TEACHER GUIDE
EXPLORE 2 LESSON 4

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 as milk travels through the digestive system, it moves in and out of multiple organs. In each organ, specialized cells produce enzymes that break down the extended molecules of milk into smaller molecules. The molecules pass from one organ to another and break down in multiple ways.

3D Learning Objective:	Time estimate:	Materials:
Students use a model that illustrates multiple scale relationships of how organs and specialized cells work together in a system to digest milk.	100 minutes	Lesson 4 Student Guide Lesson 4 Student Handout Science Theater Card Set Lesson 4 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-H3:** **Multicellular organisms have a hierarchical structural organization, in which any one**	**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.**

	system is made up of numerous parts and is itself a component of the next level.	

Directions

Part 1: Our Motivation

Return students' attention to the Module Question, *How is milk digested after it is consumed?* Share with students that they ended the last lesson by evaluating claims about which organs in the digestive system contribute to the digestion of molecules in milk. Ask students what they have figured out so far to answer the Module Question. Example responses include:

- We know that multiple organs in the digestive system contribute to the digestion of milk.
- We know that each of the organs has specialized cells that produce enzymes that break down the molecules in milk.

Ask students what they still need to know to fully figure out the Module Question. In student responses, listen for the following ideas:

- We don't know how different organs work together to digest milk.

Build off student responses to share that they will now use a model of digestion to help figure out how our organs and the specialized cells in them work together to digest the molecules in milk.

Finally, point to the category "How Does My Body Digest Milk?" on the Driving Question Board. Share a few selected questions that align with what students will investigate in this lesson.

Example student questions or ideas could include:

- How does milk get broken down in the body?
- Where does the digestion of milk occur?
- What is happening to milk during digestion?
- How do different organs work together to digest milk?

Students can record these questions on their Lesson 4 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.

Part 2: Using a Model of Digestion

Share with students that they left off the previous activity wondering how all the different organs in the digestive system work together to break down the different molecules in milk. Tell students that to help figure this out, students will engage in a Science Theater activity in which they act out this process.

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 the organs of the digestive system break down the molecules in food:

- Mouth/Esophagus - Salivary Acinar Cells
- Stomach - Chief & Parietal Cells
- Small Intestine - Epithelial Cells
- Large Intestine - Gut Microbiota
- Pancreas - Pancreatic Acinar Cells

SETUP:

Use the Lesson 4 Student Handout Science Theater Card Set and Lesson 4 Teacher Resource Science Theater Directions to set up the room. Show students the setup of the room, including where each of the tables are that represent 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 might represent what students know about the digestive system. Build off student responses to confirm that there is a station that represents each organ in the digestive system and that the food molecules will move from station to station.

ROLE ASSIGNMENT:

Next, assign specific organ and cell roles to students (or let them choose roles) and instruct students to move their assigned positions.

STUDENT SUPPORT

In Science Theater, the roles have varying levels of complexity. You may choose to use the following role-specific complexity levels to differentiate your role assignments.

- Less Complex: Pancreas
- More Complex: Small Intestine

Depending on the number of students in your classroom, you may assign one student to each role, or a pair or trio of students can complete each role. Placing your more "outgoing" students in the first acting rotation may also be helpful.

Additionally, if a student needs more time to observe the process in action before participating, allow them to participate as an observer first so they can feel more comfortable when participating in a role in the second round of implementation.

PREPARATION:

Allow some time for students to review the summary of their assigned organ and cells, the actions their role will take, and to organize the different tokens at their station. Ask students to return to their Size & Order of Magnitude tool from Lesson 3 and use it to interpret the relative size of two of the objects shown in the diagrams for their organ. Students can record these on their Lesson 4 Student Guide Part 2: Using a Model of Digestion. Use a Think-Pair-Share for students to share a few examples of what they found. Some examples may include:

- The epithelial cells in the small intestine are 10-20 um compared to the surface cells in the stomach that are 1.0-1.6 mm. If food is going through the small intestine, it must be a lot smaller than food that is in the stomach.
- The bile tube of the pancreas is close in size to the 1-3 cm diameter tube of the small intestine.

Then, ask students how an understanding of orders of magnitude can help them understand what the different representations are in the Science Theater model. Build on student responses to confirm that orders of magnitude can help them understand the different size relationships of the different parts of the models.

MODEL ENACTMENT:

Next, prepare to enact Science Theater. Share that in this Science Theater activity, students will use a fishbowl method where half of the class is engaging in the Science Theater activity, and the other half is observing the overall model. Students will have an opportunity to engage in both roles.

- The role of observers is to observe and take notes on the processes being modeled "in the body" as they happen. Observers stand "outside the body" but move around to ensure they can see and hear what is happening at each step. They can approach and/or read any visual aid as needed. They record observations of the process as it unfolds.
- The role of actors in the Science Theater will be to carry out the actions of specialized cells within organs as they contribute to the digestion of molecules in milk. Students will carry out actions such as moving from station to station, handing tokens from one type of cell to another, and carrying out other actions that specialized cells take in digestion. When they complete an action, they should verbalize what organ/cell is doing the action, what the action is, and show any tokens to the observers so that the observers will know what is happening at each step of the model.

TEACHER SUPPORT

This is the first of five Science Theater activities in this unit. Before starting, you may want to establish a set of norms for how to engage in this activity. Some examples of these norms could include:

- **You are one actor in the whole play.** Like in a real theater play, you have a specific role as one actor that helps make the whole play become a meaningful experience. Like in real theater, sometimes your role is acting; sometimes it is waiting for others to say their lines and perform their actions.
- **Clearly communicate.** As you perform your role, clearly announce your actions to the observers and the students you interact with.
- **Be patient.** Other students may not be processing information as fast as you are, so be patient and let everyone figure out their roles and actions.

Begin the activity by saying what process students will be modeling. In this case, you can say something like, "Now we will model what happens in the digestive system when a person drinks milk." Allow time for students to carry out the first act of the model.

TEACHER SUPPORT

At any time during the Science Theater, you can call a "time-out" to reiterate directions, allow students time to process actions that have occurred or next steps, or highlight a certain action. You can also give the students the autonomy to call a student "time-out" to clarify their role or point out a certain action.

SEP SUPPORT

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

In middle school, students develop models to predict and/or describe phenomena. In this unit, students build on this middle school understanding to use models to provide mechanistic explanations of phenomena. In this lesson and several others throughout the unit, students engage in a Science Theater activity to help figure out cellular- and molecular-level mechanisms that occur in the body in response to exercise and as a part of recovery from exercise.

OBSERVATION AND REFLECTION:

As students work, circulate the room to support them in engaging and observing the model. Students can write their observations on Lesson 4 Student Guide Part 2: Using a Model of Digestion. 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 (molecules?) Where do you get them from? What happens to them? 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 is happening to (molecule) at (organ)?
- What changes are happening to the molecules?

After the model is complete, give students a moment to finish collecting their notes, then have students switch roles between modelers and observers. Engage in both scenarios of the model a second time. After the second implementation of the model, allow students time to summarize what they observed in the model in the graphic organizer on their Lesson 4 Student Guide Part 2: Using a Model of Digestion.

FORMATIVE ASSESSMENT OPPORTUNITY

Students use a model that illustrates multiple scale relationships of how organs and specialized cells work together in a system to digest milk.

Assessment Artifacts:

- Students' description of the relative sizes of the different models on their station cards (Lesson 4 Student Guide Part 2: Using a Model of Digestion).
- Students' observations of how different organs and their specialized cells function to digest the nutrients (molecules) in milk (Lesson 4 Student Guide Part 2: Using a Model of Digestion).

Look Fors:

- Students identify scale relationships of biological objects using orders of magnitude (SPQ-H4).
- Students use the Science Theater model to describe the mechanism by which food is digested, including on multiple scales (MOD-H5, LS1.A-H3).

- Students describe how specialized cells in each organ contribute to the function of the organ, including the role of enzymes in digestion (LS1.A-H1).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Role of Organ & Specialized Cells in Digestion: ● Protein breakdown starts in the Stomach and continues in the Small Intestine. Pepsin is an enzyme that breaks down proteins into amino acids.	Role of Organ & Specialized Cells in Digestion: ● Protein breakdown starts in the Stomach and continues in the Small Intestine. Pepsin is an enzyme that breaks down proteins into amino acids. ● Fats-breakdown may start in the stomach, then continue in the Small Intestine. Bile breaks down fats into fat globules. ● Lactose-breakdown in the small intestine. Lipase is an enzyme that breaks down fat into free fatty acids. Lactase breaks down lactose into glucose and galactose. ● Electrolytes-may end up in the large intestine. Epithelial cells line the organs and release enzymes as well as absorb them.	Scale Relationships: ● The cells that line the stomach walls are 1,000,000 times, or at 6 orders of magnitude where the small intestine width is 200 times, or 2 orders of magnitude, seeing this difference shows the difference in size from an organ and a cell. The sucrase enzyme is about 1,000 times smaller than the epithelial cells. Role of Organ & Specialized Cells in Digestion: ● Protein breakdown starts in the Stomach and continues in the Small Intestine. Pepsin is an enzyme that breaks down proteins into amino acids. ● Fats-breakdown may start in the stomach, then continue in the Small Intestine. Bile breaks down fats into fat globules. ● Lactose-breakdown in the small intestine. Lipase is an enzyme that breaks down fat into free fatty acids. Lactase breaks down lactose into glucose and galactose. ● Electrolytes-may end up in the large intestine. Epithelial cells line the organs and release enzymes as well as absorb them.
How to Achieve This Level	Student completes 0-1 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.
- Have students read their role cards as a group and rehearse what they will do before enacting the model.

DISCUSSION AND ANALYSIS:
After students have participated in both roles (playing the role of an organ such as the small intestine and as an observer), bring the class together to hold a whole-class discussion for students to share what they observed in the model. Facilitate the discussion so students agree that the components of milk are digested in the following way:

- Lactose moves through the system into the small intestine, where epithelial cells produce lactase, which breaks lactose into glucose and galactose.
- Whey and casein proteins move through the system into the stomach, where chief cells produce pepsin, which breaks the proteins into chains of amino acids. The chains of amino acids are broken down into single amino acids in the small intestine by additional protease enzymes.
- Fats move through the system into the small intestine, where bile breaks fat into smaller globules, and lipase from the pancreas breaks the fats down into free fatty acids.
- Water and electrolytes move through the system into the small intestine.

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.

TEACHER SUPPORT
Notes of clarification on the scope of content and the progression of students' learning for Science Theater in this lesson and throughout the unit:

- Throughout the unit, Science Theater focuses on the basic physiological processes that contribute to the mechanisms that help explain the corresponding module phenomena. The biochemical processes are not specifically addressed because doing so would exceed the assessment boundaries for the DCIs addressed in this unit.
- Across modules, students will engage in Science Theater multiple times. The below table shows a progression of how students' engagement in the model will change over time.

Module 1	**Module 2**	**Module 3**	**Module 4**
Science Theater models a relatively simple system. ● Role card instructions have specific cues ● The model is limited to a single-body system ● Interactions in the model are mostly linear	Science Theater models multiple interacting body systems. ● Addition of multiple body systems ● Addition of non-linear model interactions ● Addition of exercise and recovery states	Science Theater models multiple interacting systems with multiple steps and mechanisms. ● Role card instructions are less scaffolded with few bulleted cues.	Science Theater models multiple interacting systems, and some student scaffolds are removed. ● Role card instructions do not contain bulleted cues ● Multiple specialized cells play key roles in an organ ● Student Guide cues are reduced for observers

CONCLUSION:

Conclude the lesson by sharing with students that they have just observed a complex process in the body, so in the next lesson, it will be helpful to summarize what they figured out.