produce the lactase enzyme and can digest lactose sugar during infancy and early childhood, while drinking mother's milk. But many lactose intolerant people gradually produce less lactase as they grow older. Although lactose intolerance is more prevalent among certain ethnic groups, all sectors of the population are affected.

This condition is more prevalent in certain ethnic groups such as Asians, Africans, Jewish, Native Americans, Inuits (Eskimos), and Hispanics. These cultures and their ancestors, traditionally, do not raise dairy animals or use milk as a significant food source. It is relatively uncommon among people descended from Europeans.

Lactose, a type of sugar, is normally broken down by the digestive enzyme **lactase**, which is produced by the small intestine. Lactose (milk sugar) is a disaccharide (a two-sugar carbohydrate) made of two simple sugars, glucose and galactose. When lactose works properly, it breaks down (digests) **lactose** sugar into **glucose** and



**galactose** which can then be absorbed through the intestinal lining and used by your body.

Lactose intolerance is usually caused from a deficiency in lactase—your body produces no enzyme or too little enzyme. The enzyme is not produced because the instructions to make it are missing or dysfunctional in the DNA. This is therefore an inherited disorder. When the body does not have enough lactase enzyme, the undigested and unabsorbed lactose sugar is moved into the colon (lower part of your digestive system), where it becomes fermented by intestinal bacteria. The fermentation process produces a lot of gas and causes the unpleasant discomfort of gas bloating, cramps, and diarrhea. The amount of reaction and discomfort differs among individuals. Some people can have mild symptoms that pass quickly, while others can have severe symptoms that leave them feeling ill for many hours. However, lactose intolerance is not life threatening and you are only affected when you eat foods made from milk.

If you have lactose intolerance or suspect that you might be, you should know about "hidden" sources of lactose. Although milk and foods made from milk are the only natural sources of lactose sugar, lactose is often added to prepared foods. As a result, those people with a very low tolerance for lactose should watch out for foods that contain lactose, even in small amounts. Some so-called "non-dairy" products (powdered coffee creamer and whipped toppings) may include ingredients that are derived from milk, and therefore contain lactose. Lactose is an added (inactive) ingredient in more than 20% of prescription drugs and about 6% of over-the-counter medicines. People with lactose intolerance need to read food labels with care, looking for milk and lactose among the ingredients, but also for such words as: whey curds, dry milk solids, milk byproducts, and nonfat dry milk powder. If these contents are listed on a label, the product most likely contains lactose.

Many people who are lactose intolerant avoid dairy foods and foods containing lactose. However, these foods generally do not have to be eliminated from the diet. Dairy products are sources of essential nutrients such as vitamins A and D, protein, riboflavin, calcium, magnesium, and potassium.

To make foods containing lactose easier to digest, natural enzyme supplements can be taken before or with a meal. Supplements such as Lactaid can help make lactose containing foods easier to digest. Lactaid contains the enzyme lactase that has been produced by and isolated from fungal and bacterial cultures. The caplet form of Lactaid is swallowed or chewed before eating dairy products. The drop form of Lactaid is mixed with milk to produce lactose-free milk. When you use any of these supplements, you are eating the digestive enzyme that you normally would be producing. **In this lab, you will test an over-the-counter product that claims to aid in lactose digestion.**

To identify whether you are lactose intolerant, try the following test (**CAUTION: Do not do this if you know you are lactose intolerant or have allergies for milk or other dairy products**)

*DO NOT eat any dairy products for at least 10 hours. Then on Day One, eat a normal breakfast and include a large 12 ounce glass of milk. Over the next 6 hours, keep track of any discomforts, if they occur and how severe they are. On Day Two, take 3 Lactaid capsules five minutes before your breakfast. Then eat a normal breakfast and include a large 12 ounce glass of milk. If you are lactose intolerant, you will probably notice less, or even none of the discomfort that you experienced on day one.*

## PROCEDURE

In this lab, you will investigate the action of the enzyme lactase. Specifically, you will be designing a detailed experiment to test the effect of Lactaid on milk. The directions below will guide you in planning the experiment so that you test all possible variables. The goal is to understand how Lactaid functions to help people with lactose intolerance and also to understand how enzymes function in general.

1. Read the background information at the beginning of the lab so you understand lactose intolerance, the action of the enzyme lactase and the commercial product, Lactaid.
2. You have just read in the previous section that Lactaid is really the enzyme lactase. And that lactase breaks down (digests) the disaccharide lactose into two smaller sugars: glucose and galactose. But after becoming a biology student, you have been transformed into a skeptical scientist. You are not going to take our word for it, you are going to prove it to yourself! So you begin to design an experiment to test the effect of Lactaid on milk.
3. Design a controlled experiment that shows that Lactaid does what it claims: help lactose intolerant people by converting milk products into lactose-free milk products.
4. Write up a detailed experimental plan on the accompanying **EXPERIMENTAL DESIGN GUIDE**. Make sure your experimental design includes a full battery of tests to determine that our indicator(s) work and that the Lactaid does what it says it does.
5. Before undertaking your experiment complete a chart of predictions — what result you expect: either **POSITIVE (+)** or **NEGATIVE (-)** reaction for glucose — for each of your tests.
6. You will be able to perform your experiment once you receive approval of your experimental design from your teacher.

## MATERIALS LIST:

- Spot/Well Plate
- Sheet of paper
- Glucose solution
- Milk
- Milk digestion aid (Lactaid Solution)
- Dropper/Pipette
- Toothpicks
- Glucose test strips
- Timer or clock

## EXPERIMENT RESEARCH PROPOSAL FORM

Teacher Approval \_\_\_\_\_

1. Team Members:

2. Research Relationship (What is affecting what?)

3. Research Prediction (What results do you expect?)

4. **Hypothesis** (Be specific. Include a variable you are measuring. In an If/then/because form)

5. Experimental Design (List the steps in your **procedure**) *Use the back page if you need more space*

6. **Independent Variable:**

7. **Dependent Variable:**

8. List at least 4 other factors must be **controlled**?

9. **Data Table** (Create a table to collect your data in)

10. **Proposed Plan to Analyze Data**

(In what way will you compare these numbers after you collect them?)

11. Explain what results you would need to see in your data to support your hypothesis

12. Complete the experiment. Collect the data in your Data Table. Graph your results if appropriate. Answer the Summary Questions.

### **SUMMARY QUESTIONS**

1. Clearly **describe** the results of your experiment. **What** happened?

2. Clearly **explain** the results of your experiment. **Why** did it happen?

3. Which molecule is the **enzyme** in this experiment?

4. Which molecule is the **substrate** in this experiment?

5. Which molecule is the **product** in this experiment?

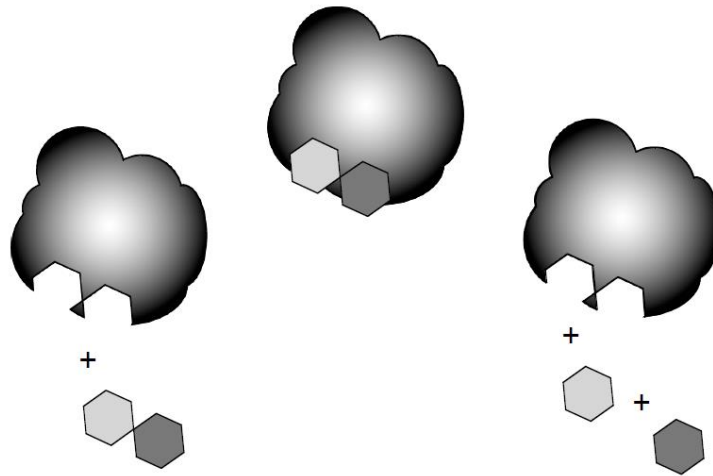
6. What type of **organic molecule** is lactose?

7. What type of **organic molecule** is lactase?

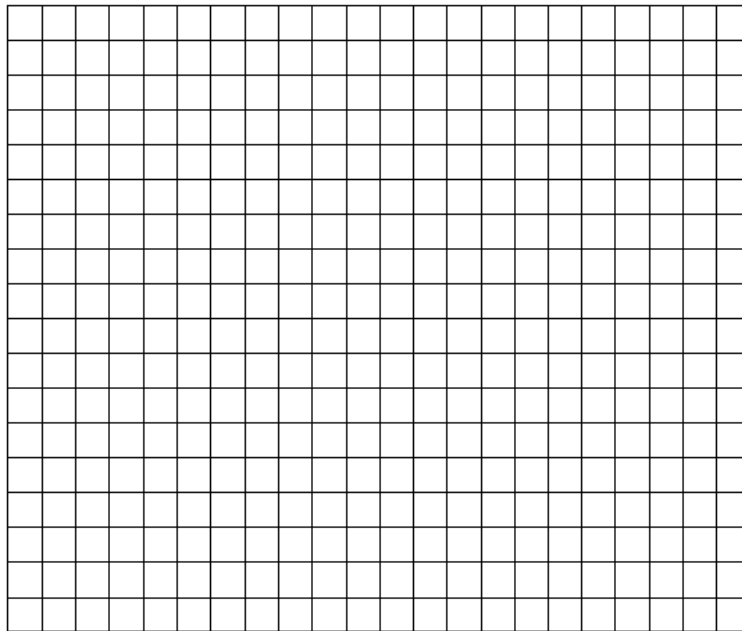
8. Write a "**word equation**" to describe the chemical reaction that occurs when Lactaid is mixed with milk.

9. Is the reaction of Lactaid and lactose sugar **dehydration synthesis** or **hydrolysis**? How do you know?
10. Is this reaction an example of **anabolism** or **catabolism**?
11. Are enzymes used up after they do their job of helping build a molecule or helping breakdown a molecule... or are they used again? Explain.
12. Can **any** enzyme be used to help in **any** reaction? Explain
13. Explain why enzymes are so important to living organisms.
14. Suggest a possible reason why the lactase in people who are lactose-intolerant doesn't function properly.
15. What was the **control** in your experiment?
16. Would Lactaid work if I put it in my Starbuck's cappuccino? Explain.
17. Predict the **temperature** for the optimal functionality of Lactaid. Explain.

18. In the following diagram, number the steps of the Enzyme Cycle (#1, #2, #3), place arrows to show the sequence of events and label: **lactase** (Lactaid), **lactose**, **glucose**, **galactose**



19. Use the following Data Table to make a bar graph representing the prevalence of Lactose Intolerance. (Make sure to include title and label axes)



Groups	Percent Intolerant
British	12
South Americans	63
Chinese	97
European Americans	12
French	18
African Americans	75
Hispanic Americans	53
Asian Americans	90

a. Which groups have the highest incidence rate of Lactose Intolerance?

b. Which groups have the lowest incidence rates of Lactose Intolerance?