TEACHER GUIDE
EXPLORE 3 LESSON 28

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 the body has a number of responses to help the body recover from the microtears in muscle fibers that happen during exercise. Immune cells move to the site of the muscle microtears. Immune cells help clear away damaged cells and reconstruct new muscle fiber cells. Satellite cells in the muscle fibers are also activated; these cells undergo cell division to differentiate into new muscle fiber cells. Finally, the muscle cells themselves increase their rate of protein synthesis, which helps rebuild proteins such as the actin and myosin proteins in the muscle fiber cells.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students use a model to help explain how feedback mechanisms can help muscle fibers return to a functional state after damage.	100 minutes	Lesson 28 Student Guide Lesson 28 Student Handout Science Theater Card Set Lesson 28 Teacher Resource Science Theater Directions

Targeted Elements

SEP:	DCI:	CCC:
MOD-H5: **Use a model to provide mechanistic accounts of phenomena.**	**LS1.A-H1:** **Systems of specialized cells within organisms help them perform the essential functions of life.** **LS1.A-H4:** **Feedback mechanisms maintain a living system's internal conditions within certain**	**SC-H3:** **Feedback (negative** or positive) **can stabilize** or destabilize **a system.**

	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.**	

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 identifying gaps in their understanding of how protein helps in muscle recovery. Ask students to share what some of those gaps were. In student responses, listen for the following ideas:

- We don't understand why our body needs to make more proteins after exercise.
- We aren't sure what the deal is with these "satellite cells" that show up when our muscles get hurt during a workout.
- We still wonder how our body knows when to crank up protein synthesis and send in more satellite cells after exercise.

Build off student responses to share that we will now gather evidence on how muscles recover after exercise. Share a few selected questions from the Driving Question Board that align with what students will investigate in the upcoming lesson. Example student questions or ideas could include:

- Why does our body need to make more proteins after exercise?
- What's the deal with these "satellite cells" that show up when our muscles hurt during a workout?
- How does our body know when to crank up protein synthesis and send in more satellite cells after exercise?

Students should record these questions on their Lesson 28 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 Anchor and Module Phenomena.

Part 2: Using a Model to Explain How Muscles Recover from Soreness

Next, students will engage in a model to determine the mechanism in the body that helps muscles recover from soreness. Share with students that they left off the previous activity wondering about the ways the body behaves to help muscles recover after exercise. To help figure this out, students will engage in a Science Theater activity.

INTRODUCTION TO ROLES:

Introduce students to the different roles in Science Theater, each of which is a specialized cell within an organ that is involved in the way muscles recover after exercise.

- Brain & Nerves
- Skeletal Muscles - Myocytes
- Skeletal Muscles - Satellite Cells
- Blood Vessels
- Immune Cells

SETUP:

Use the Lesson 28 Student Handout Science Theater Card Set and Lesson 28 Teacher Resource Science Theater Directions to set up the room. Show students the setup of the room, including where each of the tables represents each of the organs and the stations at each table that represent the different types of cells in the organ. Ask students how the setup of this activity compares to the setup of Science Theater from Lesson 19. Student responses may vary, but be sure to emphasize that there are different organs and different specialized cells involved in this process. Share that, once again, students will use a fishbowl method where half of the class engages in the Science Theater activity, and the other half observes the overall model.

TEACHER SUPPORT

This is the last of five Science Theater activities in this unit. If needed, refer back to the norms established in Lesson 4 and any additional lessons learned from the other Science Theater modeling activities (in lessons 9, 11, or 19).

ROLE ASSIGNMENT:

Next, assign roles to students and instruct students to move their assigned positions. Alternatively, students may also choose roles.

TEACHER SUPPORT

Depending on the number of students in your classroom, you may choose to assign one student to each role, or a pair or trio of students can complete each role. You may also want to assign roles based on student ability or interest. The role of the Blood Vessels is likely the easiest role in this lesson to complete in this Science Theater model.

PREPARATION:

Allow some time for students to:

- Summarize their role of the organ/specialized cells they played including the actions they took and the other organs/cells with whom they interacted.
- Summarize what they observed in the model in the graphic organizer provided.

Allow some time for students to review the summary of their organ and cells, the actions their role will take, and to organize the different tokens at their station. Students should record a summary of their actions in the blank table on their role cards. You may also want to give students in different roles time to confer with one another to cross-check the actions they have determined for their roles.

SEP SUPPORT

MOD-H5: Use a model to provide mechanistic accounts of phenomena.

The scaffolding on role cards for this lesson has been reduced to allow students to demonstrate progression for this practice. While actions of each organ and/or specialized cell can be found in the text of the roll card, the bulleted details have been removed. If a student is struggling to understand their role, prompt them to:

1. Scan their Organ/Specialized Cell Role Card, looking for the steps they will carry out during the model. Encourage them to highlight these if needed.
2. Take inventory of the tokens at their table and match these up to the steps highlighted.
3. Use cues and support from fellow students in other roles to assist in sequencing each step.

STUDENT SUPPORT

If you think your students still need additional support to move from one scale to another when analyzing these models, you can ask students to refer back to their Lesson 3 Orders of Magnitude tool and/or to record several examples of the structures shown in these models on the tool.

MODEL ENACTMENT - ACTS 1 & 2:

Begin the activity by saying what process students will be modeling. In this case, you can say something like, "In this activity, we will model what happens in two different scenarios: when a person is exercising and when they are recovering after exercise. In Act 1, we will model exercise, and in Act 2, we will model recovery." Announce that students will now start on the first act of the model in which a person is exercising.

Allow time for students to carry out the first act of the model. Remind students that when they complete an action, they should verbalize what organ/cell is doing the action, verbalize what the action is, and show any tokens to the observers so that they will know what is happening at each step of the model. This act reviews knowledge students figured out in Lesson 26, so press students to clearly explain what they know about how muscle cells help the muscle organ to function to move.

After the first act of the model is complete, give students a moment to finish completing their observations on their Lesson 28 Student Guide Part 2: Using a Model to Explain How Muscles Recover from Soreness.

Then, announce the second act of the model in which a person has stopped exercising and has drank milk to recover from the exercise. This part of the model simulates the processes in the body that occur from shortly after exercise to up to 4-7 days after.

OBSERVATION AND REFLECTION:

As students work, circulate the room to support them in engaging in the model and observing the model. Students can write responses in Lesson 28 Student Guide Part 2: Using a Model to Explain How Muscles Recover from Soreness. You can use questions like:
Modelers:

- What is the responsibility of your organ and cells? What other organs and cells will you interact with?
- What function do specialized cells carry out in your organ?
- What does it say you do with the (token/signal)? Where do you get them from? What happens to them while they are within you? Where do you hand them next?
- What changes or signals from other cells are you looking for to respond to?
- How do you think the responses of these cells and organs are helping the body return to stability after damage to the muscles?

Observers:

- What are you seeing overall?
- What things are moving throughout the body?
- What things are moving in/out of the skeletal muscles?
- What changes are happening?
- How is the body fixing the damage to the muscles?
- What changes are happening in the body to help it return to its stable state?

After the second act is complete, have students switch roles between modelers and observers and engage in the model a second time.

FORMATIVE ASSESSMENT OPPORTUNITY

Students use a model to help explain how feedback mechanisms can help muscle fibers return to a functional state after damage.

Assessment Artifacts:

- Students' explanations of the mechanisms the body uses to recover from muscle soreness as demonstrated by a model (Lesson 28 Student Guide Part 2: Using a Model to Explain How Muscles Recover from Soreness).

Look Fors:

- Students use the Science Theater model to provide mechanistic accounts of how multiple body systems and cells interact to promote the recovery of muscle fibers (MOD-H5).
- Students describe how specialized cells in each organ contribute to the function of the system or organ, including the role in the recovery of muscles (LS1.A-H1).
- Students name that the processes that the various body systems undergo to repair damaged muscles is an example of a negative feedback mechanism by which the body responds to a change in its conditions (LS1.A-H4, SC-H3).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Muscle cells get repaired after exercise. The immune system and	Myocytes detect the damage to their own structure. This is destabilization of the system. Amino acids in the bloodstream move into the	Myocytes detect the damage to their own structure. This is a change to the stable state of the muscles. In response, in a negative feedback process to help the muscles return to

	satellite cells help repair them so that they can be stronger.	actively repairing muscle cells. Another change in the body is when muscle satellite cells detect the peptide fragments from damaged muscle cells. Lastly, immune cells detect the peptide fragments from damaged muscle cells.	their stable state, there are a few things that happen. First, immune cells in the bloodstream detect damaged muscle proteins and move into the muscles, actively repairing muscle cells. These cells help create additional muscle fibers, and repair damaged muscle fibers. Another change in the body is when muscle satellite cells detect damaged muscle cells, begin to undergo cell division, and form new muscle fiber cells that are incorporated into the damaged muscle fibers. Satellite cells also fuse into the damaged muscle fiber cells to repair their structure. Lastly, amino acids from the bloodstream enter the damaged muscle cells and are used in protein synthesis to form new muscle proteins. Each of these processes helps to repair the damage to the muscles done by the microtears in exercise.
How to Achieve This Level	Student completes 0 out of 3 Look Fors	Student completes 1-2 out of 3 Look Fors	Student completes 3 out of 3 Look Fors

To Provide Additional Support for Students:

If students need additional support engaging with the model or in understanding what components, relationships, or processes the model is demonstrating, consider:

- Pausing the enactment of the model as needed and asking students to review the description of their organ's function or their role.
- Building in intentional pauses in the model for students to record what they observe and what they are doing.
- Having students read their role cards as a group and rehearsing what they will do before enacting the model.

OBSERVATION AND REFLECTION:

After the second implementation of the model, allow students time to summarize what they observed in the model in the graphic organizer provided on their Lesson 28 Student Guide Part 2: Using a Model to Explain How Muscles Recover from Soreness.

CCC SUPPORT

SC-H3: Feedback (negative or positive) **can stabilize** or destabilize **a system.** Scaffolding has been reduced in the final prompt in the Student Guide for Lesson 28 Part 2: Using a Model to Explain How Muscles Recover From Soreness to allow students to demonstrate their

progression in mastering the crosscutting concept. If a student is struggling, remind them of prompts from previous lessons, including those below.

- What conditions changed?
- What in the body senses the change?
- How do cells respond to the change?

DISCUSSION AND ANALYSIS:

After students record their ideas, bring the class together to hold a whole-class discussion for students to share what they found. Record the class consensus on the front board in a similar graphic organizer as on the Lesson 28 Student Guide.

Facilitate the discussion so that students agree that:

- When muscle microtears occur in the muscle cells, that brings the muscles out of their stable state, so the body has three different negative feedback processes to bring them back to their stable state.
- Immune cells move to the site of the muscle microtears. Immune cells help clear away damaged cells and reconstruct new muscle fiber cells.
- Satellite cells in the muscle fibers are also activated; these cells undergo cell division to differentiate into new muscle fiber cells.
- The muscle cells themselves increase their rate of protein synthesis, which helps rebuild proteins in the muscle fiber cells.

CONCLUSION:

After the discussion, ask students to consider if they think the mechanisms that they figured out are similar to that of how the body responds to changes in its temperature and changes in water in the body. Build off student responses to confirm that the body has feedback mechanisms that help bring muscle fibers back to their stable state after microtears occur, just like the body has mechanisms that try to bring body temperature and the amount of water back to a stable state when the body temperature increases. All of these are examples of the body trying to maintain homeostasis.

CCSS 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.

In the whole class discussion, students will utilize the skills associated with this standard to come to an agreement on what their updated models or explanations should look like. Use sentence starters to support student skill development.

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 more about the Module Question, *How does milk help in muscle recovery from soreness induced by intense exercise?* They should write these questions on their Lesson 28 Student Guide Part 3: Asking New Questions. Add these questions to the "Milk Protein and Muscle Soreness" 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 else they want to figure out about the Module Question.
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:

- We saw that the muscles recover from damage, but how do they get stronger after exercise?
- Do the muscles get stronger in any way after exercise?