

GOT LACTASE? BLOOD GLUCOSE DATA ANALYSIS

OVERVIEW

This activity serves as a supplement to the film *Got Lactase? The Co-evolution of Genes and Culture*. Students interpret the results of two different tests for lactase persistence: the blood glucose test and the hydrogen breath test. The activity involves graphing and analyzing research data. This lesson complements the related hands-on activity entitled "Milk: How Sweet Is It?," in which students measure glucose levels in samples of milk after adding lactase.

KEY CONCEPTS AND LEARNING OBJECTIVES

- Compounds in food are sources of energy for cells in the body. They first have to be broken down into simple molecules that can be absorbed and used by cells.
- Digestive enzymes, such as lactase, facilitate the breakdown of food molecules, including carbohydrates, proteins, and lipids.
- The human intestines contain billions of microorganisms, which play multiple roles, including fermenting undigested carbohydrates.

After completing this activity, students should be able to:

- graph research data and appropriately label all graph components, including title, axes, units, and legends.
- interpret data from different biological tests to infer whether someone is lactase persistent or nonpersistent.
- make claims based on scientific evidence and support those claims using scientific reasoning.

CURRICULUM CONNECTIONS

Text/Curriculum	Chapter Sections/Curriculum Topics
NGSS	MS-LS1.C, MS-LS4.C, HS-LS1.C, HS-LS4.C
AP (2012-13 Standards)	2.A.2, 2.D.2, 4.A.1
IB (2009 Standards)	3.2, 3.6, 6.1,
Common Core (2010)	CCSS.ELA-Literacy.RST.6-8.4, CCSS.ELA-Literacy.RST.6-8.7 , CCSS.ELA-Literacy.RST.9-12.4, CCSS.ELA-Literacy.RST.9-12.7, CCSS.ELA-Literacy.WHST.9-12.1, CCSS.Mathematics.MP.2

KEY TERMS

Enzyme, lactase, lactose, persistence, tolerance, glucose

TIME REQUIREMENT

This activity, including the extension, can be completed in one 50-minute classroom period. Viewing the short film requires an additional 15 minutes.

SUGGESTED AUDIENCE

This activity is intended for a first-year high school biology course (honors or regular).

PRIOR KNOWLEDGE

Students should have prior knowledge of constructing graphs, including using appropriate titles, axis labels, data plots, and legends.

MATERIALS

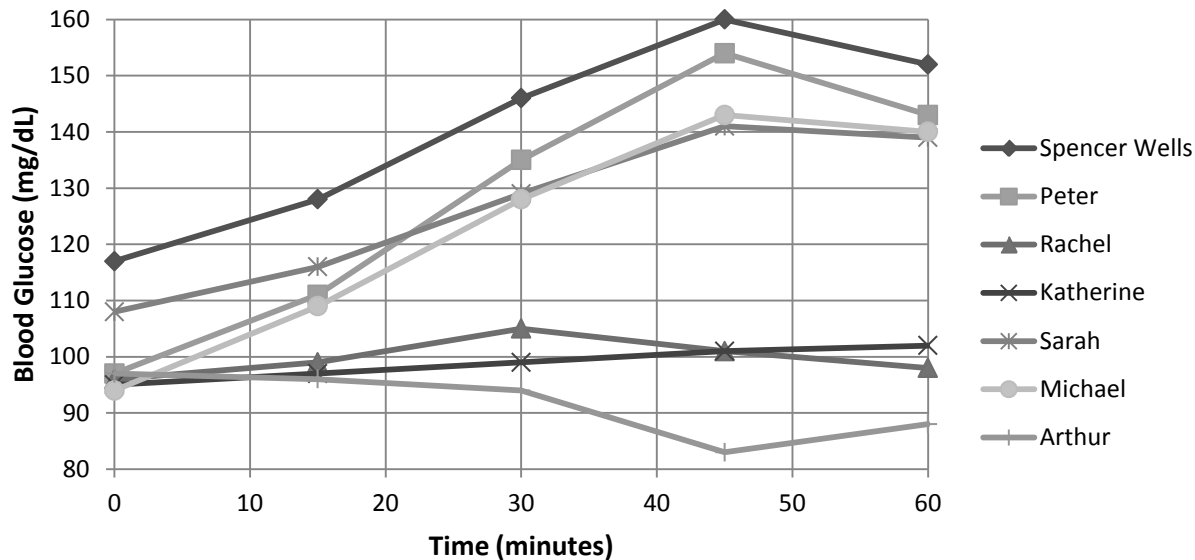
- Ruler
- Colored pencils

TEACHING TIPS

- Have the students watch the short film *Got Lactase? The Co-evolution of Genes and Culture* before doing the exercise. One of the questions refers to the film.
- You may wish to have your students work in pairs.
- Note that in the first graphing exercise, the x-axis has 10-minute time intervals but the data points are every 15 minutes. Students with limited graphing experience might need extra support to figure that out.
- To modify for students with learning differences consider having students plot fewer data points, having students plot data on full sheets of graph paper, and/or omitting some of the questions as needed.
- After completing this worksheet, you may have your students do the complementary hands-on activity entitled "Milk: How Sweet Is It?" in which students measure glucose levels in samples of milk after adding lactase.
- If you are interested in knowing more about Dr. Sarah Tishkoff's research, you may watch her 2011 Holiday Lecture entitled "Genetics of Human Origins and Adaptation" at <http://media.hhmi.org/hl/11Lect2.html>.
- To learn more about how expression of the lactase gene is regulated, proceed through the Click and Learn entitled "Regulation of the Lactase Gene" at http://www.hhmi.org/biointeractive/evolution/Lactase_Regulation/01.html.

ANSWER KEY

Lactase Persistence Blood Glucose Test Results



1. Why is measuring blood glucose levels an indicator of someone's lactase activity?

Students should point out that glucose is one of the products of the digestion of lactose by lactase.

Note: You may want to discuss with your students the fact that this is an indirect test of lactase activity. With the glucose test we are measuring one of the products of the chemical reaction catalyzed by lactase.

2. Divide these individuals 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.

Group A: **Spencer Wells, Peter, Michael, Sarah**

Group B: **Rachel, Katherine, Arthur**

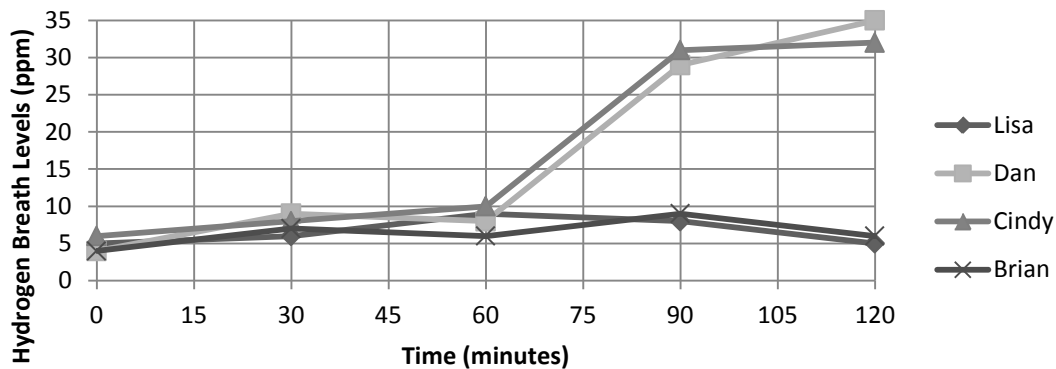
It is also acceptable for students to designate Rachel, Katherine, and Arthur as Group A and Spencer Wells, Peter, Michael, and Sarah as Group B.

3. *Explain your rationale for dividing the individuals into these two groups using data to support your answer.*
Answers will vary, but students should recognize that the graphs for individuals in Group A all look similar to one another and the graphs for individuals in Group B all look similar to one another. All individuals in Group A had a substantial increase in their blood glucose levels within 40 to 50 minutes of consuming milk. Forty-five minutes after drinking the milk, their blood glucose levels increased by 32 to 49 mg/dL. Individuals in Group B had either no increase or a small increase in blood glucose levels after consuming milk. Students may also mention that the results of people in Group A are more like Dr. Wells's glucose test results and, according to the film, he is lactase persistent.
4. *Based on these data, do you predict that individuals in Group A are lactase persistent or nonpersistent? Describe the evidence that supports this claim.*
The members of Group A are lactase persistent (or lactose tolerant). Within 45 minutes of drinking milk, their blood glucose levels increased by 32 to 49 mg/dL. This rise in blood glucose levels indicates that lactose was digested into its component sugars, glucose and galactose, which were then absorbed into the bloodstream. Students may also mention that Group A's results are similar to those of Dr. Wells and he is lactase persistent, according to the film.
5. *Based on these data, do you predict that individuals in Group B are lactase persistent or nonpersistent? Describe the evidence that supports this answer.*
The members of Group B are lactase nonpersistent (or lactose intolerant). Two of the individuals in this group (Rachel and Katherine) had a very slight increase in blood glucose levels, ranging from 7 mg/dL to 9 mg/dL, in the 60-minute period following the consumption of milk. The rise was not as steep as that for individuals in Group A. Arthur's blood glucose levels actually decreased over time. The slight rise or decrease in blood glucose levels after drinking milk suggests that lactose was not digested into glucose and galactose in the small intestine and not absorbed into the bloodstream.
- Note: You might want to discuss with students that usually an increase of 30 mg/dL or more in blood glucose levels within 40 minutes of consuming about a liter of milk is considered to be an indication that someone is lactase persistent.**
6. *If you performed the same blood glucose test on a group of people who are from the Maasai population in Kenya, predict whether their results would be more like those of Group A or Group B. Explain your prediction. (Hint: Remember from the film that the Maasai people are pastoralists.)*
The blood glucose results from the Maasai population in Kenya should be more like those of Group A. The Maasai people are pastoralists. Pastoralist cultures raise livestock. In these populations, there is selection for the ability to digest lactose because they have a reliable source of milk and milk products.
7. *A person taking a blood glucose test is usually told to fast prior to the test. Why do you think that might be necessary?*
Students should indicate that many types of food are eventually digested into glucose. If you were to eat just before drinking milk glucose levels would increase regardless of whether the lactase enzyme is active or inactive.

Note: You might want to discuss with students that because blood glucose levels are not accurately regulated in people with diabetes, variations in blood glucose levels cannot be used to determine whether someone is lactase persistent.

EXTENSION ACTIVITY

Hydrogen Breath Test Results



1. Which individuals appear to be lactase persistent? Use data to support your answer.

Lisa and Brian are lactase persistent. The hydrogen breath test results from these two individuals suggest that the level of hydrogen in their breath does not increase significantly. The data suggest that lactose is being digested in the small intestine. Lactose is not available for fermentation by bacteria in the large intestine; therefore, excess hydrogen gas is not being produced and released in their breath.

2. Which individuals appear to be lactase nonpersistent? Use data to support your answer.

Dan and Cindy are lactase nonpersistent (lactose intolerant). If lactose is not digested by lactase in the small intestine, it passes undigested into the large intestine, where it is fermented by bacteria. One of the products of fermentation is hydrogen, which can be measured in breath samples collected before drinking milk and then at a set time after. Since levels of hydrogen in Dan and Cindy's breath increased significantly after consuming milk, these data suggest they are not digesting lactose.

3. Can you think of another type of test you might do to determine a person's lactase status?

Answers will vary. Students might mention doing a genetic test to look for the lactase persistence mutation. They might also want to look for the presence of the lactase enzyme in a person's intestine. Students could also mention measuring blood levels of galactose. That is a reasonable answer, however, you might want to let students know that galactose is rapidly converted to glucose in the liver and it cannot always be detected in the circulation.

AUTHORS

Written by Ann Brokaw, Rocky River, Ohio.

Edited by Susan Dodge and Laura Bonetta, PhD, HHMI.

Field Tested by Amanda Crisostomo, Science and Math Institute; Angeliki Aravantinos, John Bowne High School; Donald R. Kirkpatrick, Marion High School; Eileen Grzybowski, Norman North High School; Jen Stites, John Hancock College Prep High School; Jennifer Corleto, Ward Melville High School; Jeremy Barlow, Uniondale High School; Kim Hayen, Heritage High School; Lisa Borgia, Rocky River High School; Mark Little, Broomfield High School; Moira Chadzutko, St. John the Baptist Diocesan High School; Nicole Reid, Spackenkill High School; Sarah Freilich, Kehillah Jewish High School; Susan Campbell, Brentwood High School; Teresa Ware, Tupelo High School.