

TEACHER GUIDE

ENGAGE LESSON 15



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 notice that during exercise, our breathing rate increases, our heart rate increases, and our muscles get tired. We think each of these has something to do with our body trying to use energy during exercise, but we aren't sure exactly how this works. We also saw evidence that athletes who drank milk after an intense workout performed better in a workout a few hours later than those who did not. We think this has to do with the nutrients in milk replenishing energy in our body, but we are not clear on how this happens.

3D Learning Objective:

Students **construct an initial explanation** to describe how **muscles get energy for exercise** and the **changes** that occur to the body during exercise.

Time estimate:

100 minutes

Materials:

Lesson 15 Student Guide
Lesson 15 Student Handout Data Set

Targeted Elements

SEP:

Pre-Assessment: 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

DCI:

Pre-Assessment: LS2.B-H2:

Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

CCC:

Pre-Assessment: 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.		
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Directions



Part 1: Our Motivation

USE OF PHENOMENA

Similarly to Module 2, this module picks up on questions and gaps in understanding that students may have had at the end of Module 1. There, they observed how several nutrients in milk enter the bloodstream after being digested. In Module 2, they investigated what happens to the water and electrolyte content of milk to help athletes recover from exercise. In Module 3, we will focus on what happens to the glucose (derived from lactose in milk) in the bloodstream and how glucose is used as a fuel source in cellular respiration to drive the movement of muscles. We will look at how the nutrients in milk help athletes perform better during a repeat workout. Later in this module, we will figure out what happens to the fat content of milk and how it can also be used for energy by muscle cells for longer-duration exercise. Accordingly, students will start this module by taking part in a phenomenon in which they exercise, note their perceived levels of energy, and generate ideas about where they think their energy is coming from. Because a class period doesn't allow for the appropriate amount of time to demonstrate recovery for a second workout, students will look at data showing the improved performance for recovery with chocolate, which will be used to look at how the body recovers (returns to its steady state). Figuring out this Module Phenomenon will help students progress in answering their questions about the overall Anchor Phenomenon and Driving Question for the unit, ***How can milk help athletes recover from physical exercise?***

To begin the lesson and make the connection between the Anchor Phenomenon and this module clear to students, return to the Driving Question Board. Having already completed Modules 1 and 2, some of the original questions on the Driving Question Board and/or those that were added in the lessons that followed have been answered or partially answered. These include questions that fall into the categories of "What's in Milk?", "Exercise, Milk, and Hydration," and "Recovery From Exercise."

Allow students to look at the other categories and questions that have not yet been addressed. These include “Exercise, Milk, and Energy” and any remaining questions or partial questions under “Recovery From Exercise.” Begin a discussion about what questions are left to answer in order to explain the Anchor Phenomenon from the unit.

Facilitate the conversation such that students recognize that many of the questions left have to do with energy (making energy, running out of energy, etc.). Students can capture the questions on their Lesson 15 Student Guide Part 1: Our Motivation to help them identify how what they are investigating next connects to the Anchor Phenomenon. Sample student questions might include:

- Do you get energy from milk?
- Is energy involved in exercise?
- What part of milk helps you get more energy to work out?
- How does the body use energy during exercise?
- How do you recover the energy you lose in exercise?

Build off student questions to share that students will now take part in a new phenomenon that will help them start to make progress on answering some of these questions.



Part 2: Experiencing and Recording the Changes in Our Bodies Between Rest and High-Intensity Exercise

Share with students that they will each complete a high-intensity workout. Students will make observations of what they are feeling and experiencing as they complete each of these workouts. Direct student attention to the list of workout options on their Lesson 15 Student Guide Part 2: Experiencing and Recording the Changes in Our Bodies Between Rest and High-Intensity Exercise. Students can choose one option from the high-intensity workout list.

STUDENT SUPPORT

Prior to sharing the workout list with students, review the list of workouts in the Lesson 15 Student Guide and revise the list based on the needs of your classroom and school in regard to space and time available. Additionally, consider any physical limitations specific students may have and suggest appropriate workout choices or alternatives for these students.

Direct students’ attention to the instructions and the data tables in their Lesson 15 Student Guide Part 2: Experiencing and Recording the Changes in Our Bodies Between Rest and High-Intensity Exercise. Ask students to silently read the instructions and the table to be prepared to record the relevant data they will take of themselves immediately after their workout. Ask a few students to share a summary of the instructions with the class to check to see if students understand what they are supposed to record and to answer any questions.

Next, instruct students on how to collect data on their heart rate and breathing rate. Students can collect heart rate data by taking their pulse in their wrist or neck for 60 seconds, and they can collect breathing rate data by counting the total number of breaths they take in one minute. Demonstrate this procedure to students or ask volunteers to demonstrate it to the class. (Suggest that students work in pairs for this.)

Prior to beginning the workout, allow time for students to collect data on their own resting heart rate and resting breathing rate. Students can record this data on their Lesson 15 Student Guide Part 2: Experiencing and Recording the Changes in Our Bodies Between Rest and High-Intensity Exercise. Then, allow students to move to the most appropriate space for the exercise that they chose. Allow students time to complete the exercise to collect their data and return to class.



Part 3: Identifying Patterns in Data and Observations

Share with students that they will now try to find similarities in the data they collected. Use a strategy such as a Mingle-Pair-Share for students to share their data and observations with each other. Students can compare their different results and try to determine if similar patterns exist across individuals.

The following are the steps in the Mingle-Pair-Share Strategy:

1. Students move around the classroom and find a peer who is not a part of their usual group.
2. Students take turns sharing their data and observations.
3. Students then find a new peer and share their data and observations once again.

Hold a whole-class discussion for students to share what they found. The purpose of this share-out is for students to quickly identify a list of changes in their bodies that were universal/nearly universal across the class. These observations will serve as the Module Phenomenon for this module. As students share, capture the consensus list of changes in a class list to reference throughout the remainder of the module. Students can record what the class finds on their Lesson 15 Student Guide Part 3: Identifying Patterns in Data and Observations. Facilitate the conversation such that students agree that:

- Heart rate and breathing rate both increased compared to rest and high-intensity exercise.
- We felt like we were getting a burning sensation in the muscles.
- Our muscles started fatiguing during high-intensity exercise
- We started getting hot and sweaty in both exercises.



Part 4: Interpreting and Analyzing Data

Briefly revisit the questions from the Driving Question Board highlighted during the Part 1: Our Motivation section of this lesson, sharing with students that they've now experienced the changes that occur in the body during a high-intensity workout. Remind students that several other questions focus on recovery after an intense workout. Share with students that, ideally, they would be able to experience recovery with milk. One way to do that would be to do a second instance of high-intensity exercise later in the day to see if their performance was maintained or improved, which would indicate they successfully recovered. However, the limitations of time for the class period don't allow for this. Therefore, share with students that instead of experiencing it for themselves, students can analyze data from experiments that tested how athletes performed in follow-up workouts after drinking milk to see how milk helped them recover.

SEP SUPPORT

INFO-H1: Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

DATA-H4: Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Though these two SEP elements are not claimed in this lesson, students are here engaging in a similar practice that they previously did in Module 2. Students analyze the experimental design and outcomes of an authentic scientific research article. Later in this module, students will progress to comparing the design and outcomes of two studies. Just as in Module 2, to prepare students for comparing studies, support students in their skills in reading the complex scientific methods text and in using what they know about the methods to analyze the results of the experiment.

Distribute the Lesson 15 Student Handout Data Set. Share that this data provides some information about how study participants performed during a secondary workout after having used chocolate milk during recovery. Students can work in groups of 2-3 students as they look through the article overview and data set. Share that the goal of each group is to understand the investigation researchers used to gather the data.

Allow students time to read through and discuss the methods and data. Students can record their answers on their Lesson 15 Student Guide Part 4: Interpreting and Analyzing Data. As students work, circulate the room and ask students pressing questions such as:

- What question were the researchers trying to answer?
- What data did they collect? Where did that data come from?
- How was the experiment designed? What did the participants in the investigation have to do? Did they do it once or more than once? Was anything changed when participants repeated the steps?
- What data is represented in each figure? What is represented along the horizontal axis and/or vertical axis of a figure?

TEACHER SUPPORT

Students might be familiar with the experimental protocols utilized in the recovery study because of their regular participation in PE physical fitness tests. Specifically, the data set represents performance on a Shuttle Run, which can also be referred to as a “Pacer Test.” You may want to ask some students to explain or demonstrate this workout setup to the class.

When students are ready to share their findings, hold a whole-class discussion. First, have students share how they interpreted the methods of the experiment. Facilitate the discussion such that students agree on the following:

- College soccer players were the participants (male and female).
- They did a shuttle run fitness test before the workout days.
- They did a morning soccer workout > drank a recovery drink right away/rested for 2 hours > drank the same recovery drink/rested two more hours > and completed their afternoon soccer workout plus another shuttle run. They did this two times on different days with a different drink the second time.
- The data in Figure 1 is from the second shuttle run.

Next, have students share what they have found regarding the outcome of the study. Facilitate the conversation so that students agree that:

- According to the data, there is evidence that milk can help athletes recover/increase their performance in a second workout.
- There may be different levels of advantages for males vs females.

Return to the outcomes of students’ exercise experience and now discuss them together with the outcomes from the recovery study. Summarize the two outcomes to introduce the Module Questions, *Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?*



Part 5: Constructing Initial Explanations

Share with students that, next, they will construct an initial explanation in small groups to answer the Module Questions, *Why are there so many changes to my body during exercise? How does milk help with recovery from these changes?* Read the expectations checklist together with the class, and remind students that at this point, any ideas are acceptable, and they don't need to worry about getting the "right" answer—just sharing what they think right now. Allow students time to write their explanations on their Lesson 15 Student Guide Part 5: Constructing Initial Explanations.

PRE-ASSESSMENT OPPORTUNITY

Students **construct an initial explanation** to describe how **muscles get energy for exercise** and the **changes** that occur to the body during different forms of exercise.

Assessment Artifacts:

- Students' initial 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?* (Lesson 15 Student Guide Part 5: Constructing Initial Explanations).

Look Fors:

- Explanations describe how students think the body gets energy for exercise (CEDS-H2, LS2.B-H1).
- Explanations describe how students think changes to heart rate, breathing rate, and muscle fatigue occur (CEDS-H2, SC-H1).
- Explanations describe how milk can help recovery for a second workout (LS2.B-H2).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	By the second half of my sprint, I felt out of breath and was breathing faster. I was breathing faster because my body needed more oxygen.	By the second half of my sprint, I felt out of breath and was breathing faster. I was breathing faster because my body needed more oxygen. When they run out of energy, they start to get tired and burn. My heart rate increased because it needed to pump blood to my muscles because they needed more blood when working hard. The blood has nutrients in it that my muscles need.	By the second half of my sprint, I felt out of breath and was breathing faster. I was breathing faster because my body needed more oxygen. When the body is exercising hard, it uses much more energy and oxygen than when resting. The muscles need the energy to move. They get the energy from the food you eat. When they run out of energy, they start to get tired and burn. My heart rate increased because it needed to pump blood to my muscles because they needed more blood when working hard. The

		Moving around fast and using muscles burns more energy, which makes me feel hot.	blood has nutrients in it that my muscles need. Moving around fast and using muscles burns more energy, which makes me feel hot. Milk helps recovery and provides the body with more energy because it has nutrients in it, like protein, sugars, fats, and electrolytes.
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

- Encourage students to sketch their thinking, explain their sketches aloud, and capture them in sentences.
- Encourage students to reference their existing models. Are there items already on the model that might play a role in explaining any of the changes?
- Encourage students to be courageous in their explanations. This is their chance to draw on previous experiences and related knowledge they already have. Remind students that any explanation is encouraged at this point, and there are no right or wrong answers. It is most important for students to share what they really think.
- 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.

DCI SUPPORT

LS2.B-H1: Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

In middle school, students learned that cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. In this unit, students build on this middle school understanding to figure out that cellular energy comes not only from aerobic respiration but also from anaerobic respiration. In this module, students explore the measurable indicators of metabolic responses because of exercise, such as changes in the amounts of glucose in the bloodstream, glucose and glycogen in muscle and liver, and the way that muscle cells produce energy in aerobic and anaerobic conditions.

SEP SUPPORT

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 they did in the past and will continue to do so in the future. In this lesson, students can use evidence from the workout data they collected and the data set provided from the peer-reviewed journal article. Because students are also sharing their background ideas, they may share other ideas that aren't necessarily tied to empirical evidence. Lessons 16, 17, 18, 19, 21, and 23 all expose students to valid and reliable evidence from a variety of sources, including their own investigation, models, and peer-reviewed data, allowing them more opportunities to demonstrate their growth for this practice.

CCC SUPPORT

SC-H1: Much of science deals with constructing explanations of how things change and how they remain stable. In this lesson, students' construct explanations of why they think bodily changes that occur throughout the exercises happen in the way they do. Throughout this module, students will figure out how various cellular- and molecular-factors in the body change during exercise, which will help them figure out the biological mechanisms by which bodily changes occur during exercise. Students will also reflect on the idea that much of the science of studying how the body responds to exercise has to do with studying how various factors in the body change or remain stable.

Student groups will next share their initial explanations with other groups using the Stay and Stray Strategy. Students can record similarities and differences they find on their Lesson 15 Student Guide Part 5: Constructing Initial Explanations.

1. After small group explanations are complete, ask groups to have one person "stay" at their table with the explanation they created to share it with classmates from other groups.
2. The rest of the team members "stray" to the other groups to learn about the other group's explanations. Allot about 2 to 5 minutes per rotation.
3. During the rotation time, students can ask questions to help gain clarity on the decisions they made. Students can ask questions such as, "What parts of the explanations do we seem to agree on?"
4. At every signal to rotate to a new group, a different team member goes back to stay with the group's work, and everyone else (including the person who first stayed) moves on to view the next product. This allows everyone to see all but one product.
5. After visiting all groups, initial small groups regroup and share new information gathered.
6. Groups discuss new ideas and decide whether or not they will integrate them into their work.

TEACHER SUPPORT

Using the Stay and Stray Strategy allows students to compare and contrast their explanations with other groups. This will help them self-evaluate the strengths and weaknesses of their explanation before implementing edits.

**Part 6: Creating a Class Consensus Explanation**

After the groups all share with each other, students will now work together to make a Class Consensus Explanation. Walk students through the class consensus discussion steps below so they can create an initial Class Consensus Explanation.

1. Deliberately pick a few student groups to share their initial expectations with the whole class. Have the first student group share their explanation.
2. During the share-out, ask questions and share reminders to help establish what consensus ideas to add to the class explanation, such as:
 - a. What parts of the explanation do we seem to agree on?
 - b. Can anyone suggest ideas we should add to the class explanation?

As parts are agreed upon, begin creating a Class Consensus Explanation on the board. Continue adding to the Class Consensus Explanation such that every group shares at least one descriptor to add. Facilitate the conversation such that the Class Consensus Explanation describes at least the following main points:

- We think the heart pumps faster to move more nutrients around the body that are needed for the body during exercise.
- We know that we breathe in oxygen and breathe out carbon dioxide. Maybe you need more oxygen during exercise, so you breathe harder.
- We think muscles fatigue and burn because they run out of energy.

TEACHER SUPPORT

As you build the class explanation, if you find disagreements, follow these steps to help resolve the disagreement.

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

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 Class Consensus Explanation, students will utilize the skills associated with this standard to come to an agreement on what the model should look like. Utilize sentence starters when necessary to support student skill development.

After a Class Consensus Explanation has been drafted, students will reflect on gaps in understanding present in the explanation. At this point, there will be gaps in the scientific mechanisms of the explanation, and this is okay because these will be addressed throughout the rest of this module. Provide guidance for students to identify gaps by asking questions like “Take a closer look at the class explanation. What seems to be missing from our description to help us explain why these changes occur in the body during exercise?”

LOOK FOR

In student responses, look for the following ideas:

- We aren’t sure why the increased breathing rate and heart rate increased during exercise. Does the body need more oxygen and nutrients during exercise?
- We aren’t sure what is happening inside the muscles to make them fatigue and burn.
- We aren’t sure how the body makes energy to make the muscles keep moving.
- We aren’t sure if there is a connection between energy and the muscles getting tired.

STUDENT SUPPORT

If students need additional support in finding gaps in the explanations, consider having students verbally describe what they think happens in the body during exercise and, as they do so, consider if any component might logically be missing. If at any stage they hesitate, they can name this as an unknown to figure out more about.

Remind students that we are in the beginning stages of the module, and they will, in the upcoming lessons, figure out more about these gaps in the explanation that they have identified.



Part 7: 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 the Module Questions. They can write these questions on their Lesson 15 Student Guide Part 7: Asking New Questions. Add these questions to the appropriate 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 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:

- Are my muscles tired because they are not getting enough energy?
- Am I breathing faster to make energy faster for my muscles?
- Do we breathe faster because we need more oxygen when exercising?
- Do glucose, fatty acids, or amino acids from milk play a role in recovery from fatigue and muscle burning?
- Why am I breathing faster/harder?
- Why am I out of breath?
- Am I breathing faster because I am not in shape?
- Am I breathing faster because I need more oxygen when I exercise?
- Which nutrients in milk help athletes recover and perform better in a second workout?
- Does milk help us recover because the protein makes our muscles stronger?