TEACHER GUIDE
EXPLAIN 2 LESSON 22

Food and Agriculture Center for Science Education

Module Questions: ***Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?***

What We Figure Out:

We figure out that milk helps our body recover from exercise by refilling the glycogen stores in skeletal muscle myocytes, and likely in the liver hepatocytes. Although we are not sure of the mechanism, we do know from data that the protein in milk increases the efficiency of this process.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students revise an explanation using multiple pieces of evidence to show how consuming milk induces changes in the body that help it recover from exercise.	50 minutes	Lesson 22 Student Guide

Targeted Elements

SEP:	DCI:	CCC:
CEDS-H2: **Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as**	**LS2.B-H1:** Photosynthesis and **cellular respiration (including anaerobic processes) provide most of the energy for life processes.**	**SC-H1:** **Much of science deals with constructing explanations of how things change and how they remain stable.**

they did in the past and will continue to do so in the future.		

Directions

Part 1: Our Motivation

USE OF PHENOMENA
Between Lessons 16-20, students will focus on the topic of exercise from the Module Phenomenon. In Lessons 21-22, they will focus on the topic of recovery from the Module Phenomenon. In Lesson 23, they will investigate a related phenomenon. They will return to the Anchor Phenomenon in Lesson 24 and revise their presentations to help their peers understand how milk can help them recover from exercise.

Have students revisit the updated explanations from their Lesson 20 Student Guide Part 2: Developing an Explanation of Heart Rate and Breathing Rate Changes During Exercise. This explanation describes how students answered the first Module Question: *Why are there so many changes to my body during exercise?* Note the explanation for the other question, "*How does milk help with recovery from these changes?"* was drafted in Lesson 15. This individual review is to see what gaps exist in the explanation from what they have learned so far in the module.

Ask students if these explanations accurately reflect the new evidence they have about how using milk as a recovery drink contributes to recovery. Listen for responses such as:

- We were able to explain how exercise impacts the body to make heart rate increase, breathing rate increase, fatigue, and muscle burning occur, but we didn't figure out how milk could help with recovery.

Next, point to the questions on the Driving Question Board related to milk and recovery from exercise. Share a few selected questions that align with what students will investigate in the upcoming lesson. Example student questions or ideas could include:

- What does milk do to help with recovery from fatigue?
- What does glucose do once it is in the bloodstream?
- How does the sugar and lactose in milk help with recovery?

Students can record these questions and ideas on their Lesson 22 Student Guide Part 1: Our Motivation. This will help students understand how this lesson connects to what they were trying to figure out about the Module Phenomenon. Use students' questions to transition to the lesson by sharing that, in this lesson, we will update our most recent explanations of the Module Questions: *Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?*

Part 2: Developing an Explanation of How Milk Helps with Recovery From Changes to the Body During Exercise

Share with students that they will now revise their explanation to update their answer to the Module Questions: *Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?* Afterward, students can combine these explanations with their explanations from Lesson 20 to have a full explanation of both Module Questions.

As students work on their Lesson 22 Student Guide Part 2: Developing an Explanation of How Milk Helps with Recovery from Changes to the Body During Exercise, circulate the room to informally assess their explanations and provide feedback by asking questions about their work.

FORMATIVE ASSESSMENT OPPORTUNITY
Students revise an explanation using multiple pieces of evidence to show how consuming milk induces changes in the body that help it recover from exercise.

Assessment Artifacts:

- Students' explanations of how the components of milk can help recovery from exercise and provide additional energy for continued exercise (Lesson 22 Student Guide Part 2: Constructing Explanations).

Look Fors:

- Students use evidence from a variety of sources, including data sets and the Science Theater model (CEDS-H2).
- Student explanations describe how milk helps the body recover from intense exercise to have glucose available to produce cellular energy via aerobic and anaerobic respiration (LS1.B-H1).
- Student explanations describe how levels of glycogen in muscles change upon recovery (SC-H1).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Drinking milk helps with recovery because milk has sugar and lactose in it. These sugars can be used to recover the body, which means you have more energy for exercise.	Our bodies require a lot of energy to participate in intense exercise. Energy for our cells, ATP, is made from glucose molecules. Glucose from muscle glycogen and liver glycogen stores is used to generate ATP during aerobic and anaerobic respiration. After a long enough amount of intense exercise, muscle and liver glycogen can be depleted enough that they have little to no glucose to contribute. Drinking a recovery beverage with carbohydrates can recover muscle glycogen to help continue to produce ATP for exercise. Milk contains sugar and lactose. In digestion, these are broken down to produce glucose, which enters the bloodstream. Glucose can then enter the muscles and liver, where it can be used in anaerobic or aerobic respiration right away, or it can be stored in the form of glycogen. So it is likely that glucose from milk, just like the carbohydrates in the studies, helps the body recover from intense exercise because it provides more glucose for immediate use or later use as stored glycogen to make ATP to help move the body.	Our bodies require a lot of energy to participate in intense exercise. Energy for our cells, ATP, is made from glucose molecules. Glucose from muscle glycogen and liver glycogen stores is used to generate ATP during aerobic and anaerobic respiration. After a long enough amount of intense exercise, muscle and liver glycogen can be depleted enough that they have little to no glucose to contribute. We saw in John L. Ivy et al. 2002 and in John A. Carrithers et al. 2000 that, after intense cycling exercise, muscle glycogen was depleted to 0 mmol/L in each study group and to less than 100 mmol/L in each study group, respectively. Drinking a recovery beverage with carbohydrates can recover muscle glycogen to help continue to produce ATP for exercise. We saw in John L. Ivy et al. 2002 and in John A. Carrithers et al. 2000 that after drinking the recovery beverage, which contains carbohydrates, muscle glycogen levels increased from 0 mmol/L to over 30 mmol/L in each study group, and from less than 100 mmol/L to over 200 mmol/L in each study group, respectively. Milk contains sugar and lactose. In digestion, these are broken down to produce glucose, which enters the bloodstream. Glucose can then enter the muscles and liver, where it can be used in anaerobic or aerobic respiration right away, or it can be stored in the form of glycogen. So it is likely that glucose from milk, just like the carbohydrates in the studies, helps the body recover from intense exercise because it provides more glucose for immediate use or later use as stored glycogen to make ATP to help move the body.
How to Achieve This	Student completes 0 out of 3 Look	Student completes 1-2 out of 3 Look Fors	Student completes 3 of 3 Look Fors

Level	Fors		

To Provide Additional Support for Students

As students work in groups, approach each group to look at their work. If students need additional support in developing their explanations, consider:

- Asking the following questions:
  - What evidence from the previous lessons did you find to add to your explanation?
  - What new ideas did you add to your explanation? What are you trying to describe?
  - What changes occur in the body's glycogen stores after intense exercise? Why do these changes occur? How does milk help with recovery from these changes?
  - How are the muscles getting energy for exercise? Where is it coming from? How can drinking milk help give the muscles more energy?
- Providing students with time to organize the evidence they found, come up with a list of evidence as a class, and discuss which pieces of evidence are most relevant to the explanation of how our muscles recover after exercise.
- Engage students in a peer feedback session. Provide students with the Look Fors, and use a protocol such as Tell-Ask-Give or norms such as SPARK. Students can use the Look Fors to provide feedback to each other on how they can improve selected Look Fors in their work.

Part 3: Updating the Recovery Model

Ask students to reorient to the Driving Question for the unit, ***How can milk help athletes recover from physical exercise?*** Share with students that because they are now focusing on how milk helps recovery from exercise, they will now update the Class Consensus Recovery Model from Lesson 12. Share with students that they can take the explanations they wrote in Part 2: Developing an Explanation of How Milk Helps with Recovery From Changes to the Body During Exercise to help inform how to build these models.

TEACHER SUPPORT

Here students should be adding onto the Class Consensus Models from Lesson 12, which should be displayed as a large mural on a class wall or saved digitally for projection for the entire class.

First, orient students to the current Class Consensus Recovery Model. Ask students which of the nutrients on the model we should now focus on. Build off student responses to share that we currently know that the glucose that comes from lactose and sugar in milk goes into the bloodstream after digestion and that we can start by focusing there.

Hold a whole-class discussion in which the class adds to the existing Class Consensus Recovery Model. Students can write their initial ideas for additions on their Lesson 22 Student Guide Part 3: Updating the Recovery Model. Walk students through the class consensus discussion steps below so they can create the Class Consensus Model.

1. Each group should select one or more reporters to share one part of their explanations to add to the models. Have the first group share one idea to add to the consensus models. This can be one component, arrow, relationship, or any other feature the group wants to select.
2. The next reporters can agree with, disagree with, or revise parts of the model that have already been added or can add new parts. Continue this process until both of the full Class Consensus Recovery Models are built.
3. As students share, some strategies you can use to help the class build the consensus model are:
    a. Helpful sentence starters such as:
        i. We agree with _____'s group, and we also want to add _____.
        ii. We disagree with _____'s group because _____
        iii. We would like to change _____ because (evidence).
    b. Use discussion prompts such as asking the class:
        i. Is there anything else that needs to be added to this component before we move on?
        ii. How does this idea fit with what is on the model currently?
        iii. What new body systems are we introducing? Which organs are included in these systems? What specialized cells are a part of this organ, and what are their functions?
        iv. How are we showing the movement of matter in this model? The movement of energy? How are milk nutrients shown in this model?

As you are building the class model, if you find disagreements, follow these steps to help resolve the disagreement:

1. Summarize the two sides of the disagreement.
2. Ask the students to pause and reflect on their reasoning to be on that side.
3. Prompt students to again re-discuss the area of disagreement.
4. If students still disagree, suggest that we can represent areas of disagreement on the class model with question marks or other annotations of uncertainty.

CCCS SUPPORT

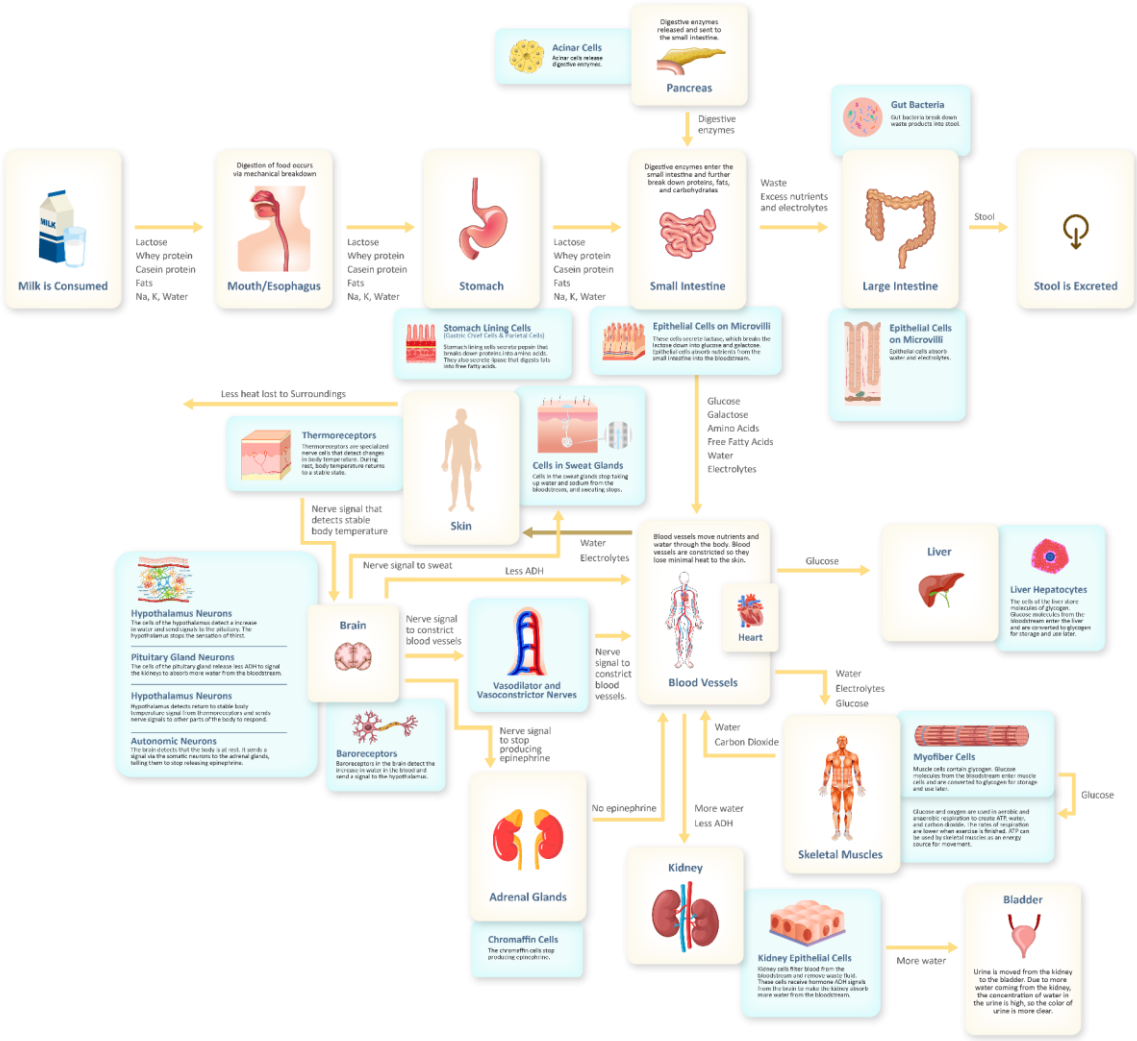
SL 9-10.1(d): Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.

Because student explanations may differ, it is important to emphasize that the revisions to the model are being made based on evidence. You may want to ask students to discuss the difference between evidence vs. opinion when discussing what components to include in the Class Consensus Model.

The following page shows an example of what a Class Consensus Model may look like, though you will want to follow the ideas of your class rather than drive them to this exact model.

Example Class Consensus Model

Recovery Model



Part 4: Asking New Questions

As a final step in this lesson, students will create a new list of questions that can help them determine what additional information they need to know to help them figure out more about situations where an athlete could potentially use up more blood glucose than it can replace during exercise. They can write these questions on their Lesson 22 Student Guide Part 4: Asking New Questions. Add these questions to the "Exercise, Milk, and Energy" category of the Driving Question Board so they can continue to be referenced in the coming lessons.

To facilitate students asking questions, use the Question Formulation Technique.

1. With their group, students take 5 minutes to brainstorm questions about what they need to know about how an athlete might use more blood glucose than it can replace during exercise.
2. Students then look at all their questions and choose the 3-5 questions they think are most important to be answered to help them figure out the Module Questions.
3. A representative from each group will then share their prioritized questions with the whole class. As students share their prioritized questions, they will add them to the Driving Question Board.

LOOK FOR

In student responses, listen for the following ideas:

- Is it possible to run out of glucose for cellular respiration?
- What happens when you keep exercising and you don't take in more glucose to recover glycogen?