TEACHER GUIDE
Life Science

LEARNING UNDEFEATED
Educate | Elevate | Empower

Where Did the Sugar Go?

Topic(s): Biology, Body Systems

Grade level(s): 6th-8th grades

Time: 45-60 minutes

NGSS Alignment: MS-LS1-3, MS-LS1-7

TEKS Alignment: 7.12B, 7.13B

LSSS Alignment: 7-MS-LS1-3, 7-MS-LS1-7

ACTIVITY OVERVIEW

In this activity, students are challenged to think about how sugar moves through the body while also considering the various daily considerations a person with diabetes must think about. This activity includes 3 student stations: meal prepping, monitoring, and motion. At the meal prepping station, students are challenged to plan a meal that fits the carbohydrate constraints of a diabetic patient. At the monitoring station, students use a glucometer to test simulated patient blood samples taken before and after eating a meal to understand where sugar travels to after digestion. At the motion station, students use glucose test strips to test simulated patient plasma samples taken before and after exercising to better understand why sugar leaves the blood during exercise.

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ALIGNMENT TO STANDARDS

NGSS:

MS-LS1-3. Use an argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

TEKS:

7.12B. Identify the main functions of the systems of the human organism, including the circulatory, respiratory, skeletal, muscular, digestive, excretory, reproductive, integumentary, nervous, and endocrine systems.

LSSS:

7-MS-LS1-3. Use an argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

LEARNING OUTCOMES

Students will know:

- The functions of the digestive, circulatory, and muscular systems.
- What diabetes is.

Students will understand:

- How sugar/nutrients travel through different body systems.
- Why muscles need sugar.
- The importance of exercise in maintaining healthy blood glucose levels.
- The considerations and changes a diabetic person has to make to their daily life.

Students will be able to:

- Create a meal plan within the constraints of a diabetic's nutrition needs.
- Use glucometers to measure blood glucose levels of simulated patient samples.
- Analyze blood glucose data to determine if a patient is diabetic.
- Use glucose test strips to measure glucose levels in simulated patient plasma samples.
- Analyze glucose data to determine how exercise affects glucose levels.
- Form an argument supported by evidence for how the body moves sugar to different areas of the body.

CAREER CONNECTIONS

Phlebotomists

Phlebotomists draw blood for tests, transfusions, research, or blood donations.

Work Environment: Phlebotomists work mainly in hospitals, medical and diagnostic laboratories, blood donor centers, and doctors' offices.

Duties: Professionals in these jobs have the following duties and more: draw blood from patients and blood donors, label the drawn blood for testing/processing, assemble and maintain medical instruments such as needles, test tubes, and blood vials.

Median Salary: $36,320 (US Bureau of Labor, 2020)

Source: https://www.bls.gov/ooh/healthcare/phlebotomists.htm

Heath Education Specialist

Health education specialists develop programs to teach people about conditions affecting well-being. Community health workers promote wellness by helping people adopt healthy behaviors.

Work Environment: Health education specialists and community health workers are employed in a variety of settings, including hospitals, nonprofit organizations, and government agencies. Most work full time.

Duties: Professionals in these jobs have the following duties and more: develop programs, materials, and events to teach people about health topics, help people find health services or information, collect and analyze data to learn about a particular community, and advocate for improved health resources and policies that promote health.

Median US Salary: $48,140 (US Bureau of Labor, 2020)

Source: https://www.bls.gov/ooh/community-and-social-service/health-educators.htm

Medical Scientist

Medical scientists conduct research aimed at improving overall human health.

Work Environment: Medical scientists conduct research aimed at improving overall human health.

Duties: Professionals in these jobs have the following duties and more: design and conduct studies that investigate both human diseases and methods to prevent and treat them, create

and test medical devices, and standardize drug potency, doses, and methods to allow for the mass manufacturing and distribution of drugs and medicinal compounds.

Median US Salary: $91,510 (US Bureau of Labor, 2020)

Source: https://www.bls.gov/ooh/life-physical-and-social-science/medical-scientists.htm

Dietitians/ Nutritionist

Dietitians and nutritionists plan and conduct food service or nutritional programs to help people lead healthy lives.

Work Environment: Dietitians and nutritionists work in many settings, including hospitals, nursing homes, clinics, cafeterias, and for state and local governments.

Duties: Professionals in these jobs have the following duties and more: counsel clients on nutrition issues and healthy eating habits, evaluate and monitor the effects of nutrition plans and practices, create educational materials about healthy food choices and lifestyle, and document clients' progress.

Median Salary: $63,090 (US Bureau of Labor, 2020)

Source: https://www.bls.gov/ooh/healthcare/dietitians-and-nutritionists.htm

Biochemist

Biochemists and biophysicists study the chemical and physical principles of living things and of biological processes.

Work Environment: Biochemists and biophysicists typically work in laboratories and offices to conduct experiments and analyze the results. Most work full time.

Duties: Professionals in these jobs have the following duties and more: plan and conduct complex projects in basic and applied research, isolate, analyze and synthesize proteins, fats, DNA, and other molecules, research the effects of substances such as drugs, hormones, and nutrients on tissues and biological processes.

Median Salary: $94,270 (US Bureau of Labor, 2020)

Source: https://www.bls.gov/ooh/life-physical-and-social-science/biochemists-and-biophysicists.htm

BACKGROUND INFORMATION

In this activity, students will go through three different stations to investigate where sugar goes after you eat it and how diabetic patients process sugar differently from non-diabetic individuals. Students will proceed through three stations each related to something that diabetics need to accommodate for in their daily routine: meal planning, sugar monitoring, and exercise.

Sugar is a necessary molecule in the body as it is one of the main sources of energy. The sugar glucose, a monomer, can be found in many different foods. Once consumed, the digestive system works to break down the food into its simplest components. In the case of sugar, the mouth and small intestine break down large sugar molecules into simpler forms, like glucose.

Once small enough, the sugar molecules can travel from the digestive system to the circulatory system. The circulatory system transport nutrients, like sugar, around the body to cells that need it to make energy. This means that it is especially important to get sugar from the circulatory system to the muscular system to make energy to allow for movement.

Diabetes impedes this process because the body isn't making enough insulin or because the body can't use the insulin as well as it should. Insulin is used to signal to the body when there is too much glucose in the blood. When the system is working properly, when glucose levels start to rise, insulin is released, and glucose is removed from the blood stream and stored in the liver. Without insulin to signal the move to storage, it continues to travel in the blood stream and, when, chronic, can lead to kidney damage, cardiovascular damage, or damage to the retina.

In our stations, we will use blood or plasma glucose levels to understand where sugar is moving to and from. Healthy blood glucose levels change depending on the context of the last meal. Below is a table outlining healthy versus diabetic blood glucose levels.

	Fasting	2 hrs after oral glucose test	Random (not considering meal time)
Healthy	<100 mg/dL	<140 mg/dL	
Diabetic	>125 mg/dL	>200 mg/dL	> 200 mg/dL

What is diabetes?

- https://www.cdc.gov/diabetes/basics/diabetes.html

Diagnosing Diabetes Lesson Bundle

- https://www.howsciencepowersus.com/education-resources/educator-resources-cardiovascular-renal-metabolic

Digestion and Absorption of Sugar

- https://www.sugarnutritionresource.org/the-basics/digestion-absorption-of-sugar

Nick Jonas Discussing Living with Diabetes

- https://www.youtube.com/watch?v=uWOzpwiZuHc

REAGENT PREPARATIONS

Concentrated Dextrose Solution (Stock, 4,000 mg/dL)

- Combine 8g dextrose and 200mL dH_2O

Blood Glucose Samples (Patients A and B)

- To make Patient A1 samples (250 mg/dL):
  - Combine 12.5mL of 4,000mg/dL dextrose, 187.5mL dH_2O, and 30mL red food coloring
  - Invert to mix
  - Aliquot into dropper bottles for student use
- To make Patient A2 samples (1,500 mg/dL):
  - Combine 75mL of 4,000mg/dL dextrose, 125mL dH_2O, and 30mL red food coloring
  - Invert to mix
  - Aliquot into dropper bottles for student use
- To make Patient B1 samples (100mg/dL):
  - Combine 5mL of 4,000mg/dL dextrose, 195mL dH_2O, and 30mL red food coloring
  - Invert to mix
  - Aliquot into dropper bottles for student use
- To make Patient B2 samples (160mg/dL):
  - Combine 8mL of 4,000mg/dL dextrose, 192mL dH_2O, and 30mL red food coloring
  - Invert to mix
  - Aliquot into dropper bottles for student use

Plasma Glucose Samples (Patients C and D)

- To make Patient C1 samples (2,000mg/dL):
  - Combine 100mL of 4,000mg/dL dextrose and 100mL dH_2O
  - Invert to mix
  - Aliquot into flip top bottles for student use.
- To make Patient C2 samples (1,000mg/dL):
  - Combine 50mL of 4,000mg/dL dextrose and 150mL dH_2O
  - Invert to mix
  - Aliquot into flip top bottles for student use.
- To make Patient D1 samples (250mg/dL):
  - Combine 12.5mL of 4,000mg/dL dextrose and 187.5mL dH_2O
  - Invert to mix
  - Aliquot into flip top bottles for student use.
- To make Patient D2 samples (100mg/dL):
  - Combine 5mL of 4,000mg/dL dextrose and 195mL dH_2O
  - Invert to mix
  - Aliquot into flip top bottles for student use.

STUDENT STATION SET-UP

There are three stations that will need to be set up for this activity. At each station, there should be 6 workspaces for students to use in pairs.

Station 1: Meal Planning

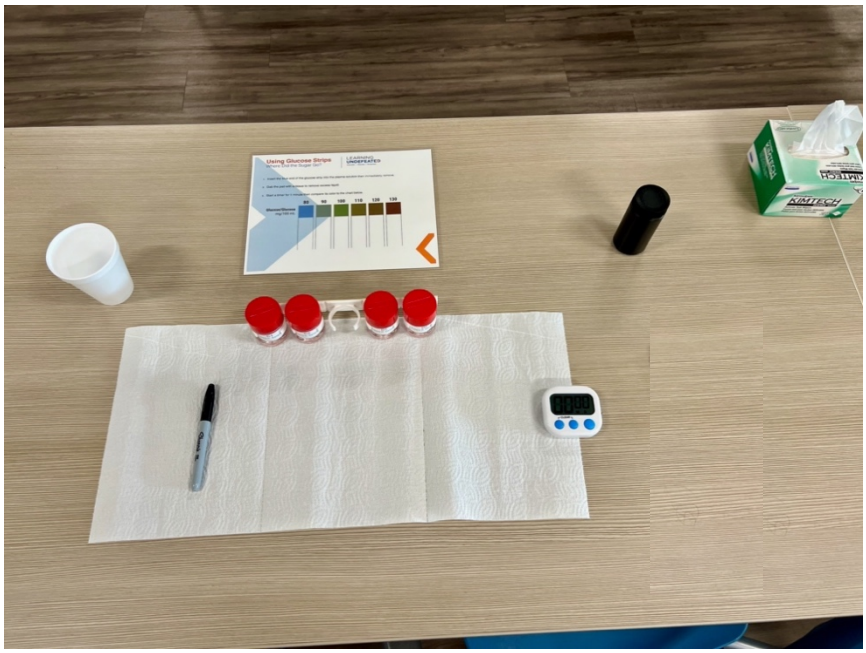
1. Calculators

Station 2: Monitoring

1. Labeled plastic microscope slides (Patient A and Patient B)
2. Patient A blood samples, in dropper bottle (A1 and A2)
3. Patient B blood samples, in dropper bottle (B1 and B2)
4. Glucometer
5. Glucometer strips
6. Glucometer instructions (laminated)
7. Tissues
8. Waste Bins for test strips and tissues
9. Paper towels for work surface

Station 3: Motion

1. Patient C plasma samples, in flip-top bottle (C1 and C2)
2. Patient D plasma samples, in flip-top bottle (D1 and D2)
3. Glucose test strips (black bottles)
4. Glucose color comparison chart (laminated)
5. Timers
6. Waste Bins for test strips
7. Paper towels for work surface



LESSON PLAN

Slide 1: Where Did the Sugar Go?

- Introduce today's activity about body system and diabetes while passing out the *Where Did the Sugar Go?* Worksheet. Have students read the introduction as the class gets settled.
- After reading, instruct students to look at the question at the bottom of the first page. Have students "Think, Pair, and Share." (Think about the question on their own, then discuss it with a partner, then finally discuss as a class.)
    - What is glucose and how does it relate to diabetes?
        - *Glucose is a simple sugar that can be found by itself or in complex sugars like disaccharides or polysaccharides. This is the molecule that makes things taste sweet. Those with diabetes can't regulate how much glucose they have in their blood.*

Slide 2: Learning Objectives

- Explain to students that at the end of today's activity, they will have done the following:
    - Create a meal plan within the constraints of a diabetic's nutrition needs.
    - Use glucometers to measure blood glucose levels of simulated patient samples.
    - Analyze blood glucose data to determine if a patient is diabetic.
    - Use glucose test strips to measure glucose levels in simulated patient plasma samples.
    - Analyze glucose data to determine how exercise affects glucose levels.
    - Form an argument supported by evidence for how the body moves sugar to different areas of the body.

Slide 3: Cells

- As the video loops, ask students what they know about cells.
    - This can include different components or organelles or types of cells they are familiar with.

Slide 4: Tissues

- Explain to students that cells in multicellular organisms are organized into tissues, groups of similar cells that work together on a specific task.
- Ask students to think of the human tongue. Ask them what they think the main purpose of the tongue is?
    - Main responses should be moving food/objects in the mouth and tasting,
- Advance slide to show next images. Explain that in the case of moving things, muscular cells work together to form muscle tissues that make up the bulk of the tongue itself.

Slide 5: Organs

- Explain to students when tissues work together on a task, we call that an organ.
- Have them think of the mouth as an organ. Ask what is the main function of the mouth?
    - To chew food into smaller pieces so we can swallow.
- Ask students what different components are needed to make that happen?
    - Teeth (made of bone and nerves tissue), tongue (made of muscle and nerve tissue, cheeks (made of epithelial and muscle tissue).
- Explain that we need these many tissues working together to accomplish this one specific goal of chewing and swallowing food.

Slide 6: Organ/ Body Systems

- Explain to students when organs work together on a task, we call that an organ or body system. These allow for different parts of the body to work together toward a goal.

- Ask students to think of the mouth we mentioned on the last slide. Ask students which system do they think the mouth is a part of? What larger goal does the mouth help out with?
    - The mouth is part of the digestive system. The mouth helps to make the food small so other organs can break down the food so we can get energy and then later remove the waste.
- Advance slide to show next image. Explain that there are many different body systems. The respiratory system works with the lungs, nose and mouth and other muscles to breath, bringing oxygen and removing carbon dioxide. Our skeletal system creates a frame for our body shape as well as joints to allow for points of movement. Our musculatory system is needed to move the bones they are attached to. And our circulatory system is needed to transport nutrients like sugar and oxygen around the body.
- Together all of these systems work together to create an organism, in this case, a human.

Slide 7: Type 1 Diabetes

- Explain to students that today they will be investigating the body systems and how they relate to type 1 diabetes. Ask students if they know anything about diabetes.
    - Students might mention diabetic people have different blood sugars levels, or that they have to use special devices to measure some components in their blood. It's okay if students have no prior knowledge of this condition.
- Play the video to introduce students to type 1 diabetes.
    - *Teachers Note: The video does include English closed captions. Video can be stopped at 1:58.*
- Ask students what component stops working when people have diabetes? What does that component do?
    - Insulin is no longer made. Insulin signals to the body cells to take in glucose from the bloodstream.
- If needed, remind students that glucose is a sugar that our bodies use for energy. If the energy can't get to the cells in our muscles or brains, we won't be able to move around or think as quickly. Insulin is needed, like a key, to unlock a door and let glucose into the cells.

Slide 8: Today's Investigation

- Introduce students to the two focuses for today's activity:
    - How do body systems work together to move sugar around the body?
    - What does a person with diabetes have to change or add to their daily routine to maintain healthy blood glucose levels?
- Break students into groups of two to three and assign each group a station in the laboratory/classroom.
    - *Teacher's Note: Students will work on their worksheets, but have their responses recorded collectively through the slides.*
    - *Teacher's Note: Students should be given about 10-12 minutes at each station before being told to rotate. After all groups have been to the three stations, group data can be collected on the following slides and used to facilitate a conversation about their results.*

Slide 9: Station 1: Meal Planning

- Review the goal of the station: to create a meal for a diabetic person while also maintaining their budget.

- Ask students what things they took into consideration the first time they designed the meal.
    - Students might have focused on flavors others might have focused on price.
- Explain that in order to keep the blood sugars at a healthy level, the diabetic person needs insulin alongside their meal. What other factors did you need to think of once that became clear?
    - Carbohydrates in each item as well as the amount of insulin on hand and how much carbohydrates would be removed with a single dose of insulin.

Slide 10: Station 2: Monitoring Blood Glucose After Eating

- Review the goal of the station: to understand how blood glucose was affected by eating.
- Before diving into the data, ask students the questions related to their station.
    - What body system did the sugary drink go through to enter the body of the patient?
        - *The digestive system*
    - Based on the blood sugar test that you conducted, after the first body system breaks down the drink, what system does the sugar travel to next?
        - *The circulatory system*
- Ask for one group's data for Patient A and B or collect a class average and record on the slide.
- Ask students the following data analysis question from their handout:
    - What differences do you notice between Patient A and Patient B?
        - *Patient A had higher starting and ending blood sugar and the rise from before to after was much larger than that of Patient B. Both patients saw an increase in blood sugar after eating.*
- Ask students if they were able to diagnose the patients using the expected diabetic and non-diabetic values.
    - *Patient A is diabetic and Patient B is non-diabetic.*

Slide 11: Station 3: Motion

- Review the goal of the station: to understand how blood glucose was affected by exercise.
- Ask for one group's data for Patient A and B or collect a class average and record on the slide.
- Go over the data analysis questions with students:
    - For both patients, what happened to the blood sugar (glucose) level after exercising?
        - *After exercising, both patients experienced a decrease in blood sugar.*
    - What body system does the sugar move to when you are exercising?
        - *The musculatory system*

Slide 13: Part 3: Motion CER

- Review the information that was provided for the CER at the third station: Patient C's doctor has asked them to include more exercise in their routine to help with their blood sugar levels but Patient C is skeptical.
- Review the provided graph and information about the study that the doctor tried to use to convince Patient C of their point.
    - In this experiment, healthy adults were split into two groups: one group that had been exercising vigorously 5-7 days/week for 6 months and one group that had done no

exercise training for at least 12 months. To collect the data, the participants had blood glucose (blood sugar) measured before and after consuming a sugary drink.

- Referring to the graph on the slide, ask students which group has overall lower blood glucose levels?
    - The trained group
- Advance Slide and have 1-2 students read their CER: first their claim, then their evidence and then their reasoning. If students select answers that don't make sense encourage other students to argue why another option should have been selected
        - *Correct Answer: I agree with the doctor that it would be good for Patient C to exercise regularly. The graph shows that the trained group had overall lower blood sugar levels than the untrained group. People who train have a lower glucose (sugar) tolerance and their bodies respond to sugar quickly to keep blood sugar levels low.*
- If time allows, review the final CER with students. This can also be a student's exit ticket or homework.
    - Write an argument using the claim evidence reasoning model to make a strong claim to Patient C explaining whether or not the body systems (circulatory, digestive, muscular) interact to affect blood glucose.
        - I ***agree*** *that the body systems (circulatory, digestive, muscular) interact to affect blood glucose levels. Table 1 and 2 show that eating a sugary drink results in higher blood glucose after 1 hour. Table 3 and 4 show that exercising will decrease blood sugar levels. The digestive system is used to take in food and breaks it down to create the simple sugar, glucose. This is then absorbed into the blood as we see evidenced in tables 1 and 2. The job of the circulatory system is to transport this sugar, along with oxygen and other nutrient and waste, around the body. When exercising, the body will need more sugar and oxygen to make energy required to move the muscles. We see this evidenced in tables 3 and 4 when the blood sugar decreases after exercising. All of the systems work together to change blood glucose levels throughout the day.*