TEACHER GUIDE
EXPLORE 2 LESSON 27

Food and Agriculture Center for Science Education

Module Question: *How does milk help in muscle recovery from soreness induced by intense exercise?*

What We Figure Out:

We figure out that after exercise, the body responds to exercise-induced damage to muscle fibers by increasing a process called protein synthesis in the muscle cells. The body also increases the amount of a type of cell called a satellite cell at the site of the muscle fiber injury. We suspect that these responses are part of a homeostasis response and negative feedback that will help the body recover from the damage done to the muscle cells.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students use multiple data sets to compare and contrast how feedback mechanisms respond to help stabilize muscle tissue after a workout.	50 minutes	Lesson 27 Student Guide Lesson 27 Student Handout Data Set Group A Lesson 27 Student Handout Data Set Group B Lesson 27 Student Handout Data Set Group C

Targeted Elements

SEP:	**DCI:**	**CCC:**
DATA-H4: **Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.**	**LS1.A-H4:** **Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or**	**SC-H3:** **Feedback** (negative or positive) **can stabilize or destabilize a system.**

	discourage (negative feedback) what is going on inside the living system.	

Directions

💡 Part 1: Our Motivation

USE OF PHENOMENA
Between Lessons 26-30, students will focus on the Module Phenomenon. In Lesson 31, they will return to the Anchor Phenomenon and create presentations to help their peers understand how milk can help them recover from exercise.

Remind students that they concluded the last lesson by sharing what they think they still need to figure out about how muscles feel less sore after they have been made sore because of exercise. Ask students to share some of those ideas. Example student questions or ideas could include:
- Do amino acids help in muscle cell recovery?
- How do proteins in milk help with muscle recovery?
- What other body systems play a role in muscle recovery?
- Is muscle recovery a form of homeostasis?
- How does milk help repair muscle damage?

Students should record these questions on their Lesson 27 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.

Build off student responses to share that we will now gather evidence to help figure out how muscles recover from soreness and how milk helps with this process.

📈 Part 2: Analyzing and Interpreting Data

Ask students to recall previous examples from the unit of feedback mechanisms the body has shown in response to changing conditions. Confirm any relevant examples, such as sweat and vasodilation in response to temperature increase or thirst in response to water loss. Share with students that, to make progress on figuring out how muscles recover from the microtears they experience from exercise—the ones that make them sore—students will compare and contrast data on the feedback responses that the body has to the microtears.

Share the Lesson 27 Student Handout Data Set Group A, B, and C with students. Each handout contains two different study data sets:
- Group A: Rates of Protein Synthesis
- Group B: Response of Satellite Cells
- Group C: Inflammation Response

Allow students time to choose which of the three data sets they want to analyze. Students will compare and contrast the pair of studies in this group to determine what the findings are from the data and if the findings are consistent with one another.

STUDENT SUPPORT
When students are choosing their data sets to compare and contrast, Data Set C is likely the least complex when it comes to comparing the findings of the studies. Consider assigning groups specific data sets based on student ability or interest.

DCI SUPPORT
LS1.A-H4: Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.
While this lesson doesn't develop knowledge of this DCI explicitly, it serves as a stepping stone toward fully working with the DCI. In this lesson, students are exposed to measurable indicators of the body's responses to microtears in muscles. In this next lesson, students will build on the knowledge of how the levels of various molecular factors change to figure out how the changes in these factors work together mechanistically as a negative feedback mechanism that responds to the injury caused by the microtears in the muscles.

SEP SUPPORT
DATA-H4: Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. Students have had multiple opportunities throughout the unit to grow their proficiency in this SEP. Accordingly, all

scaffolding in the prompts for this SEP has been removed, and students are presented with a single prompt instead. If a student is struggling, remind them of previous prompts, including those below.

1. Determine what question the scientists were trying to answer for each data set.
2. Summarize the methods used and the data collected for each study individually.
3. Compare the methods and outcomes for each study to determine if they are consistent.

Instruct students to record their analysis of the data on their Lesson 27 Student Guide Part 2: Analyzing and Interpreting Data. Allow students time to find trends in the data and to compare the findings across studies. As students analyze the data, circulate the room to support students in their analysis. Ask questions to support student thinking, such as:

- What was the goal of this experiment?
- What was the experiment design? What were they measuring? How did they set up the experiment?
- What is on the X and Y-axis of the graph?
- What trends do you see in the data on the graph?
- What would you look for to decide if the findings of the two studies are consistent? How would you determine that?

FORMATIVE ASSESSMENT OPPORTUNITY
Students use multiple data sets to compare and contrast how feedback mechanisms respond to help stabilize muscle tissue after a workout.

Assessment Artifacts:
- Students' comparison of the two data sets to determine if the findings are consistent (Lesson 27 Student Guide Part 2: Analyzing and Interpreting Data).

Look Fors:
- Students analyze the methods and results of two different data sets and compare the consistency of the findings (DATA-H4).
- Students compare the data shown in the two different studies and record what changes they notice to the quantity of the variable (specific to their data sets) (LS1.A-H4, SC-H3).

Assessment Rubric:

	Emerging	Developing	Proficient

Sample Student Response	Data Set A Example: Both studies measured the changes to the amino acids in the muscles after exercise. The amino acids increased and this means the muscles get stronger.	Data Set A Example: The first study showed WMP was a little more effective than whey protein. The second study only looked at whey protein and compared men to women. Both studies showed similar results, with the amount of protein synthesis increasing after drinking the recovery drink.	Data Set A Example: The first study showed WMP was a little more effective than whey protein. The second study only looked at whey protein and compared men to women. FSR increased above the resting rate for all. Men's and women's rates reacted differently at different times. It wasn't obvious if there was more of an advantage for one sex or the other. Both studies showed that drinking protein drinks (at least for healthy people) increases the rate of FSR above rest. They both showed that FSR remains increased for at least 210 minutes after in one and 28 hours in the other. I would say that these findings are consistent with one another.
How to Achieve This Level	Student completes 0 out of 2 Look Fors	Student completes 1 out of 2 Look Fors	Student completes 2 out of 2 Look Fors

To Provide Additional Support for Students:
If students are struggling with comparing and contrasting the data set, consider providing the following supports:
- Ask students to explain the methods and data presented to identify similarities and differences.
- Hold a class discussion about what it means for two data sets to have similar methods and/or similar outcomes. Build a class definition of what to look for to determine if the two are similar.
- If a student seems overwhelmed, ask them to look at the figure and notice what is represented across the bottom (x-axis) on the side (y-axis). Then ask, "What does each line/bar represent?" Finally, focus on one line/set of bars and ask them to make a sentence describing what it is showing by using their answers to the previous question.
- 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.

After students have individually analyzed their data set, use a Jigsaw Strategy to have students share their analysis of the different data sets with their peers.
1. Create groups of three for a jigsaw where each student has one of the three data sets.

2. Instruct students to meet with a group of three who chose one of the same data sets as they did. Provide time for students to discuss and record the experimental methods of the studies, the results of the studies, and if the findings from the studies are consistent.
3. Next, have students return to their original group of three and share the findings from their data set with the other members of their group.

Next, hold a whole-class discussion for students to share out what they found in each of the data sets. As students share out, record summaries of the findings made by the students on the front board. Facilitate the class discussion so that students agree that:

● Data Set A: After exercise, the body is actively trying to repair muscle fibers more than it is when the body is at rest. Drinking milk and/or protein also helps increase the amount of protein synthesis and, therefore, muscle recovery.
● Data Set B: Cells called satellite cells fuse with muscle fibers at the site of the microtear after the muscle fibers are damaged during exercise. More satellite cells are found on the torn muscle fibers after exercise.
● Data Set C: The number of inflammatory cells called neutrophils, lymphocytes, monocytes, and leukocytes in the bloodstream increases after exercise in both humans and mice.

STUDENT SUPPORT

Allowing students space to reflect individually and then share their thoughts in small groups increases access for all learners who are not comfortable speaking in front of large groups. For their thoughts and opinions to get elevated to large group discussions, you can alter this whole-group share-out by instructing speakers to share what they heard their partners share instead of repeating their own thoughts and questions.

??? Part 3: Asking New Questions

As a final step in this lesson, students will create a new list of questions to help them determine what additional information they need to know to help them figure out how protein helps in muscle recovery. They can write these questions on their Lesson 27 Student Guide Part 3: Asking New Questions. Add these questions to the "Recovery From Exercise" 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 dairy foods are created and distributed.

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 Question.
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:
- Why does our body need to make more proteins in protein synthesis after we exercise?
- What do satellite cells do when they fuse to the muscle cells?
- How do the immune cells help the muscles to recover?