TEACHER GUIDE
ELABORATE LESSON 6

Food and Agriculture Center for Science Education

Module Question: *How is milk digested after it is consumed?*

What We Figure Out:

We figure out that molecules like glucose, amino acids, water, and fatty acids pass through epithelial cells of the small intestine and eventually enter the bloodstream. Different types of molecules take specific journeys. Glucose, amino acids, water, and sodium pass through the epithelial cells and enter the liver, which then distribute them to the bloodstream. Fats pass through the epithelial cells into the lymphatic system, and from there, the lymphatic system passes them to the bloodstream.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students use multiple models at related scales to provide a mechanistic account of the process of nutrient absorption via specialized cells in the small intestine. Students revise a model to describe the relationships between components of the digestive and circulatory systems, including the scale relationships that show how organs are made of systems of specialized cells.	150 minutes	Lesson 6 Student Guide Lesson 6 Student Handout Structures of the Small Intestine Lesson 6 Student Handout Body System Models

Targeted Elements

SEP:	DCI:	CCC:
MOD-H3: Develop, **revise,** and/or use **a model based on evidence to illustrate** and/or predict **the**	**LS1.A-H1:** **Systems of specialized cells within organisms help them perform the essential functions of life.**	**SPQ-H4:** **Using the concept of orders of magnitude allows one to understand how a model at**

relationships between systems or between components of a system. **MOD-H4:** **Develop** and/or use **multiple types of models to provide mechanistic accounts** and/or predict phenomena**, and move flexibly between model types based on merits and limitations.**	**LS1.A-H3:** **Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.**	**one scale relates to a model at another scale.**

Directions

Part 1: Our Motivation

Display the Class Consensus Model from Lesson 5. Ask students to recall what gap they identified in the Class Consensus Model at the end of Lesson 5. Build off student contributions to confirm that students wanted to figure out more about what happens to some of the molecules after they are digested. For example, the lactose, amino acids, and fatty acids that go into the small intestine seem to not go anywhere else.

Have students review their questions from the Driving Question Board. Ask students which of these questions correspond to the gaps in the model we need to figure out more about. Students can record these questions on their Lesson 6 Student Guide Part 1: Our Motivation.

Example student questions that may be on the Driving Question Board from Lesson 5 could include:

- What happens in the (organ) to help in digestion?
- How do cells contribute to digestion?
- Where are molecules going next?
- How do the molecules get to the rest of the body to help in recovery?
- How are these molecules flowing throughout the body?
- Are some molecules used differently than others?
- Do molecules get used at the same time?

Build off student responses to share that students will now explore what happens to the molecules in the small intestine and how they get to the rest of the body.

Part 2: Observing the Structure of the Small Intestines

Share with students that to investigate what happens to the molecules in the small intestine it will help them to take a closer look at the structure of the small intestine. Ask students to view the Lesson 6 Student Handout Structures of the Small Intestine camera images of the interior of the small intestine at the microscopic level. In small groups, have students record what they notice and wonder about how the shape and structure of the interior structures within the small intestine might help it get nutrients to the rest of the body on their Lesson 6 Student Guide Part 2: Observing the Structure of the Small Intestines. Students may use the Size & Orders of Magnitude tool from Lessons 3-5 as a reference for the size of these structures.

Use a Think-Pair-Share for students to share what they notice in these images and what they wonder about them. Facilitate the conversation such that students agree that:

- There are a lot of wavy structures on the interior surface of the small intestine.
- There are a lot of villi on the curved pieces on the interior of the small intestine.

Confirm, using previous information from the Lesson 3 Student Handout Station Cards, that the structures that students are seeing are called the villi of the small intestine. Share that these structures give the small intestine more surface area than if it were a flat structure, which means there is more surface area to interact with the molecules inside the small intestine. Share with students that they will now view how these specialized structures interact with nutrients to get the nutrients to the rest of the body.

Part 3: Using Models to Observe What Happens to Nutrients in the Small Intestine

Introduce students to Lesson 6 Student Handout Body Systems Models, and share that they will use these five models to determine what happens to the nutrients in the small intestine. First, students will orient themselves to the different size scales represented in each of the models. Ask students to work with a partner to record the different scales shown in each model and to reflect on how orders of magnitude can help them interpret the scale relationships between models.

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 Size & Orders of Magnitude tool and/or to record several examples of the structures shown in these models on the tool.

CCC SUPPORT
SPQ-H4: Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. In this lesson, students analyze multiple different models that depict body structures at different scales, which allows the students to interpret the scale relationships between the models.

Invite a few students to share what they have found. As students share, record student responses about which models show which scales in a similar table on the front board. Then, facilitate the conversation such that students agree that orders of magnitude can help students understand how the size of the structures and units shown in one model are related to the size and units in another.

Share that to indicate that now that students have oriented to the relative scales the different models are showing, students will evaluate the merits and limitations of the five different models. Students will use the merits of each of the five models to explain how the nutrients in the small intestine get to the rest of the body. Students can review the models on their Lesson 6 Student Handout Body System Models and record their observations on their Lesson 6 Student Guide Part 3: Using Models to Observe What Happens to Nutrients in the Small Intestine.

Ask students what they think the terms “merits” and “limitations” mean. Build on student responses to define merits as what a model clearly depicts and the limitations as what a model does not show or shows in an unclear way.

STUDENT SUPPORT
To help students understand what the merits and limitations of models are, you may want to show them an example, such as two or more different maps of the same geographical region (for example, a topographic map vs. political maps vs. a road map). Share with students that these maps are all models, or representations, of a real-life geographical area, but they each bring some different features into focus while obscuring others. Ask students to describe what information each map best shows and how they can combine it to better understand the region compared to just looking at one map. When using analogies, be sure to consider what kind of analogy will be most relevant to the lives of your students.

Allow students time to analyze each model, determine the merits and limitations of each model, and record their observations on their Lesson 6 Student Guide Part 3: Using Models to Observe What Happens to Nutrients in the Small Intestine. As students work, circulate the room to press students to explain the merits and limitations that they have found. Use questions such as:

- What do you think this model shows that the others do not?
- What science ideas does this model bring into focus? What is not focused on?
- How does the scale shown in this model relate to the scale shown in this other model? By what order of magnitude do they differ?
- What scale does this model bring into focus? What is not focused on?

After students have identified the merits and limitations of the models, ask students to use the merits of the different models to explain how they think nutrients get from the small intestine to the rest of the body. Ask students why they think using multiple models to explain this process could be beneficial to understanding the full process. Build off student responses to share that:

- Different models have different merits and bring different things into focus. So, using multiple models and being able to understand the connections between the merits of one model and another can help us understand the full process.

FORMATIVE ASSESSMENT OPPORTUNITY

Students use multiple models at different scales to provide a mechanistic account of the process of nutrient absorption via specialized cells in the small intestine.

Assessment Artifacts:

- Students' reflections on how orders of magnitude can help them understand the multiple models (Lesson 6 Student Guide Part 3 Use Models to Observe What Happens to Nutrients in the Small Intestine).
- Students' explanation using merits of multiple models of how nutrients are absorbed via specialized cells in the small intestine (Lesson 6 Student Guide Part 3: Using Models to Observe What Happens to Nutrients in the Small Intestine).

Look Fors:

- Students state that orders of magnitude can help understand the relationships between models and units of length at different scales (SPQ-H4).
- Students use the merits and limitations of multiple models to construct a mechanistic explanation (MOD-H4).
- Students identify how specialized cells, the epithelial cells of the small intestine, help move nutrients from the small intestine eventually to the bloodstream (LS1.A-H1).

Assessment Rubrics:

	Emerging	Developing	Proficient
Sample Student Response	Order of Magnitude Reflection: The different units help you see the size of the organs and cells. Explanation: The cells in the small intestine help digest nutrients by moving them into the bloodstream.	Order of Magnitude Reflection: The different units help you see the size of the organs and cells. Explanation: As shown best by Model 4, the epithelial cells that line the villi are only one cell thick, so nutrient molecules like amino acids, fatty acids, and sugars from the small intestine can move through them. The molecules in the small intestine cross the epithelial cells in a variety of ways depending on what type of molecule it is, which is clear in Model 2. Then, as Model 1 shows, glucose, amino acids, and water move directly into the bloodstream. Fats are put into chylomicrons and move into the lymph vessels, which later move into the bloodstream. The arteries and blood vessels can carry the blood to the rest of the body, as shown in Model 5.	Order of Magnitude Reflection: Orders of magnitude help me understand how one model relates to another and the relative size of different units of length shown in the different models. For example, Model 4 shows the entire gastrointestinal tract to be between three and five meters in length. Model 1 shows the intestinal villus within the gastrointestinal tract carrying nutrients such as amino acids which can be as small as 0.7 nm. Explanation: As shown best by Model 4, the epithelial cells that line the villi are only one cell thick, so nutrient molecules like amino acids, fatty acids, and sugars from the small intestine can move through them. The molecules in the small intestine cross the epithelial cells in a variety of ways depending on what type of molecule it is, which is clear in Model 2. Then, as Model 1 shows, glucose, amino acids, and water move directly into the bloodstream. Fats are put into chylomicrons and move into the lymph vessels, which later move into the bloodstream. The arteries and blood vessels can carry the blood to the rest of the body, as shown in Model 5.
How to Achieve This Level	Student completes 0-1 out of 3 Look Fors	Student completes 2 out of 3 Look Fors	Student completes 3 out of 3 Look Fors

To Provide Additional Support for Students:

- Focus students' attention on parts of the models that they may be overlooking.

- Ask students to trace the journey of the molecules from the small intestine to a distant part of the body, such as the head or foot.
- Ask students to use the different models to track what steps each type of molecule takes.
- Ask additional pressing questions such as:
    - Which model best helps you understand what is happening at the body system level? At the organ level? At the cellular level? At a specialized structure level?
    - How do the nutrients get out of the small intestine? What role do epithelial cells play in this process? What role do villi play? What role do enterocytes play?
    - How do nutrients get to the different parts of the body after leaving the small intestine?
- 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 used the models to explain how the molecules in the small intestine get to the rest of the body, use a strategy such as a Mingle-Pair-Share for students to share their explanations.

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 arguments.
3. Students then find a new peer and share their arguments once again.

Facilitate the conversation such that students agree that:

- As shown best by Model 4, the epithelial cells that line the villi are only one cell thick, so nutrient molecules like amino acids, fatty acids, and sugars from the small intestine can move through them.
- The molecules in the small intestine cross the epithelial cells in a variety of ways depending on what type of molecule it is, which is clear in Model 2.
- Then, as Model 1 shows, glucose, amino acids, and water move directly into the bloodstream. Fats are put into chylomicrons and move into the lymph vessels, which later move into the bloodstream.
- The arteries and blood vessels can carry the blood to the rest of the body, as shown in Model 5.

Share with students that they will next use what they figured out to update their Class Consensus Models from Lesson 5.

Part 4: Revising a Model of How Milk is Digested

Students will use the evidence gathered to revise the Class Consensus Model to better answer the Module Question, *How is milk digested after it is consumed?* Show students the Class Consensus Model from Lesson 5. Ask students to recall the model conventions from Lesson 5: Part 2 that they used previously, including boxes to represent parts of the digestive system, arrows to represent the movement of milk molecules from one component to another, zoom-ins to represent smaller-scale structures, and scale bars or labels to indicate the relative sizes of organs and cells.

Share with students that now we have figured out the role of two different **body systems** in how milk helps us recover from exercise. Ask students to use their prior knowledge to name the two systems they have worked with so far. Build off student responses to name the digestive system and the circulatory system and share that we can represent both in the model.

Ask students to brainstorm and record revisions that they think they should now add to help the Class Consensus Model more accurately show what happens to the molecules in milk after milk is consumed. Students can record their revision ideas on their Lesson 6 Student Guide Part 4: Revising a Model of How Milk is Digested.

FORMATIVE ASSESSMENT OPPORTUNITY

Students revise a model to describe the relationships between components of the digestive and circulatory systems, including the scale relationships that show how organs are made of systems of specialized cells.

Assessment Artifacts:

- Students' suggested revisions to the class consensus model (Lesson 6 Student Guide Part 4: Revising a Model of How Milk is Digested).

Look Fors:

- Student revisions suggest showing the interactions between components of the digestive system and circulatory system, including which molecules move from one component to the next (MOD-H1).
- Student revisions suggest showing how specialized cells contribute to the function of absorbing nutrients in the small intestine (LS1.A-H1).
- Student revisions suggest showing multiple levels of organization of the digestive and circulatory systems, including the system, organ, and cell levels (LS1.A-H3).
- Student revisions suggest indicating the relative sizes of organs and cells in the circulatory system (SPQ-H4).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Student revisions suggest adding: ● The circulatory system.	Student revisions suggest adding: ● We should add the bloodstream since that is where the nutrient molecules end up. ● We should add the epithelial cells of the small intestine because the nutrients pass through these cells to enter the hepatic portal vein.	Student revisions suggest adding: ● We should add the bloodstream since that is where the nutrient molecules end up. ● We should add the epithelial cells of the small intestine because the nutrients pass through these cells to enter the hepatic portal vein. ● We should add the relative sizes of the structures in the bloodstream. ● We should add the interactions of the circulatory system and the digestive system through the epithelial cells.
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:

- Ask students to identify what new representations they are including on the model and explain why it is important to their new sensemaking (understanding).
- Ask students to identify the components that are missing from the system represented in their model. What would they add to represent them?

After students have brainstormed revisions to the Class Consensus Model, hold a whole-class discussion in which the class adds revisions to the Class Consensus Model. You can use the following steps:

1. Each group should select one or more reporters to share the revisions that they want to make to the model. Have the first group share their revision idea and add it to the consensus model. 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 revisions to the model. Continue this process until the full Class Consensus Model is 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. What evidence do you have for _____?
    ii. Why are you making this revision? What does it help explain about how milk is digested?

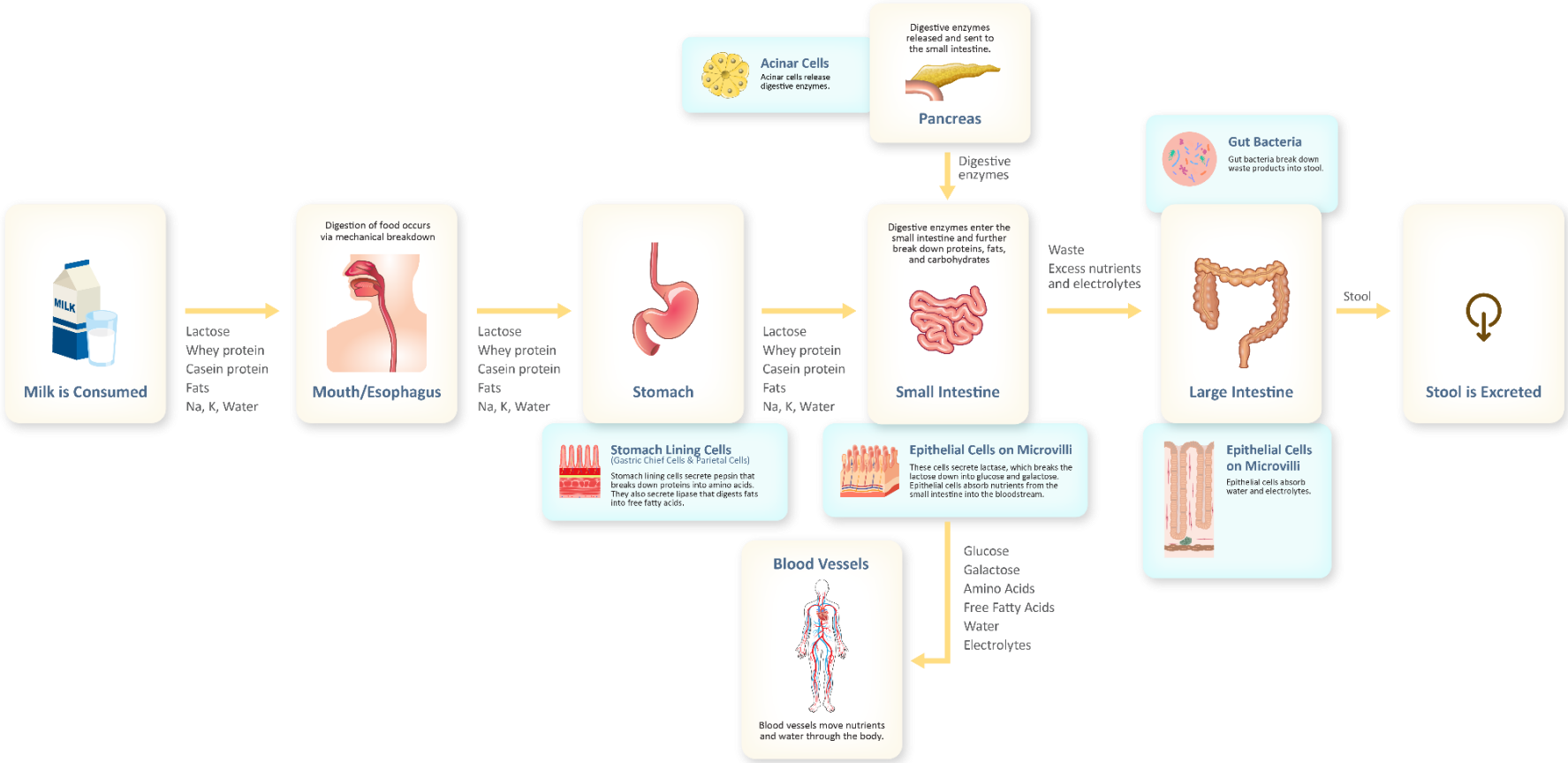
CCSS SUPPORT

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

Below is 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. Students will copy the final Class Consensus Model on their Lesson 6 Student Guide Part 4: Revising a Model of How Milk is Digested.

Example Class Consensus Model



Remind students that in Lesson 5, they had identified that the digestive system, its cells, and other structures are organized into a hierarchical system of organization. Ask students how they think the additions they have made to the model fit into a hierarchical system of organization. Build off student responses to indicate that the circulatory system and digestive system interact via the epithelial cells in the small intestine and that both systems are organized into a hierarchical system of organization.

Share with students that they will next return to the Anchor Phenomenon to figure out how what they have learned will help them update their presentations to their peers.