TEACHER GUIDE
EXPLAIN LESSON 4

Food and Agriculture Center for Science Education

Module Question: *How does the dairy system produce dairy products and get them to our table?*

What We Figure Out:

We figure out that producing dairy foods involves a system that includes many different components. Each of these components has inputs and outputs. Some of the inputs and outputs remain within the system, but others move outside of the system and have consequences on the environment.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students revise their initial models to show how the dairy food system is a combination of major technological systems with various inputs and outputs, allowing it to perform its specific task of dairy food production.	50 minutes	Lesson 4 Student Guide Lesson 3 Student Handout Dairy System Component Cards (10 cards in each set, 1 set per group of 4-5)

Targeted Elements

SEP:

MOD-H3:
Develop, **revise,** and/or use **a model based on evidence to illustrate** and/or predict **the relationships between** systems or between **components of a system.**

DCI:

ETS2.B-H1:
Modern civilization depends on major technological systems, including those related to agriculture, health, water energy, **transportation, manufacturing,** construction, and communications.

CCC:

SYS-H1:
Systems can be designed to do specific tasks.

SYS-H2:
When investigating or describing a system, the boundaries and initial conditions **of the system need to be defined and their inputs**

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		and outputs analyzed and described using models.

Directions

Part 1: Our Motivation

Students will individually review their Class Consensus Model from Lesson 2 Student Guide Part 4: Creating and Sharing Initial Models. This model shows how dairy products get to their table.

The goal of this individual review is to see what gaps exist in the model from what they have learned so far in the module.

Ask students if these models accurately reflect the new evidence we have about the components of the dairy system and how they function. Listen for:

- No, because there are parts of the dairy system we didn't account for.
- We think there are different interactions between parts that we haven't accounted for yet.

Build off student responses to share that we will use the component cards from Lesson 3 to identify the sequence in the dairy system and create a new model.

Finally, point to the Dairy Industry category of questions on the Driving Question Board. Share a few selected questions that align with what students will investigate in the upcoming lesson.

Example student questions or ideas could include:

- We have made models of the dairy system, but what parts are we missing?
- I think we need to know more about the order of the steps in the dairy system.
- What steps are we missing?

Students can record these questions in 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: Review Initial Dairy System Model

With their Class Consensus Model from Lesson 2: Student Guide Part 4: Creating and Sharing Initial Models, students will identify specific components in their model that they think are supported by the evidence they have gathered or that they think they should revise. They will put these thoughts on the graphic organizer in the Lesson 4 Student Guide Part 2: Review Initial Dairy System Model.

Student responses may look like:

- Some parts of my model align with the new information we learned. I have the step about cows feeding and being milked. I think I accurately showed the last two steps (transportation to the products on our shelves).
- I am missing steps about how the milking process happens and steps related to processing and testing of milk. I am also missing the stores/restaurants/schools that we get the products from.

TEACHER SUPPORT

If students find that they cannot find areas of improvement, consider:

- Focusing students' attention on a gap they did not find in their model and asking, what do you think is happening here?
- Asking students: Why do you think this model is complete? Tell me more about why you believe the model is complete.

Individuals will share thoughts with the class. Write these thoughts on the board in a T-chart listing components they support and components that need revisions. This chart will capture the class's current thinking, and the class can revisit this list as they continue throughout the lesson.

Share with students that they will next have the opportunity to use the ideas they write in the T-chart to revise their models.

Part 3: Sequencing the Dairy System Components

Place students back into the groups from their Lesson 3 Student Handout Dairy System Component Cards. Each group should have one student with two of the ten dairy system cards.

With their groups, students will work together to arrange the cards in the order they think represents the sequence of steps involved in creating a dairy product and transporting it to the consumer. They will write the order on their Lesson 4 Student Guide Part 3: Sequencing the Dairy System Components.

TEACHER SUPPORT

It is important to call these cards "component cards" as they represent individual components of the dairy production system. This will support students in thinking about the dairy production process as a system. As they work through this lesson, students will see that each component plays a specific role in the larger system.

First, students will ensure they have all the cards in the sequence; each group should have ten total. Then, students will place them in the order they think represents how dairy products are made.

As students work, circulate the room to ask pressing or challenging questions.

- Pressing question examples:
  - What evidence do you have for that component's placement in the sequence?
  - How come you have this card before that card?
  - How do these two cards seem to relate to each other?
- Challenging question examples:
  - What if this card moved before that card?
  - Would that make sense or not? Why or why not?
  - How does your sequence compare to ____'s idea?

When each group is complete, allow each group to share their sequence and write on their student guide. To complete this sharing step, allow each group to nominate a speaker to share with the entire class at once. Each group will share in 1-2 minutes.

The purpose of sharing at this step is so the class agrees on the sequence before moving to the next step. Here is a complete sequence:

- Crops are grown
- Cows are fed
- Cows are cared for
- Cows are bred, have calves, and produce milk
- Cows are milked 2 or 3 times a day
- Milk is cooled and tested for safety
- Milk is loaded and transported in an insulated tanker truck
- Milk is further tested for safety and quality at processing facility
- Milk is processed into dairy products; dairy products are shipped to retailers and customer

Share with students that even though we came up with the sequence of the cards, we haven't yet figured out how the cards link together to form a system that produces a dairy product. We'll do this now by linking together inputs, outputs, and the boundaries of the system.

Students will pick one of the components they became an expert on and find a student who has the card sequenced before or after their chosen component card.

TEACHER SUPPORT
At this point, you may need to choose students to group strategically based on their chosen component cards. This will make sure that all components are chosen and have a two-component system created and further along in the lesson when the students complete a four-component system.

Next, students will create a two-component system model that includes everything they found consensus on. The model will need to include both system components along with the inputs, outputs, and boundaries of the two-component system. Students can use the same model conventions they used in their previous models. This can include:

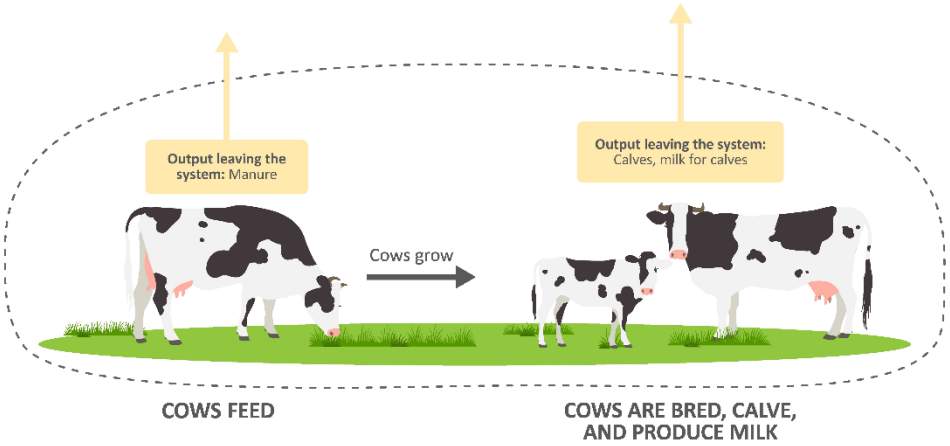
- Using images, icons, and pictures to visually represent different components of the system.
- Arrows from one component to another show things that move from one step to the next.
- Using a dashed line to show system boundaries.

Additionally, now introduce that students can use arrows that cross the system boundary (either moving inwards or outwards) to represent how some inputs or outputs of the system either come from outside the system or have effects outside the system. Ask students to consider why identifying system boundaries might be important. Listen for student responses that indicate that there might be other things that influence the dairy system that we still need to pay attention to, or that the dairy system influences outside things that we need to pay attention to.

Students can draw their models on chart paper. As the students are working, walk around and engage in conversations with groups as they work.

- If a group is missing model conventions, remind them to refer to the Model Conventions Chart to ensure all areas are completed.
- If a group needs more support on their inputs, outputs, and boundaries, ask students to talk through the connection between their two components. For example, this might sound like, "The system starts with growing feed for cattle and bringing it to the cattle who feed on it and then produce milk."

Here is an example of a completed pair's two-component model:



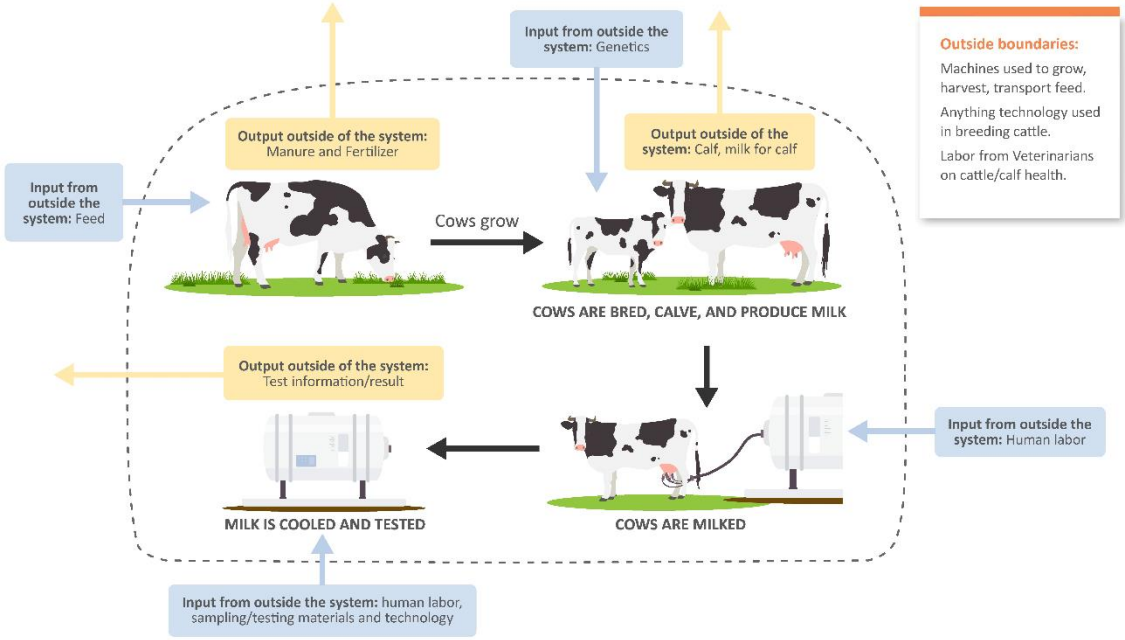
Next, share with students that we will now expand what we define as the system until we build the full system. Note to students that a system can be whatever the person analyzing wants to define as the system. Here, we are expanding our system boundaries and definition of what is inside the system until we build the full dairy production system. Each pair should find another pair with the steps immediately after or before their two-component model. The newly formed group will repeat the steps above to create a four-component model.

Students should use the Four Component System Collaboration protocol to do so:

1. Student pairs share their two-component models with the other pair to discuss their components. During this discussion, students point out their inputs, outputs, and what is outside the boundaries of their two-component model. The other group will ask questions to clarify any points that seem unclear.
2. Next, students will create a four-component system model that includes everything previously on their two-component models. Because the size of the system has now expanded, students will need to consider how the inputs, outputs, and boundaries of the system have changed compared to their previous two-component systems.

a. Students can use the same model conventions they used in their previous models.
b. Groups can draw their new four-component model on new chart paper or revise their existing chart paper.

Here is an example of a completed four-component model:



Part 4: Create a Class Consensus Model

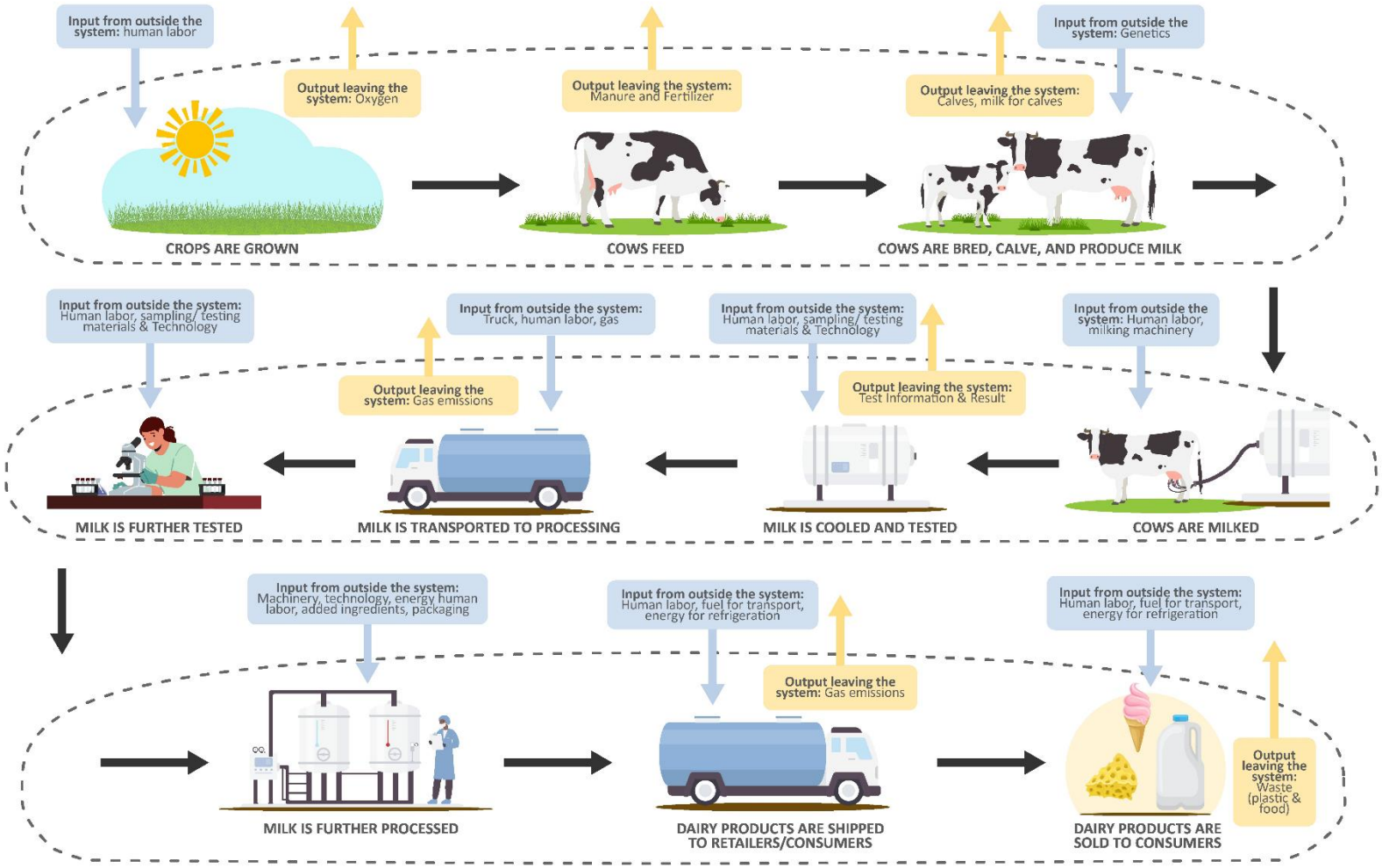
The class will now produce a new Class Consensus Model that shows how dairy foods get to consumers. Ask students to share their four-component models in order from the start to the end of the dairy production system.

1. Each group should select one or more reporters to share their model. Have the first group share their model and add one part of it to the consensus model. This can be one component, arrow, relationship, or any other feature that 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 to it. 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. 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 on the model currently?
    iii. Where would we place the system boundary? What is inside of the system? What is outside?
    iv. Is this something that moves from one component of the model to another? Or is this something that comes in from outside of the system or goes out of the system?

Students can copy this new consensus model onto their Lesson 4 Student Guide Part 4: Create a Class Consensus Model as the model is being built.

Here is an example of a completed Class Consensus Model:



After students have completed the class consensus model, ask them to reflect on the use of boundaries in the system model. Use a Think-Pair-Share to have students share their responses with the class.

CCC SUPPORT
SYS-H1: Systems can be designed to do specific tasks.

SYS-H2: When investigating or describing a system, the boundaries and initial conditions **of the system need to be defined and their inputs and outputs analyzed and described** using models.

In middle school, students analyzed the design of systems by determining that systems can have sub-systems and be a part of larger systems. In this module, students build on this idea by using their knowledge of a system's interactions to identify the function of the system, SYS-H2 focuses on defining the boundaries of the system. This element can help students analyze the impacts of a system, including the relationship between its design and the intended and unintended effects the system design has on the environment externalized costs of a system that extend beyond its boundaries.

Establishing the boundaries of the system here will help students understand throughout the unit how the dairy system's design was focused mostly on accomplishing a single task: producing dairy products efficiently for consumers. By establishing this, students engage in SYS-H1.

One of the CCC focuses of this unit is for students to understand how the design of a system can produce intended consequences (e.g., producing dairy products at low cost). Students will establish this intended design in these models. Later in the unit, in the remainder of this module and again in modules 2-3, students will figure out some of the unintended consequences of the design of the dairy system that extend outside of the system itself. If students need additional support working with these CCCs, consider:

- SYS-H1: Ask students to step back and view the model as a whole. What seems to be the purpose of the dairy system and the way it was designed?
- SYS-H2: Use an analogy as noted in Lesson 3. For example, a garden needs inputs like soil, seeds, fertilizer, sunlight, and water to produce outputs of fruits/vegetables/flowers at the end of the season. At the same time, if the system boundaries include only the garden, then things beyond its boundaries that the garden interacts with include human labor, how the garden affects local wildlife, and how local weather influences the garden.

FORMATIVE ASSESSMENT OPPORTUNITY

Students revise their initial models to show how the dairy food system is a combination of major technological systems with various inputs and outputs, allowing it to perform its specific task of dairy food production.

Assessment Artifacts:

- Students' models of the dairy production system (Lesson 4 Part 4 Create a Class Consensus Model)
- Students' reflections on the goal of the dairy system and how the system interacts with outside systems (Lesson 4 Part 4 Create a Class Consensus Model).

- Students' explanations of how a dairy product gets to the consumer (Lesson 4 Part 5 Construct an Explanation About a Dairy Product Journey (task described below).

Look Fors:

- Models include system inputs, outputs, and boundaries. (MOD-H3) (SYS-H2)
- Models show inputs moving into the dairy system from outside its boundaries and outputs that move outside of the dairy system. (SYS-H2)
- Reflections on the model describe why determining the boundaries of the system can give insight into the system's function and how it impacts the world outside of the system boundaries. (SYS-H2)
- Models and explanations describe how the dairy system supports the needs of modern civilization to bring food to consumers. (ETS2.B-H1) (SYS-H1)

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Any student artifact describes the overall function of the dairy system, including how the function of some of its components or their inputs and outputs contribute to the overall function of the system.	Student model includes: • An input and an output for each part of the system and how they connect to one another. • The system boundaries are clearly defined Student reflection describes: • How the boundaries of the system help to determine what factors enter and leave the system. Student explanation describes: • The overall function of the system.	Student model includes: • An input and an output for each part of the system and how they connect to one another. • The system boundaries are clearly defined • Inputs and outputs that cross the system boundaries are shown and accurately described. Student reflection describes: • How the boundaries of the system help to determine what factors enter and leave the system. • How the boundaries can help show what impacts the system has on the outside world. Student explanation describes: • How each component of the system

			contributes to the system's overall function.
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 models. If students are struggling to identify how to connect their components and determine the system boundaries:

- Ask questions such as:
  - What components are important to include to explain how dairy products are made?
  - Pick two components that you think interact with each other. What are some ways you use pictures or words to show this interaction?
  - Based on your model, what seems to be the overall task that the dairy system accomplishes?
  - Use systems language with questions such as, "What inputs and outputs are important for this component?", "What things are a part of this system and what things are outside of this system?", or "What impacts does this component have that affect things outside of the system?"
- Focus students' attention on a certain part of the model they may be missing.
- Ask students to describe how the parts of the system are linked together and what each part requires to do its job.

Part 5: Construct an Explanation About a Dairy Product Journey

Individually, ask students to select one dairy product they want to focus on. Share with students that they will construct a detailed explanation of how this product gets to their table. Student explanations can be written in the Lesson 4 Student Guide Part 5: Construct an Explanation About a Dairy Product Journey, and should include:

- A description of each of the components of the dairy system and how they contribute to making a dairy product.
- The inputs and outputs that are associated with each component of the process.
- The boundaries of the system, including what interacting systems, objects, impacts, or processes are outside the dairy system.
- The purpose of the dairy system and how the design of the system influences its purpose.

To assist students, use supports such as:

1. Remind students to write their explanation from the beginning to the end of the system. It might be helpful for some students to narrate the system by recording themselves talking through the process, then listening to the narration and writing out their explanation.
2. Start by walking through the first step of the model as a class and asking students to explain what they see. Ask the students, "How would you start writing a story about the journey of how yogurt gets to your table?" Then, ask the students, "How would you describe step one of the dairy system - crops are grown? How does this contribute to getting this dairy product to your table?"
    a. Student responses for yogurt, for example, might sound like, "To get to the yogurt I eat every morning requires a lot of steps. It all begins with farmers growing crops to feed cows. This requires plants, probably water, and time to create the crops needed."
3. Tell the students that they just started the first part of their explanation. Now, they will individually complete the rest of the explanation using a dairy product they choose.

TEACHER SUPPORT

This is the first-time students construct a written explanation in this unit. Remind them that they are verbally explaining what they see in the model. Prompt them by saying, "If you couldn't see this model, how would you describe it to me?"

CCSS SUPPORT

WHST 9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. Students engage with this standard when they develop their written explanation of a dairy product's journey through production. To fully construct their explanation, students use their knowledge of the technical processes associated with the dairy production.

?? Part 6: Asking New Questions

As a final step in this lesson, students will create a new list of questions that can help them determine what additional information they need to know to help them figure out the steps of the dairy system. They can write these questions on their Lesson 4 Student Guide Part 6: Asking New Questions. Add these questions to the Dairy Industry 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 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:

- I wonder if we have accurately captured all the inputs and outputs of the system.
- I wonder how the parts of the system can impact the environment outside the boundaries of the system.
- I wonder what the environmental impacts are of the system overall.

Build off student questions to share that students will next investigate the ways the dairy system impacts the environment and its other impacts outside of its boundaries.