INTRODUCTION

Although we can easily digest milk as babies, most of us lose this ability as adults. This is because we usually stop producing lactase, an enzyme that breaks down the main sugar in milk. However, about one-third of people worldwide still produce lactase as adults. In this activity, you will learn about a test for whether someone is likely to produce lactase. This test is based on the amount of a sugar called glucose in a person's blood.

MATERIALS

- ruler
- colored pencils

BACKGROUND

Milk is packed with proteins, fats, and carbohydrates that support the growth, development, and survival of baby mammals. The main carbohydrate in milk is a sugar called **lactose**. To digest milk, lactose must be cleaved, or broken down, by **lactase**, an enzyme produced in the small intestine. Lactase cleaves lactose into two smaller sugars, **glucose** and **galactose**, which are easily absorbed through the walls of the small intestine. Once these sugars are absorbed into the bloodstream, they can be delivered to the cells of the body and used for energy.

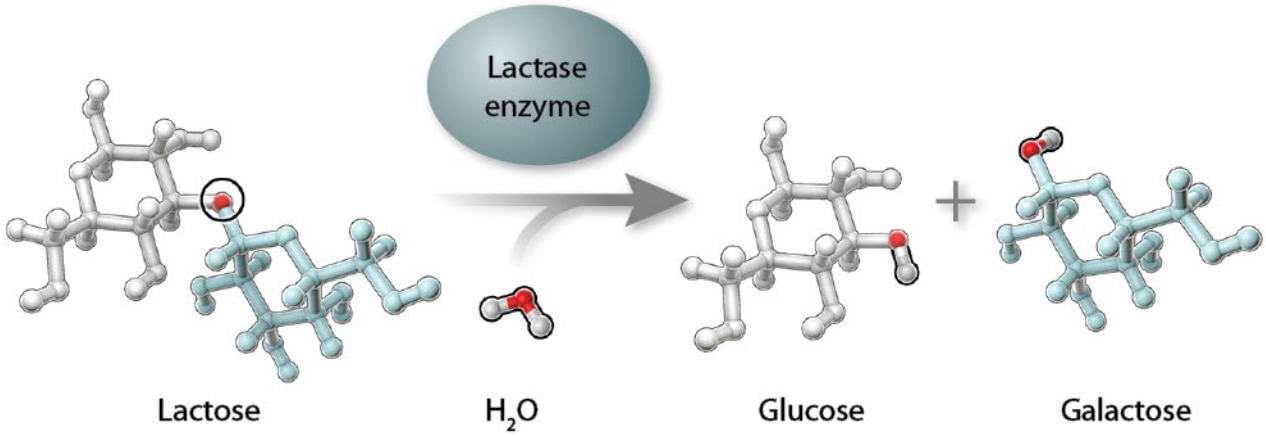


Figure 1. A diagram showing how the lactase enzyme cleaves the sugar lactose.

As baby mammals grow up and stop drinking their mother's milk, their bodies usually stop producing the lactase enzyme (presumably because it is no longer needed). Individuals that do not produce lactase as adults are called **lactase nonpersistent**. Most mammals are lactase nonpersistent and do not drink milk as adults. Humans are unusual in that some adults continue to drink milk from other mammals, such as cows.

When an individual who is lactase nonpersistent drinks milk, they cannot easily break down the lactose in the milk. The lactose passes from their small intestine to their large intestine, where it is fermented by bacteria. Fermentation produces various gases in the large intestine, which can cause abdominal pain, bloating, flatulence, and diarrhea — all symptoms of **lactose intolerance**, the inability to digest lactose. Most adults are lactase nonpersistent and thus typically lactose intolerant (although some may not know it because their symptoms are mild). However, about 35% of the global human population continues to produce lactase into adulthood. These individuals are called **lactase persistent** and are typically **lactose tolerant**, meaning that they can digest lactose easily and drink milk without problems.

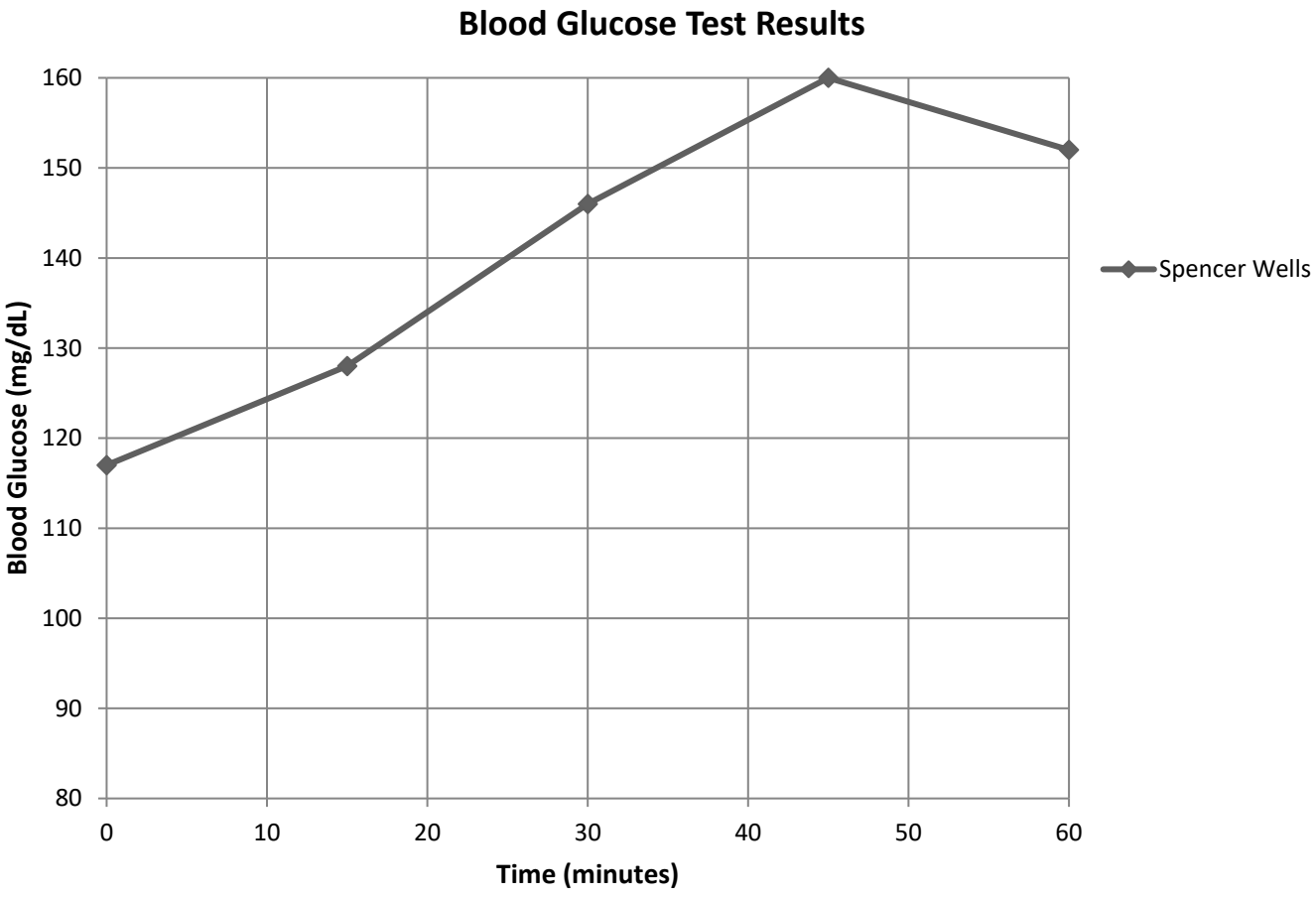
PROCEDURE

There are several ways to test whether someone is lactase persistent or nonpersistent. One method, the blood glucose test, is shown in the short film *Got Lactase? The Co-evolution of Genes and Culture*. Table 1 shows the blood glucose levels of the film's narrator, Spencer Wells, and six other individuals over time. The glucose levels were measured using glucose strips and a glucose reader similar to the one in the film. After baseline levels (i.e., the ones at "0 minutes") were measured, each person drank a liter of milk. Their blood glucose levels were measured again at 15, 30, 45, and 60 minutes after drinking the milk.

Table 1. Blood glucose test results for seven adults tested in Sarah Tishkoff's laboratory.

	Blood Glucose (mg/dL)				
Individual	**0 minutes**	**15 minutes**	**30 minutes**	**45 minutes**	**60 minutes**
Spencer Wells	117	128	146	160	152
Peter	97	111	135	154	143
Rachel	96	99	105	101	98
Katherine	95	97	99	101	102
Sarah	108	116	129	141	139
Michael	94	109	128	143	140
Arthur	97	96	94	83	88

1. Plot the data in Table 1 on the graph below, which already includes the results for Spencer Wells. Add more entries to the legend as needed.



After graphing the data, answer the following questions.

2. Why might someone's blood glucose levels after drinking milk indicate their lactase activity?

3. Divide the individuals in Table 1 into two groups (A and B) based on their blood glucose test results. Write the names of the individuals in each group, including Spencer Wells, below.

   Group A:

   Group B:

4. Explain your rationale for dividing the individuals into these two groups. Use data from your graph to support your answer.

5. Based on these data, do you think the individuals in **Group A** are lactase persistent or nonpersistent? Describe the evidence that supports your answer.

6. Based on these data, do you think the individuals in **Group B** are lactase persistent or nonpersistent? Describe the evidence that supports your answer.

7. If the blood glucose test was performed on people from the Maasai population in Kenya, would their results be more like those of the individuals in Group A or Group B? Explain your prediction. (Hint: As discussed in the film *Got Lactase? The Co-evolution of Genes and Culture*, the Maasai traditionally raise cows for food.)

8. A person taking a blood glucose test is usually told to fast (i.e., to not eat or drink anything but water) before the test. Why do you think that might be necessary?

EXTENSION: The Hydrogen Breath Test

Another common way to test whether a person is lactase persistent or nonpersistent is the hydrogen breath test. This test uses the amount of hydrogen in a person's breath to check for lactose fermentation. As described in the "Background" section, undigested lactose is fermented by bacteria in the large intestine. Fermentation produces several gases, including hydrogen, that can exit the body through the anus. These gases can also be absorbed into the blood, circulated to the lungs, and eliminated through the breath.

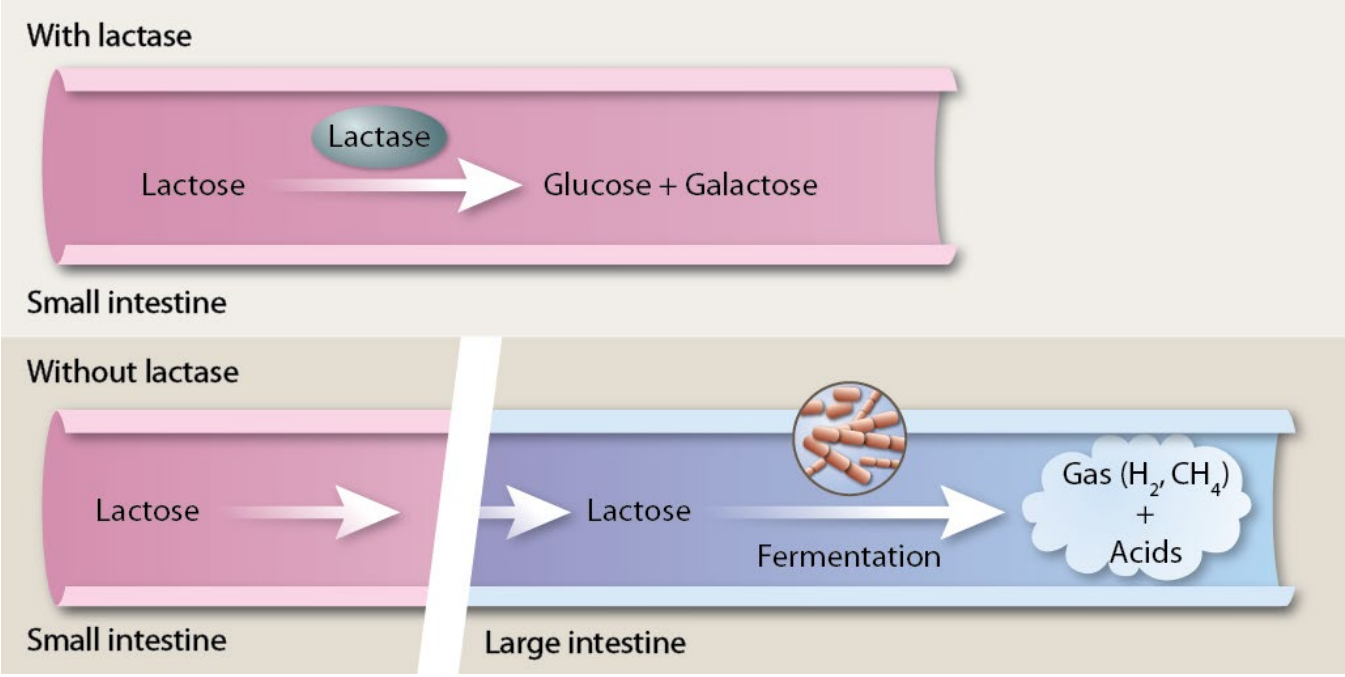


Figure 2. A diagram comparing what happens to lactose in the intestines of individuals with and without the lactase enzyme.

Table 2 shows the levels of hydrogen in the breath of four adults tested for lactase persistence. As in Table 1, the measurements at "0 minutes" represent baseline levels before drinking milk. The other measurements were taken at various times after drinking milk.

Table 2. Hydrogen test results for four adults.

	Hydrogen Breath Levels (ppm)				
Individual	**0 minutes**	**30 minutes**	**60 minutes**	**90 minutes**	**120 minutes**
Lisa	5	6	9	8	5
Dan	4	9	8	29	35
Cindy	6	8	10	31	32
Brian	4	7	6	9	6

1. Create your own graph of the data in Table 2. Your graph should include a title, labels for the *x*- and *y*-axes, and a legend.

After graphing the data, answer the following questions.

2. Which individuals in Table 2 are likely to be **lactase persistent**? Use data from your graph to support your answer.

3. Which individuals in Table 2 are likely to be **lactase nonpersistent**? Use data from your graph to support your answer.

4. Think of another type of test to determine whether a person is lactase persistent or nonpersistent. Describe your idea in one or two sentences.