TEACHER GUIDE
EXPLAIN 2 LESSON 12

Food and Agriculture Center for Science Education

Module Questions: ***Why do we get sweaty and thirsty after exercise? Why does the color of our urine change? How does milk help us recover from these effects?***

What We Figure Out:
We figure out that sweat, thirst, and urine color changes are all changes that occur during exercise because of changes in the levels of water in the body. The body has a feedback mechanism that tries to maintain normal levels of water in the bloodstream. This mechanism occurs when exercising; the body produces a lot of sweat that pulls water out of the bloodstream in an effort to reduce temperature. The osmoreceptors in the brain sense the reduced amount of water in the bloodstream. These signals are detected by the hypothalamus region of the brain to create a sensation of thirst. The pituitary region of the brain sends signals via a hormone called ADH to the kidney to absorb less water from the blood, leading to less water moving to the bladder, where it is stored as urine. The urine color becomes darker because it contains less water. The amount of water in the blood begins to return to its stable state. This response is an example of how the body tries to maintain homeostasis.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students revise an explanation using evidence to show how the body uses feedback mechanisms to maintain stable internal conditions when those conditions begin to change.	50 minutes	Lesson 12 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**	**LS1.A-H1:** **Systems of specialized cells within organisms help them perform the essential functions of life.**	**SYS-H3:** **Feedback** (negative or positive) **can stabilize or destabilize a system.**

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.**	**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.**	

Directions

Part 1: Our Motivation

USE OF PHENOMENA
Between Lessons 9-12, students will focus on the Module Phenomenon. In Lesson 14, they will return to the Anchor Phenomenon to create presentations on how milk can help athletes recover from exercise.

Have students individually review their Class Consensus Explanation from Lesson 10 Part 2: Developing an Explanation of Sweat and Temperature Changes During Exercise and Recovery. This explanation describes how students answered the Module Questions, *Why do we get sweaty and thirsty after exercise? Why does the color of our urine change? How does milk help us recover from these effects?* 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 thirst, sweat, and urine color change are related. Listen for responses such as:

- We didn't explain how sweat was related to water loss in the body and how that makes urine color change and thirst happen.

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

- How are sweat, urine color-change, and thirst related?
- Why do thirst and urine color changes happen at the same time?

Students should record these questions and ideas in Lesson 12 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 explanations of the Module Questions, *Why do we get sweaty and thirsty after exercise? Why does the color of our urine change? How does milk help us recover from these effects?*

Part 2: Developing an Explanation of Sweat, Thirst, and Urine Color Change After Exercise

As a brainstorming activity, prior to constructing explanations, present the blood volume graph from Lesson 11 Part 3 on the projector and break the graph into four segments: pre-exercise, exercise, rest and rehydration, and max effort exercise. Ask students to describe what mechanisms occur to affect water volume in the blood at each of these stages. Use a Think-Pair-Share to have students share their ideas and annotate the graph as students share. Remind students that they can use their resources from Lesson 11 to help them here. There is no need to come to a specific consensus at the moment. Students can use what the class brainstorms here to help write their explanations below.

Share with students that they will now revise their explanations to update their answers to the Module Questions, *Why do we get sweaty and thirsty after exercise? Why does the color of our urine change? How does milk help us recover from these effects?* As students work on their Lesson 12 Part 2: Developing an Explanation of Sweat, Thirst, and Urine Color Change After Exercise, circulate the room to formatively assess their explanations and provide feedback by asking questions about their work.

FORMATIVE ASSESSMENT OPPORTUNITY

Students revise an explanation using evidence to show how the body uses feedback mechanisms to maintain stable internal conditions when those conditions begin to change.

Assessment Artifacts:

- Students' explanations of sweat, thirst, and urine color change after exercise (Lesson 12 Student Guide Part 2: Developing an Explanation of Sweat, Thirst, and Urine Color Change After Exercise).

Look Fors:

- Students construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources, including data sets and the Science Theater model (CEDS-H2).
- Students describe how they think exercise changes the conditions of the body, including temperature change, sweat, thirst, and urine color change (LS1.A-H4, SC-H1).
- Students describe how a negative feedback mechanism responds to water and temperature changes in the body and brings them back to a stable state (LS1.A-H4, SC-H3).
- Students describe how specialized cells in each organ contribute to the function of the system or organ (LS1.A-H1).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Workouts make people get hot and sweat, which means they lose water and it makes them thirsty. There is not enough water in the body, so urine color gets darker. This happens when the kidneys lose more water in the urine. When you drink milk, you get more water. When there is enough water in the body, the urine color gets lighter. This happens when the kidneys get more water to the urine.	After a person works out, they typically get hot. The body has multiple ways in which it tries to cool down. First, it makes sweat by pulling water from the bloodstream. Then, it makes the blood vessels dilate to move more heat outside the body. Sweat also makes you lose water. The osmoreceptors in the brain sense the reduced amount of water in the bloodstream. The brain creates a sensation of thirst and sends more signals via a hormone called ADH to the kidney to absorb less water from the blood, leading to the urine color becoming darker. When recovering, the body stops making sweat because it cools down. When you drink milk, the water in the milk moves	After a person works out, they typically get hot. We observed the changes in body temperature due to exercise in the scientific study from Lesson 9 Part 2. Before exercise, the body temperature starts at a normal, stable state at about 36.5° C. When exercising, body temperature increases by about 0.5-1.0° C. Then, after exercise, body temperature returns to about 36.6° C (Lesson 9 Part 2: Analyzing Changes in Body Temperature). The body has multiple ways in which it tries to cool down. First, thermoreceptors in the skin and muscles detect a change in temperature. They send a nerve signal to the hypothalamus in the brain, which then sends a signal via nerves to the sweat glands to produce sweat to cool the body. The hypothalamus also signals the vasodilation nerves to expand the blood vessels, allowing blood to bring heat from the body to the surroundings. This is one example of a feedback mechanism the body has to respond to the increase in temperature of the body to bring the temperature back to its stable state.

		into the bloodstream, which helps recover the amount of water in the blood. The osmoreceptors in the brain sense a normal amount of water in the bloodstream. The brain signals the sensation of thirst and signals to the kidney to absorb more water from the blood, resulting in urine color becoming clearer.	The loss of water in sweat occurs because water moves from the bloodstream to the skin in sweat. In our graph of water volume in the bloodstream, we saw that blood volume decreased during two instances of exercise. First, during the moderate effort exercise, it decreased by about 10%. Then, during the max effort exercise, it decreased by 10-20% (Lesson 11 Part 3: Analyzing Data About the Water Content of Blood During Exercise). Osmoreceptors detect the decrease in water in the blood and send a signal to the brain. The hypothalamus in the brain receives the signal from the osmoreceptors. This results in the sensation of thirst and an increased production of ADH from the pituitary gland in the brain. The pituitary region of the brain sends ADH to the kidney via the bloodstream to absorb less water from the blood, leading to less water moving to the bladder, where it is stored as urine. The urine color becomes darker. This process is also a negative feedback loop and is how the body prevents additional water loss (observed in Science Theater). In recovery, when someone stops exercising, they cool down. The temperature change is detected by thermoreceptors, which send a signal to the hypothalamus, which then signals the sweat glands to stop sweating. When someone drinks milk, the water in the milk moves through digestion into the bloodstream, which brings the amount of water in the blood back to its stable state. The osmoreceptors detect this change, cease the sensation of thirst, and send less ADH to the kidneys. The kidneys can now absorb more water from the bloodstream, passing it on to the bladder as urine. Urine is a lighter color as a result (observed in Science Theater).

How to Achieve This Level	Student completes 0-1 out of 4 Look Fors	Student completes 2-3 out of 4 Look Fors	Student completes 4 out of 4 Look 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 is the stable state the body is trying to maintain?
  - How does the body try to return to its stable state? What does the body do?
  - 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?
  - How is stability defined and described in your explanation? How will that help us explain feedback mechanisms in body systems?
- 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 why we feel thirsty and experience changes in urine color in exercise.
- Asking students how this mechanism is similar to the mechanism they figured out for how body temperature is regulated.
- Providing students with a diagram template, such as the one below, to visualize how the osmoregulation feedback mechanisms in the body function.
- 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 Effects of Exercise and Recovery Models

Ask students to reorient to the Driving Question for the unit, ***How can milk help athletes recover from physical exercise?*** Share with students that they will now update the Class Consensus Models from Lesson 10. Share with students that they can take the explanations they wrote in their Lesson 12 Student Guide Part 2: Developing an Explanation of Sweat, Thirst, and Urine Color Change After Exercise to help inform how to build these models.

TEACHER SUPPORT

Here, students should be adding to the Class Consensus Models from Lesson 10, which should be displayed as large murals on a classroom wall or digitally saved for projection for the entire class.

Hold a whole-class discussion in which the class builds two Class Consensus Models: The Effects of Exercise Model and the Recovery Model. Walk students through the class consensus discussion steps below so they can create the Class Consensus Models.

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 full Class Consensus Models are updated.
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 currently on the model?
        iii. What new body systems are we introducing? Which organs are included in these systems? How can we draw a system boundary around them? How do they interact with other body systems and/or organs?
        iv. What specialized cells are we showing? What is their function?
        v. How are we showing the feedback mechanisms that the body uses to maintain water homeostasis in this model?

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

1. Summarize the two sides.
2. Ask the students to pause and reflect on their reasoning for being on that particular side of the disagreement.
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.

CCSS SUPPORT

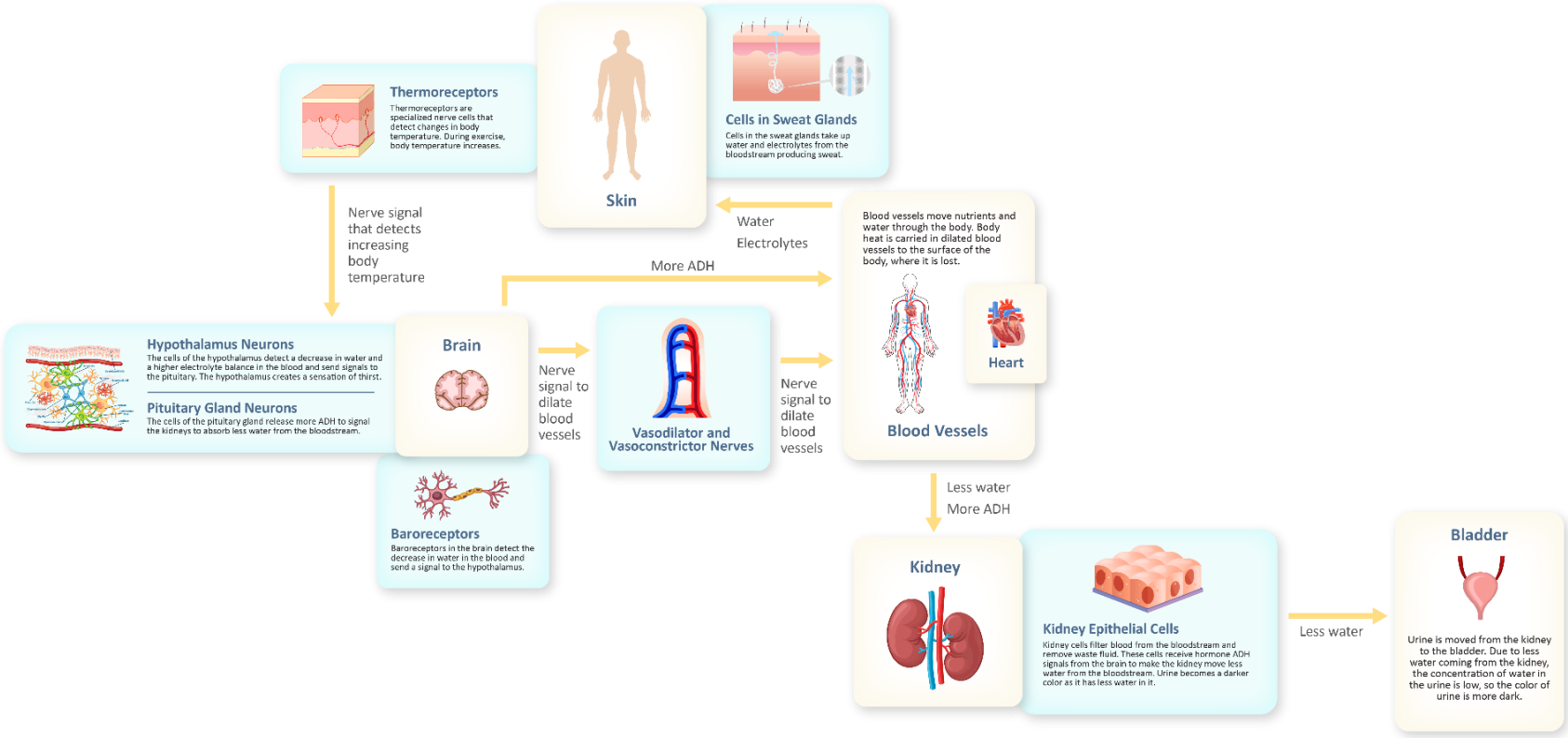
SL 9-10.1(d): Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.

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 Models.

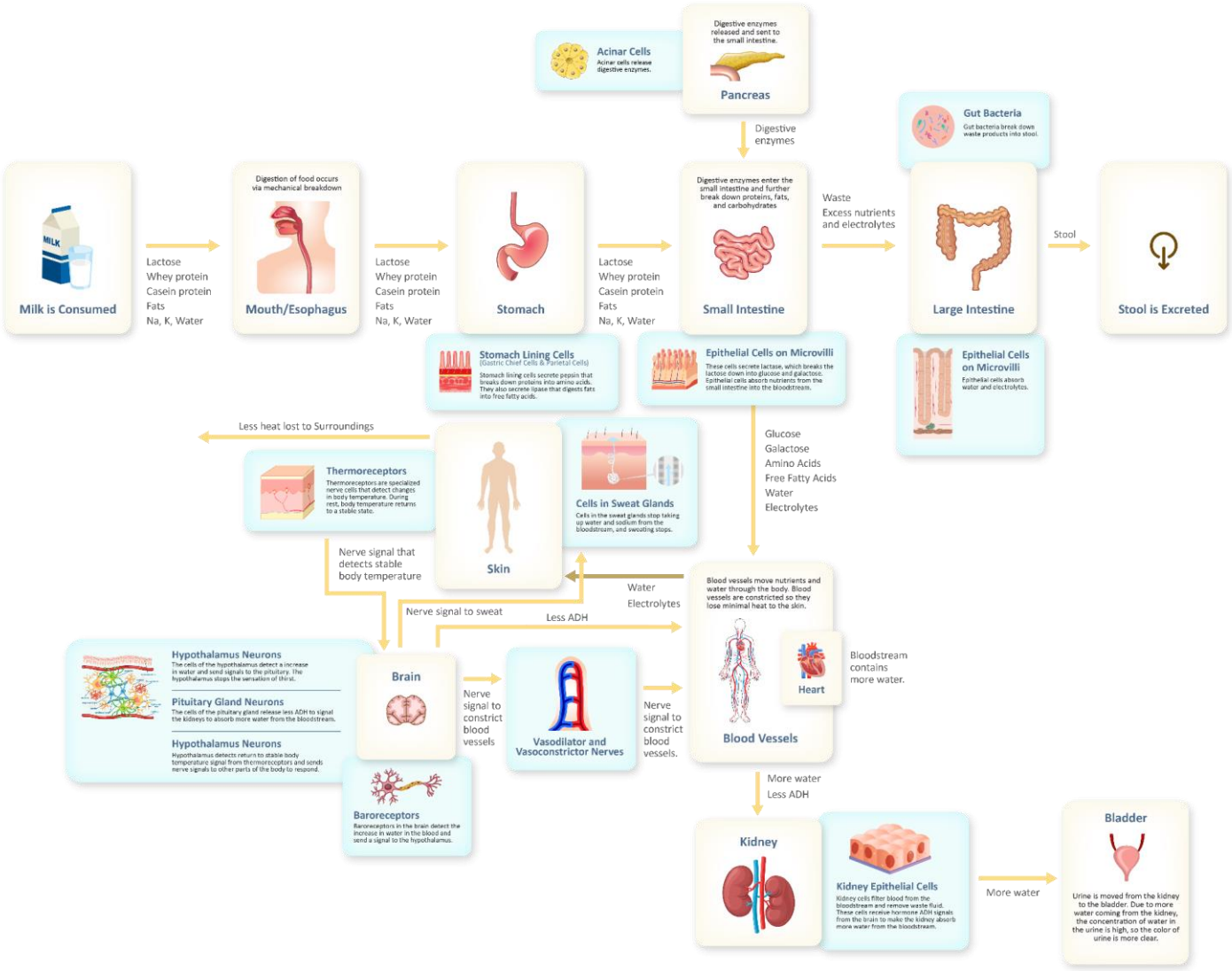
The following pages show an example of what these Class Consensus Models may look like, though you will want to follow the ideas of your class rather than drive them to this exact model.

Example Class Consensus Models

Effects of Exercise Model



Recovery Model



Share with students that these models will be a continuous record of changes that happen in the body in response to exercise and how milk helps the body recover from these changes. Share with students that we will continue making progress on our Module Questions first and

later the Driving Question for the unit, which will help us continue adding to these models. If students need a personal record of the model in addition to the class model, you can provide students with a digital image of the model or have them take an image with their personal device, if available.

Part 4: 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, *Why do we get sweaty and thirsty after exercise? Why does the color of our urine change? How does milk help us recover from these effects?* They can write these questions on their Lesson 12 Student Guide Part 4: Asking New Questions. Add these questions to the "Exercise, Milk, and Hydration" category from 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 will take 5 minutes to brainstorm questions about what they need to know about sweat, thirst, urine, and exercise.
2. Students will then look at 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:

- What happens in the body when too much water is lost?
- What happens if you drink too much water?
- What happens to the electrolytes from milk? Do they help with hydration?