TEACHER GUIDE
EXPLAIN 1 LESSON 9

Food and Agriculture Center for Science Education

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

What We Figure Out:

We figure out how the greenhouse effect involves the release of greenhouse gases into the atmosphere. These greenhouse gases change the balance of energy in the Earth system. The amount of thermal energy trapped in the Earth system increases compared to the amount of solar energy entering the system, which leads to changes in overall average surface temperature. Students depict the ability of carbon dioxide and methane to re-radiate thermal energy from the Earth, explaining their role in the greenhouse effect.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students revise their greenhouse effect models to illustrate how energy flows into and within the Earth system depending upon atmospheric greenhouse gas concentrations.	50 minutes	Lesson 9 Student Guide

Targeted Elements

SEP:	DCI:	CCC:
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.**	**ESS2.D-H3:** **Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.**	**EM-H2:** **Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.**

Directions

Part 1: Our Motivation

Have students individually review their Class Consensus Model from Lesson 7 Student Guide Part 4: Sharing Initial Models. This model shows how students answered the Module Question: *"How could cow burps be influencing climate change?"* 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 they have about greenhouse gases and how Earth's temperature rises. Listen for responses such as:

- No, because there are parts of the model we didn't show, such as the different types of energy or the greenhouse effect.
- We think there are different interactions between parts we haven't accounted for yet, like how greenhouse gases affect temperature.

Next, 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 the upcoming lesson. Example student questions or ideas could include:

- How is methane from cow burps tied to changes in temperatures and climate change?
- What is climate change?
- Where does the methane in cow burps go in the atmosphere? What does it do?

Students can record these questions and ideas in Lesson 9 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 initial models that help explain our Module Question: "*How could cow burps be influencing climate change?"*

Part 2: Revisiting Initial Models

Ask students if it makes sense at this point to only show cow burps in our models based on what they've learned. Listen for responses indicating that there are other parts of the model they now need to include based on what they know about how different kinds of greenhouse gases can produce the greenhouse effect.

Build on student responses to agree that, to show a comparison of their effects, we can include a second source of greenhouse gasses: carbon dioxide from factories and transit in the dairy system. Based on this reasoning, students will add to their existing model or include a second model panel to compare emissions from cow burps and emissions from transit for comparison.

Students will revise their initial model that shows how they would now answer the Module Question: "*How could cow burps be influencing climate change*?" As students work on their Lesson 9 Part 2: Revisiting Initial Models, circulate the room to formatively assess their models and provide feedback by asking questions about their models.

FORMATIVE ASSESSMENT OPPORTUNITY

Students revise their greenhouse effect models to illustrate how energy flows into and within the Earth system depending upon atmospheric greenhouse gas concentrations.

Assessment Artifacts:

- Students' revised models and explanations of how cattle burps influence climate change (Lesson 9 Student Guide Part 2: Revising Initial Models).

Look Fors:

- Models include the relationships between systems or between components of a system. (MOD-H3)
- Models include how energy flows into and within the Earth system depending upon atmosphere greenhouse gas concentrations. (MOD-H3) (SYS-H3) (EM-H2)
- Models show the movement of matter as it moves between components of the model and into and out of the system. (MOD-H3) (EM-H2)
- Models include how human activity has increased greenhouse gas concentrations and thus affects climate. (MOD-H3) (ESS2.D-H3)

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Student model shows the components of the system under consideration, including components such as the	Student model shows: • Movement of matter (methane and carbon dioxide) from the cattle and the truck to the atmosphere, respectively.	Student model shows: • Movement of matter (methane and carbon dioxide) from the cattle and the truck to the atmosphere, respectively. • An accumulation of methane and carbon

	Earth, the cattle, and the atmosphere.	• An accumulation of methane and carbon dioxide in the atmosphere. • A system boundary that includes the cattle, the Earth, and the atmosphere. • Movement of light energy from the Sun to the Earth.	dioxide in the atmosphere. • Movement of light energy from the Sun to the Earth, followed by movement of thermal energy from the Earth to the atmosphere. • An interaction of matter (greenhouse gases) and energy (thermal energy radiated from the Earth) in the atmosphere. • A relative difference in the amount of thermal energy lost to outside the system (into space) vs reflected into the Earth system. Methane reflects more thermal energy back into the Earth system.
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 models, consider asking the following questions:

- What evidence from the previous lessons did you use to find new components to add to your model?
- What new ideas did you add to your model? What are you trying to show?
- Are the boundaries of the system still the same, or do you think they should change? If they need to change, what needs to be shown as part of the system now?
- How do you think methane and carbon dioxide added to the atmosphere result in the greenhouse effect? Do you think they act the same or differently?
- What flows of energy within, into, and out of the system should we show in this model? How will that help us explain the greenhouse effect?

Part 3: Class Consensus Model

After students have created their individual models, hold a whole-class discussion in which the class builds a Class Consensus Model. Walk students through the class consensus discussion steps below so they can create the Class Consensus Model.

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 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 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:
        1. We agree with _____'s group, and we also want to add _____.
        2. We disagree with _____'s group because _____
        3. 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. How are we showing the movement of matter in this model? The movement of energy?
        v. How are we showing the greenhouse effect in this model and its relationship to matter and energy in the system?
        vi. What similarities should we show between the methane panel and the CO_2 panel? What differences?

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

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

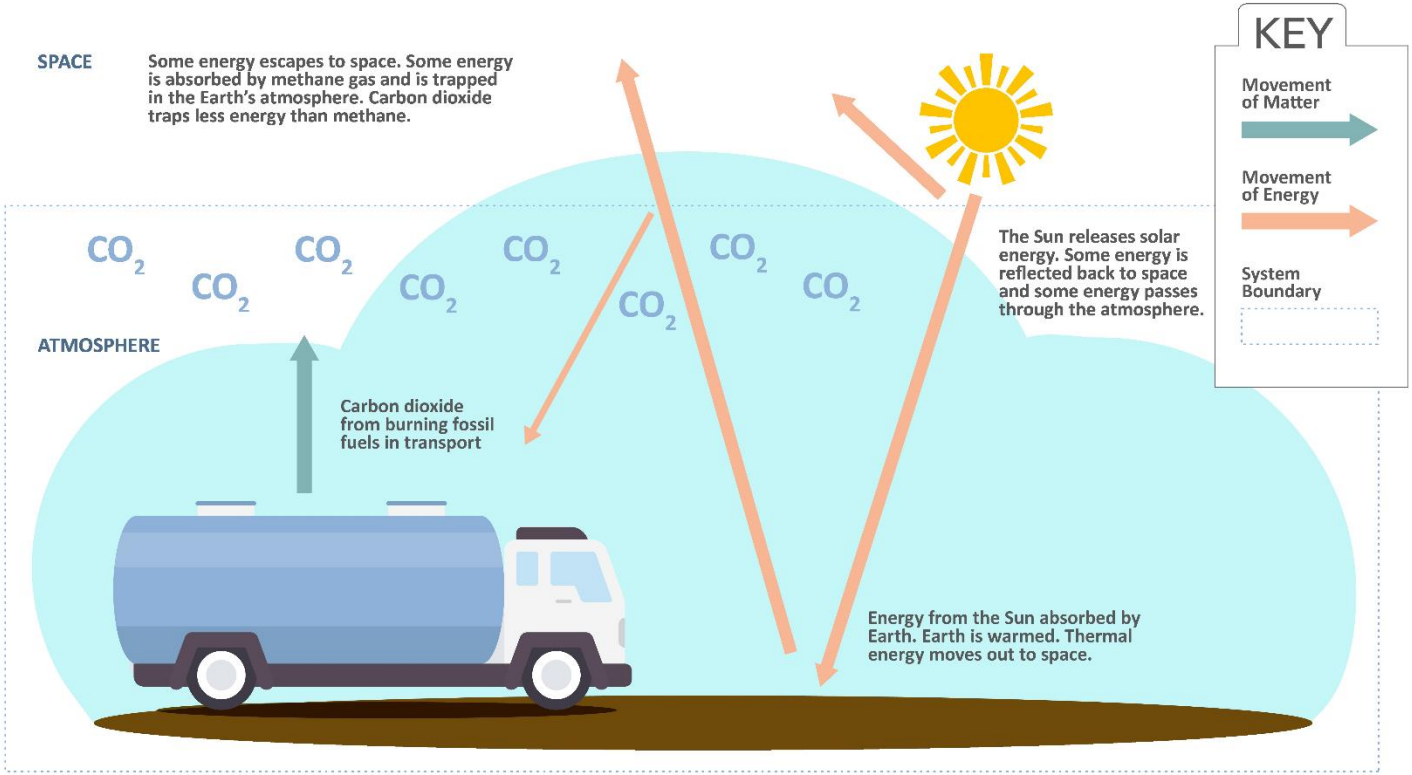
CCSS SUPPORT

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.

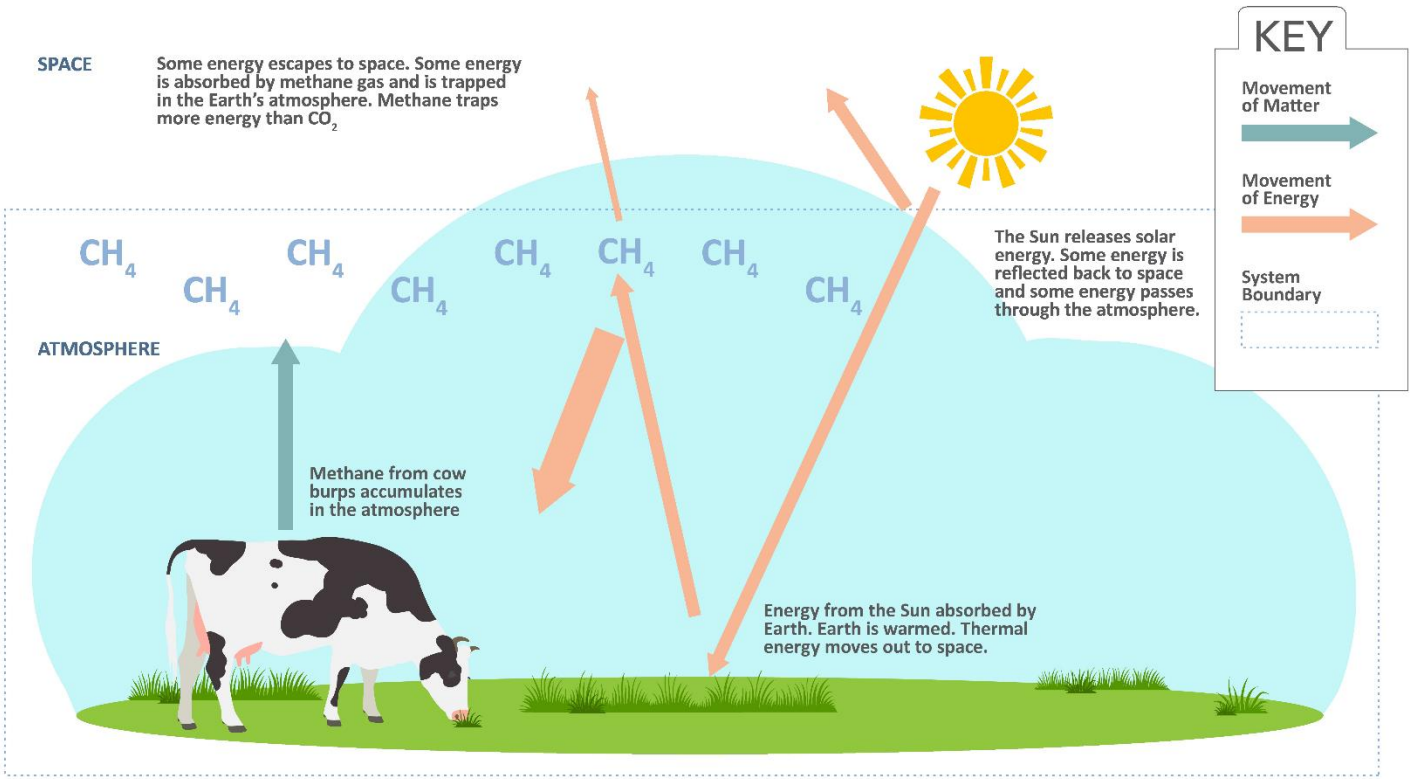
Because student models may differ, it is important to emphasize this standard to help students focus on evidence vs. opinion when discussing what components to include in a Class Consensus Model. By centering the conversation around the evidence presented and the elements of a strong model with clear inputs and boundaries aligning with the content presented in the module, there is guidance on how to justify understanding among peers.

Here is one 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 in Lesson 9 Student Guide Part 3: Class Consensus Model.

Example Class Consensus Model



(Continued on next page)



The dairy system and its emissions can contribute to climate change, namely the increase in average temperatures. Earth is warmed by solar radiation. This solar radiation warms the planet, which then gives off thermal energy. The thermal energy is trapped in the atmosphere, which is the atmospheric temperature we feel. Greenhouse gases like carbon dioxide and methane play a role in trapping heat in the atmosphere. Global GHG concentrations have increased over time, particularly since the Industrial Revolution, due to human activity emitting fossil fuels into the atmosphere. An increase in GHG concentrations in the atmosphere causes the average surface temperature of Earth to rise. If the input of electromagnetic energy is not balanced with the output of thermal energy in Earth's system, then the temperature will rise. Carbon dioxide from transportation in the dairy system and methane from cow burps move into the atmosphere. These greenhouse gases prevent thermal energy from the Earth from exiting the Earth system, which will raise the temperature.

After the Class Consensus Model is built, you can help students unpack how they have used the term **climate change** throughout the module so far. In this module, students have uncovered how the greenhouse effect can give rise to changes in Earth's average surface temperature. Share with students that the long-term shifts in Earth's average surface temperature, in addition to other changes in long-term climate patterns, are what we mean when we say climate change.

?? 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 Question: *"How could cow burps be influencing climate change?"* They can write these questions on their Lesson 7 Student Guide Part 5: Asking New Questions. Add these questions to the Greenhouse Gas and Climate 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:

- Do human activities or cow burps contribute more to greenhouse gases in the atmosphere?
- Throughout history, what has caused more greenhouse gases in the atmosphere, humans, or cow burps?
- What are the other parts of the dairy system that lead to climate change?
- Is there more carbon dioxide or methane in the atmosphere?
- Which is worse for the atmosphere, carbon dioxide or methane?
- Is there any way to get rid of greenhouse gases in the atmosphere?