TEACHER GUIDE
ELABORATE 1 LESSON 12

Food and Agriculture Center for Science Education

Module Question: *How could cow burps be influencing climate change?*

What We Figure Out:

Even though greenhouse gas emissions from the dairy system are significant, they are much less in quantity compared to the emissions from other production industries such as transit and manufacturing. We create written arguments on how the dairy industry compares to other industries in terms of carbon dioxide emissions.

3D Learning Objective:	Time estimate:	Materials:
Students construct, use, and present a written argument based on data and evidence to compare the quantity of carbon dioxide emissions from various human activities.	50 minutes	Lesson 12 Student Guide Lesson 12 Student Handout Greenhouse Gas Emissions by Sector

Targeted Elements

SEP:	DCI:	CCC:
ARG-H4: **Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence.**	**ESS2.D-H3:** **Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.**	**SPQ-H1:** **The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.**

Directions

Part 1: Our Motivation

Display the Class Consensus Model from Lesson 11. Ask students to reflect on why they set out to make these models. Listen for student responses, such as students wanting to answer the Module Question: *"How could cow burps be influencing climate change?"*

Ask students if they think cow burps and transit from the dairy industry are the only factors contributing to greenhouse gases in the atmosphere. Allow students to share any additional ideas from their background experience. Listen for students to share any ideas related to emissions from other industries, such as manufacturing, transit, or other agricultural sectors. Record these in a class list. Build off student responses to share that we will expand our view beyond the dairy system to compare greenhouse gas emissions from the dairy system to those of other modern technological systems to see just how much dairy contributes to climate change compared to other industries.

Finally, point to the Greenhouse Gas and Climate category of questions 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 do the greenhouse gasses from dairy compare to the role played by other human-designed systems?
- Does the dairy system have higher or lower emissions than the production of other resources?
- Is the dairy industry contributing to climate change more than other industries?

Students can record these questions 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 investigative phenomenon. Use students' questions to transition to the question, *"How do greenhouse gas emissions from the dairy industry compare to those from other industries?"*

Part 2: Develop an Initial Argument About Greenhouse Gas Emissions Across Sectors

Share with students that to share their current thinking about how the greenhouse gas emissions from the dairy industry compare to the emissions of other industries, students will develop a claim that states if they think dairy production emits more, similar, or less greenhouse gases compared to other industries.

Ask students if they want to add any other greenhouse gas emission sources to the class list to compare with dairy industry emissions. Encourage them to start with the industries they see in their community or have experience with. Record this list on the board as students share. Some example industries could include:

- Manufacturing
- Transit
- Electricity generation
- Residential heating and cooling
- Other agriculture

Based on the list of industries, allow students time to work on writing an initial claim. Students can choose one or more of these industries to compare what they think the emissions of the dairy industry are.

As students work, circulate the room and ask probing questions:

- What were different people in the media claims saying about the emissions of the dairy industry?
- What have you heard about the quantity of emissions from the dairy industry? What about other industries?

STUDENT SUPPORT

If students need additional support in writing an initial claim, consider reminding students that any idea is accepted at this point. Students can revise these claims later in the lesson after gathering evidence.

Use the Four Corners Routine to have students share which claim that they made:

1. Label four corners of the room:
    - Corner 1: The dairy industry emits more greenhouse gases than other individual industries.
    - Corner 2: The dairy industry, by itself, emits more greenhouse gases than all other industries combined.
    - Corner 3: The dairy industry emits about the same amount of greenhouse gases as other individual industries.
    - Corner 4: The dairy industry emits less greenhouse gases than other individual industries.
2. Ask students to move to the corner that best represents their position.
3. With a nearby peer, students will share why they chose this corner.
4. Hold a brief, whole-class discussion for students to share their argument supporting why they picked this corner with the whole class and to counter-argue why their corner is more accurate than those chosen by other students.

At this point, students do not necessarily need to reach a consensus, so let students discuss their claims and any reasoning they have as you see fit. Students should capture their initial claim on their Lesson 12 Student Guide Part 2: Develop an Initial Argument About Greenhouse Gas Emissions Across Sectors.

Part 3: Analyzing Data on the Greenhouse Gas Emissions by Industrial Sector

Share with students that, to make progress on figuring out how emissions from the dairy industry compare to those of other industries, students will analyze data on greenhouse gas emissions by sector. Ask students how they can use the lens of scale, proportion, and quantity to investigate this question. Listen for student responses that indicate that students can compare the quantities of emissions from industries to see which industry contributes the most greenhouse gasses to the atmosphere.

Share the Lesson 12 Student Handout Greenhouse Gas Emissions by Sector. Instruct students to record the analysis of the current trends of greenhouse gas emissions from each industry on their Lesson 12 Student Guide Part 3: Analyzing Data on the Greenhouse Emissions by Industrial Sector. Students should also include their initial thoughts about human impact and greenhouse gases to consider if human activity changes in the various industries discussed.

Allow students time to find trends in the graphs. As students analyze the graphs, circulate the room to support students in their analysis. Ask questions to support student thinking, such as:

- What does the title of the graph mean?
- What is on the X and Y-axis of the graph?
- What trends do you see in the data on the graph?
- Is there any information in this data set that you might be able to ignore? What seems to be the most important information?

CCSS SUPPORT

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
Students engage in this standard as they analyze Greenhouse Gas Emission by Industrial Sector data. Students interpret the various axes and axes scales used in the different graphs to extract trends from the data sets. This is important because the units used for each data set are unique and must be understood independently before they can be compared.

STUDENT SUPPORT

If students need additional support interpreting the data sets, consider:

- Providing students with an annotation strategy, such as showing arrows on different segments of the graph to indicate increases or decreases.
- Focusing students on specific parts of the graphs that they may be overlooking.
- Establishing what the graph is showing by asking students to describe what each graph axis is measuring.

If there are students demonstrating high engagement with these data, encourage them to explore some of these data sets further on their own time. Provide prompts such as, "What else in these data sets are you curious about?", "Why might that industry contribute so much (or so little) to greenhouse gas emissions?", or "What do you think that industry has done to increase or decrease their emissions over the years?" Additionally, you could prompt students to make a list of the human activities that are discussed in the data sets. This list can include how temperature might change if this activity were decreased/increased.

Part 4: Revising Initial Arguments Using Evidence

Ask students how they can continue to use the lens of scale, proportion, and quantity to now evaluate the initial claims they made in this lesson. Listen for student responses to indicate that they can use the emissions data they gathered to compare the quantity of emissions of dairy and agriculture with other industries to see if their initial claims were valid or not. Build off student responses to share with students that they will now return to the initial claims they made, update them, and use the evidence they have gathered to support their new claims.

Allow students time to revise their initial claims in their Lesson 12 Student Guide Part 4: Revising Initial Arguments Using Evidence. As students work, circulate the room to ask pressing questions:

- I see you wrote _____. What new evidence do you have to support your position?
- What did you previously think about the emissions of the dairy industry? What do you think now?
- How significant is the quantity of emissions from the dairy industry compared to that of the other industries?

FORMATIVE ASSESSMENT OPPORTUNITY
Students construct, use, and present a written argument based on data and evidence to compare the quantity of carbon dioxide emissions from various human activities.

Assessment Artifacts:

- Students' revised arguments about how greenhouse gas emissions from the dairy industry compare to that of other industries (Lesson 12 Student Guide Part 4 Revising Initial Arguments With Evidence).

Look Fors:

- Student arguments include at least two pieces of specific evidence they gathered from the data sets provided. (ARG-H4)
- Student arguments compare the quantity of greenhouse gas emissions from one industry to another. (SPQ-H1)
- Student arguments refer to specific greenhouse gases being added to the atmosphere, such as carbon dioxide and methane. (ESS2.D-H3)

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	The dairy industry emits less greenhouse gas emissions than other industries. I saw data that said that its emissions are less.	The dairy industry emits less greenhouse gases than other individual industries. We can see in the Dairy Industry Emissions Data that milk production, processing, and transport accounts for 2.7% of total GHG emissions in 2007. This means that nearly 97% of GHG emissions are coming from other industries outside of dairy.	The dairy industry emits less greenhouse gases than other individual industries. We can see in the Dairy Industry Emissions Data that milk production, processing, and transport accounts for 2.7% of total GHG emissions in 2007. This means that nearly 97% of GHG emissions are coming from other industries outside of dairy. Furthermore, the greenhouse gas emissions of sectors such as transportation, electric power, and industry have all increased by more than 10% since 1990 (18.6%, 15.7%, and 11.3% respectively), but greenhouse gas emissions by all agricultural industries have increased only 7.2%. Lastly, according to Our World in Data, methane emissions by agriculture have increased, but have seemed to level off as of 2020.
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:

As students are working, approach them to see their arguments. If students need additional support revising their argument, consider providing the following prompts:

- What data did we look at in this lesson?
- What evidence will best help you compare the quantity of emissions from different industries?
- What was the purpose of looking at these different data sets?
- How does this data connect to our claim? How could you use it in your argument?
- How does this evidence support or refute your initial claim? Do you think you need to revise your initial claim based on this new evidence?

Use a strategy such as a Four Corners Routine, in which students move to a corner of the room according to the positions they took in their arguments:

1. Label four corners of the room:
    - Corner 1: The dairy industry emits more greenhouse gases than other individual industries.
    - Corner 2: The dairy industry, by itself, emits more greenhouse gases than all other industries combined.
    - Corner 3: The dairy industry emits about the same amount of greenhouse gases as other individual industries.
    - Corner 4: The dairy industry emits less greenhouse gases than other individual industries.
2. Ask students to move to the corner that best represents their position.
3. With a nearby peer, students will share why they chose this corner.

Hold a brief, whole-class discussion for students to share their argument supporting why they picked this corner with the whole class and to counter-argue why their corner is more accurate than those other students chose. Allow time for students to argue until a consensus is reached that the dairy industry emits much less greenhouse gases than other technological industries.

To conclude the lesson, you can have students reflect on how their thinking has changed across the lesson. You can give students a sentence starter, such as, “I used to think _____. Now I think _____.” and have them share their ideas with a peer and the class. Importantly, in this conversation, emphasize that students’ initial claims were based on their own background experience and that these new claims are based on evidence.