CALIFORNIA'S CLIMATE-SMART FARMS

DAIRY AND GREENHOUSE GASES

OVERVIEW

In these three activities, students explore the relationship between dairy farming and greenhouse gases, focusing on methane. Each activity in the set is designed to stand alone. The activities may also be combined to make a more complex learning progression.

GRADE LEVEL: 6–8

CENTER FOR ECOLITERACY

CENTER FOR ECOLITERACY

Published by Learning in the Real World

CALIFORNIA FOOD FOR CALIFORNIA KIDS® downloadable resource

Center for Ecoliteracy
David Brower Center
2150 Allston Way, Suite 270
Berkeley, CA 94704-1377

For more information about this activity, email info@ecoliteracy.org or visit www.ecoliteracy.org

Learning in the Real World®

Learning in the Real World is a publishing imprint and registered trademark of the Center for Ecoliteracy, a not-for-profit, tax-exempt organization. Created in 1997, Learning in the Real World offers resources to support schooling for sustainability, stories of school communities, and the ecological framework that informs the work of the Center.

CALIFORNIA FOOD
FOR CALIFORNIA KIDS®

Table of Contents

DAIRY AND GREENHOUSE GASES

Summary of Activities

.

ACTIVITY	TIME	MATERIALS
ACTIVITY 1 **What do cow burps have to do with climate change?** Students analyze graphical data showing milk production and greenhouse gas emissions in California to identify relationships between dairy cattle milk production and methane emissions.	• One 50-minute period	• Copies of student pages • Access to internet (optional)
ACTIVITY 2 **How do cows produce methane?** Students plan and conduct an investigation to observe how organic materials break down to produce methane, modeling what happens in cows' stomachs.	• One 50-minute period to set up, plus time to analyze results	• Copies of student pages • Materials for investigation: different kinds of food waste, water bottles, tape, marker, blender, funnel, balloons, or materials for student-designed investigation
ACTIVITY 3 **How can people minimize methane from dairy farming?** Students read a profile of Straus Family Creamery, which is working to address climate change in its dairy production, and identify additional steps individuals can take.	• One 50-minute period	• Copies of student pages • Access to internet (optional)

Background

Did you know that California is “cow country”? Dairy is California’s top agriculture commodity in terms of revenue, and California is the leading dairy producer in the United States. It produces almost 20 percent of the nation’s milk supply. The average California dairy cow makes 10,000 kg of milk—about 2,630 gallons—a year.

Like other farmers, dairy farmers are concerned with our changing climate. High heat and drier conditions can increase stress in dairy cattle and reduce their milk production. High heat can also reduce the amount of grass available for grazing.

Grazing livestock are a significant contributor to greenhouse gases, primarily from methane. In a process known as enteric fermentation, bacteria in cows’ stomachs help break down and absorb nutrients from cows’ feed, producing methane as waste. Cows emit most of this methane from their mouths as belches. A single cow can belch 70–120 kg of methane a year. In addition, cow manure emits considerable quantities of methane as it breaks down.

Methane is responsible for about a quarter of human-generated global warming. While it is much less prevalent than carbon dioxide (CO^2) and it breaks down in the atmosphere faster, methane is many times more effective than CO^2 at trapping heat. Pound per pound, it has a global warming potential more than 28 times greater than CO^2 over a 100-year period.

A California law will require dairy farmers to significantly reduce methane emissions from their operations starting in 2024. One way they may do that is through methane digesters, which transform manure into energy that can be used to power engines and vehicles. They are also experimenting with changes to their cows’ diets: adding seaweed, for example, can greatly reduce methane emissions from belching.

Cows grazing at Straus Family Farm

Resources

- **Dairy Methane Initiatives.** California Department of Food and Agriculture. This slide presentation outlines the California dairy industry and efforts to reduce methane emissions. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.epa.gov/sites/default/files/2017-11/documents/cdfa-dairy-methane-initiatives_moffitt.pdf
- **Meat and Dairy: Major Problem or Part of the Solution? Understanding Food and Climate Change: A Systems Perspective.** Center for Ecoliteracy. This chapter in the companion to the interactive guide (below) provides an overview of common arguments about the impact of meat and dairy on climate. https://foodandclimate.ecoliteracy.org/systems-perspective/pg0010.xhtml
- **Understanding Food and Climate Change: An Interactive Guide**. Center for Ecoliteracy. This guide uses text, photography, and video to help students and educators learn how food and climate systems interact and how personal choices can make a difference. The Agriculture Production page touches specifically on dairy production. https://foodandclimate.ecoliteracy.org/interactive-guide/cover.xhtml

Extension Ideas

- In addition to methane, dairy farming can produce carbon dioxide, nitrous oxide, and other greenhouse gases. Encourage students to research the sources of these gases in dairy production and what dairy farmers are doing to minimize them, and then to create an infographic showing what they learned.
- To help students explore the cow digestive system more deeply, conduct a lesson from the California Academy of Sciences, **"Ruminating on the Digestive System."** https://www.calacademy.org/educators/lesson-plans/ruminating-on-the-digestive-system.
- Invite students to share their personal or cultural connections to dairy products or dairy farming. For background about some cultural connections, see the book ***Cultures of Milk: The Biology and Meaning of Dairy Products in the United States and India*** by Andrea S. Wiley.
- Encourage students to explore another strategy to reduce methane emissions in California and also help to conserve water by reducing the flooding of rice paddies. For one place to start, see "**Could Changing the Way We Farm Rice Be a Climate Solution?**" https://civileats.com/2020/04/23/rice-farming-has-a-huge-carbon-footprint-could-it-become-a-climate-solution/
- Challenge students to create an educational campaign (PSA, poster, social media, etc.) to inform others about the relationships among methane, agriculture, and climate change they learned from the activities.

Note: Complete activity sets for all the *California's Climate-Smart Farms* lessons are available at: https://www.ecoliteracy.org/download/climate-smart-lessons

ACTIVITY 1

What Do Cow Burps Have to Do with Climate Change?

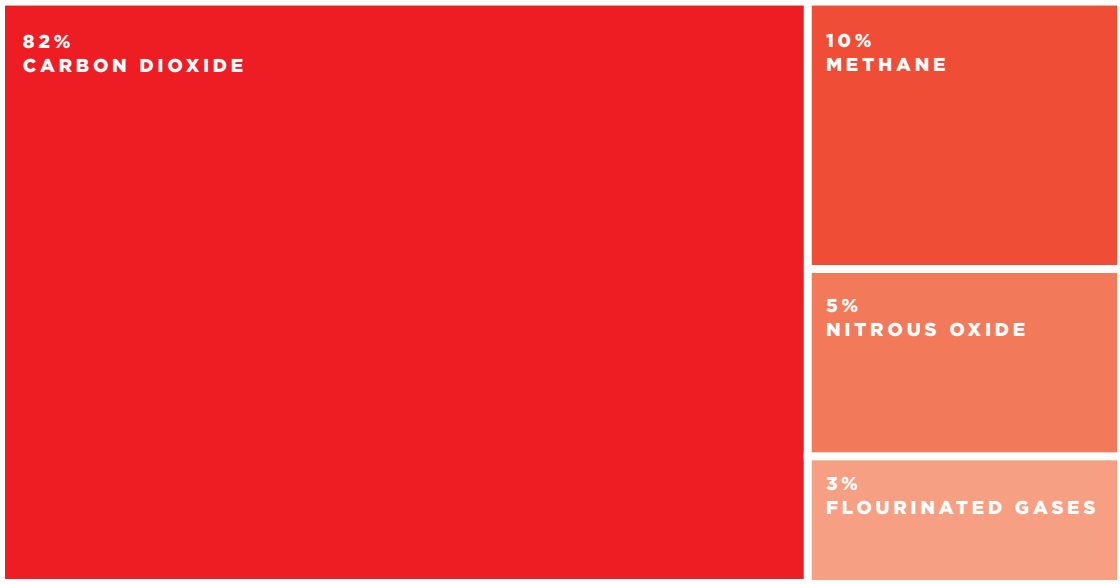
Students analyze graphical data showing milk production and greenhouse gas emissions in California to identify relationships between dairy cattle milk production and methane emissions.

What Do Cow Burps Have to Do with Climate Change?

Evidence

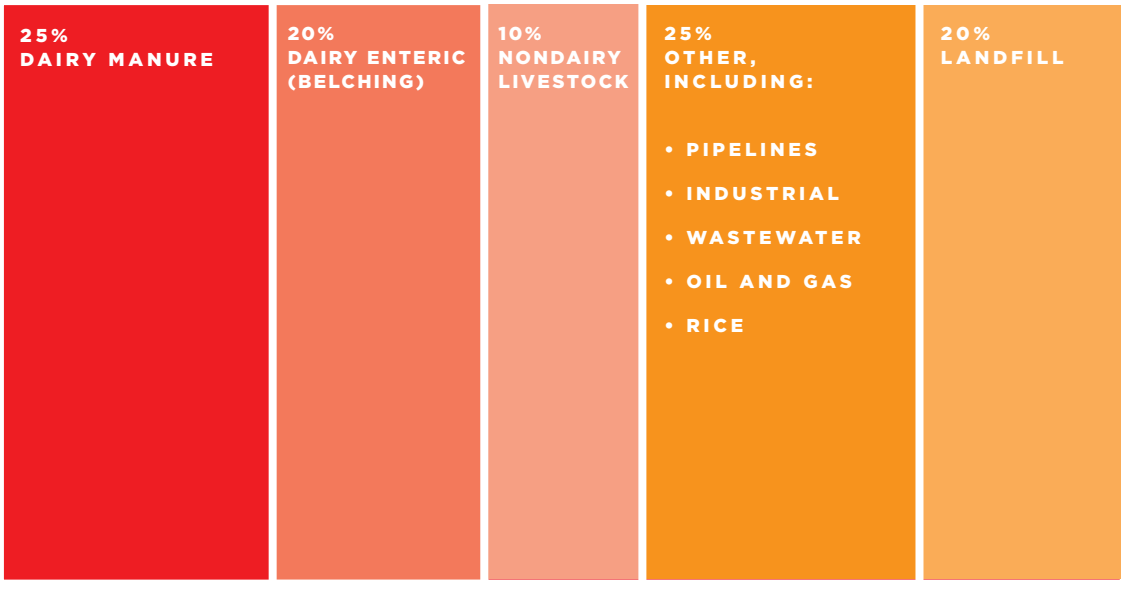
Methane is a greenhouse gas. Greenhouse gases trap heat in the Earth's atmosphere and are necessary for life on Earth. Increased levels of greenhouse gases from human activities are causing changes in Earth's climate. Methane is second to carbon dioxide in the amount of greenhouse gas emitted in the United States.

US GREENHOUSE GAS EMISSIONS IN 2017

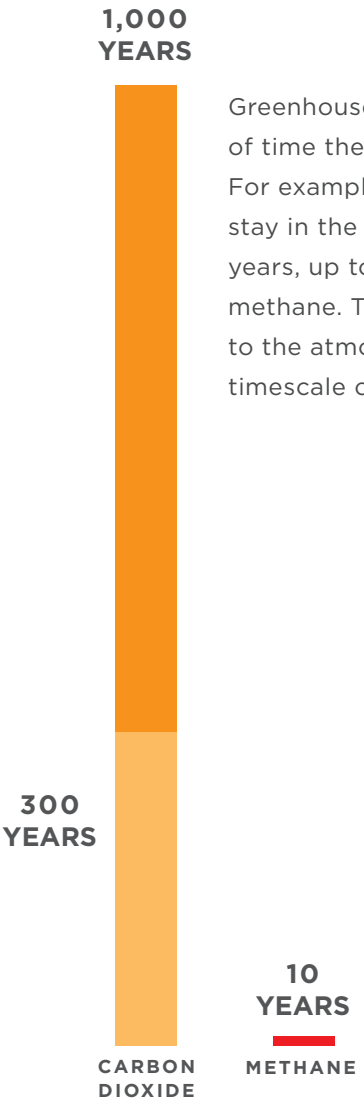


According to the California Air Resources Board, 25 percent of California's methane emissions are from dairy manure and 20 percent are from dairy cows belching.

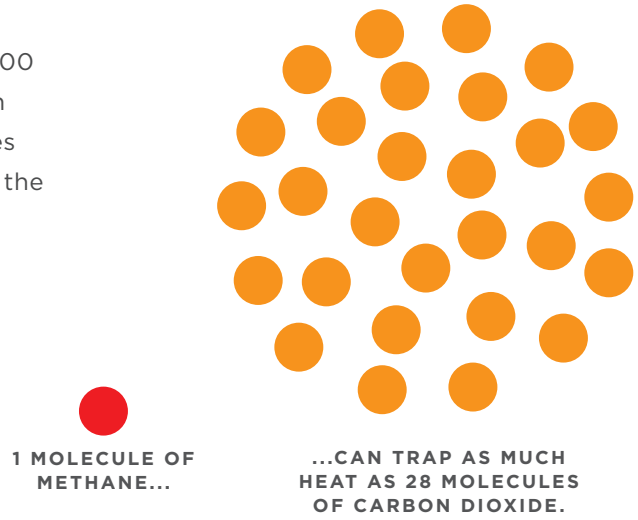
SOURCE OF METHANE EMISSIONS IN CALIFORNIA IN 2017



STRENGTH OF GREENHOUSE GASES



Greenhouse gases vary in the amount of time they stay in the atmosphere. For example, carbon dioxide can stay in the atmosphere 300 to 1,000 years, up to 100 times longer than methane. That means that changes to the atmosphere can endure on the timescale of many human lives.



Although it leaves the atmosphere more quickly, pound per pound, methane is 28 times more potent than carbon dioxide as a heat-trapping gas.

GLOSSARY TERMS

Enteric (adjective) Relating to the intestines.

Carbon dioxide (CO^2) (noun) A colorless, odorless gas with each molecule composed of one carbon atom and two oxygen atoms.

Greenhouse gas (noun) A gas in the atmosphere that absorbs the sun's energy and helps hold heat in.

Methane (noun) A colorless, odorless gas with each molecule composed of one carbon atom and four hydrogen atoms.

Guiding Question: What Do Cow Burps Have to Do with Climate Change?

POSSIBLE ANSWERS

Look at the evidence from the previous page. **What possible answers to the question are presented?**

DIGGING DEEPER

Research to find out more about how methane from cows and other sources compare to carbon dioxide as a greenhouse gas. Places to start:

- **Methane: The Other Greenhouse Gas.** KQED. This 4-minute podcast describes sources of methane and how it compares to CO^2 as a greenhouse gas. https://opb.pbslearningmedia.org/resource/kqedcl11.sci.ess.methanetheothergreenhousegas/methane-the-other-greenhouse-gas/
- **Methane Sources.** NASA. This 2-minute video shows a visualization of different sources of methane across the globe. https://climate.nasa.gov/climate_resources/225/video-methane-sources/
- **How Bad of a Greenhouse Gas is Methane?** Scientific American. This article compares the greenhouse gas potency or strength of methane and CO^2. https://www.scientificamerican.com/article/how-bad-of-a-greenhouse-gas-is-methane/
- **Methane vs. CO^2.** University of Chicago. Play the video to see a description of mathematical models comparing CO^2 and methane in terms of concentrations and Earth's warming over time. http://climatemodels.uchicago.edu/slugulator/slugulator.mp4

Summarize what you learned:

WHAT DO YOU THINK?

Using the evidence from the previous pages and your additional research, explain your answer or solution to the question.

Claim: Write a sentence stating your answer.

EVIDENCE

Data: Include data that supports your claim.

REASONING

Explanation: Share how your evidence supports your claim.

ACTIVITY 2

How Do Cows Produce Methane?

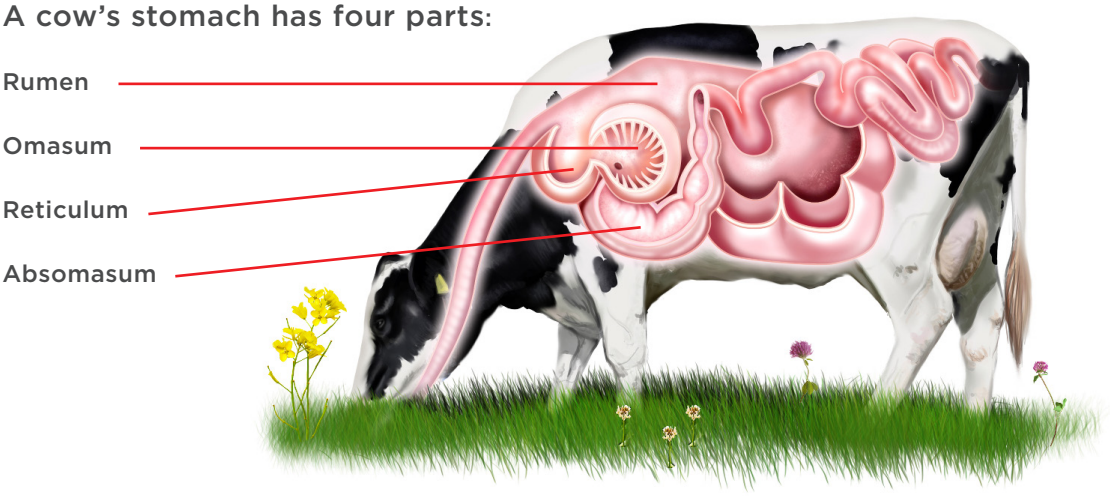
Students plan and conduct an investigation to observe how organic materials break down to produce methane, modeling what happens in cows' stomachs.

How Do Cows Produce Methane?

Evidence

Dairy cows eat grass and other plant materials that are tough and hard to digest. Like other ruminants, their stomachs have four compartments. Bacteria in the cow's first stomach, or rumen, help to break down the food so that it can be absorbed. As the bacteria do their work, they emit methane, which is a greenhouse gas.

A cow's stomach has four parts:



Plan and carry out an investigation, such as the following, to learn what happens as materials break down in a cow's stomach to produce methane.

EXAMPLE INVESTIGATION

1. Choose four different kinds of food waste to investigate. For example: carrot peelings, potatoes, lettuce, and watermelon.

2. Wash out four empty clear glass or plastic bottles that are the same size. Label each with a different food item and mark a line ¾ of the way from the bottom of each bottle.

3. Weigh your food items. Some scales weigh items in grams and some weigh items in ounces. Depending on the kind of scale you have, weigh 60 grams or two ounces of each food item. One at a time, cut up and puree each item in a blender with ½ cup of water.

Then, using a funnel, pour each into a separate bottle. (Clean the blender between each food.) Fill each bottle with water up to the line.

4. Place a balloon over the mouth of each bottle and secure it with tape so that no air can get in or out.
    - What do you think will happen?

5. Observe the bottles every day for the next week.
    - What did you notice about the balloons and food?
    - What do you think is happening inside the bottles? The balloons?

GLOSSARY TERMS

Enteric (adjective) Relating to the intestines.

Fermentation (noun) The chemical breakdown of a substance by bacteria or other microorganisms.

Methane (noun) A colorless, odorless gas with each molecule composed of one carbon atom and four hydrogen atoms.

Rumen (noun) The first part of the stomach of cows and other ruminants, which partly breaks down food through fermentation.

Ruminant (noun) One of a group of animals that can get nutrients from plant material by fermenting it in a specialized stomach. Cattle, sheep, deer, and giraffes are ruminants.

Guiding Question: How Do Cows Produce Methane?

POSSIBLE ANSWERS

Look at the evidence from the previous page. **What possible answers to the question are presented?**

DIGGING DEEPER

Research to find out more about cows, cow digestion, and methane. Places to start:

- **What's the Fuss About Cow Burps?** Science News. This 2-minute video describes how cows produce methane and its effect on the planet. https://www.youtube.com/watch?v=WshrROiPlD0
- **Ruminant Digestion - Methane.** This 2.5-minute video describes how enteric methane is produced from fermentation in cows' guts. https://www.youtube.com/watch?v=3NG5foxD2HI
- **How Cows Eat Grass: Exploring Cow Digestion.** U.S. Food and Drug Administration. This article details the unique digestion system of the cow. https://www.fda.gov/animal-veterinary/animal-health-literacy/how-cows-eat-grass

Summarize what you learned:

WHAT DO YOU THINK?

Using the evidence from the previous page and your additional research, explain your answer or solution to the question.

Claim: Write a sentence stating your answer.

EVIDENCE

Data: Include data that supports your claim.

REASONING

Explanation: Share how your evidence supports your claim.

ACTIVITY 3

How Can People Minimize Methane from Dairy Farming?

Students read a profile of Straus Family Creamery, which is working to address climate change in its dairy production, and identify additional steps individuals can take.

Straus Family Creamery and Farm in Marin and Sonoma Counties

How Can People Minimize Methane from Dairy Farming?

Evidence

The Straus Family Creamery produces premium organic milk products and is committed to practices that sustain its animals, its dairy, and the Earth. The dairy farm was founded in 1941 after Bill Straus fled wartime Europe with his family. He and his wife, Ellen, became leading environmentalists in the Bay Area. Later, the family established the first certified organic dairy farm west of the Mississippi River and the first 100% certified organic creamery in the United States.

For its creamery, Straus buys certified organic milk from eight other organic family farms in Northern California's Marin and Sonoma Counties, which it uses to make products such as yogurt and ice cream. The Straus family also raises its own cows that graze on sweet, pesticide-free grasses that thrive in the mild coastal climate of Marin County.

Albert Straus, founder and CEO of Straus Family Creamery

Straus bottles its milk in reusable glass bottles, keeping waste out of landfills and oceans. It also has installed a water system so that it can reuse its water instead of sending it down the drain.

How does this organic farm address methane emissions? Led by manager Albert Straus, the farm uses a methane digester to capture methane from the cows' manure and transform it into electricity. The digester provides enough renewable energy to power the entire dairy farm and charge farm vehicles. It has reduced methane emissions by more than 3.5 million pounds of carbon dioxide each year—roughly equivalent to removing about 350 cars from roads.

Straus Family Creamery: https://www.strausfamilycreamery.com/

Straus's vehicle powered with electricity generated by their methane digester

California has laws in place to reduce greenhouse gas emissions in the state. The 2030 goal is to reduce total methane emissions from the state's dairy farming to 60 percent of 2010 levels. To meet these requirements, most dairy farms will need to reduce their methane emissions. In addition to converting cow manure into energy, dairy farmers may employ other practices like using feed that is easier for cows to digest to reduce belching, adding feed supplements like red seaweed, or using manure storage systems that confine methane.

GLOSSARY TERMS

Carbon dioxide (CO^2) (noun) A colorless, odorless gas with each molecule composed of one carbon atom and two oxygen atoms.

Greenhouse gas (noun) A gas in the atmosphere that absorbs the sun's energy and helps hold heat in.

Methane (noun) A colorless, odorless gas with each molecule composed of one carbon atom and four hydrogen atoms.

Renewable energy (noun) Power from sources that cannot be used up, such as the sun, wind, and waves.

Guiding Question: How Can People Minimize Methane from Dairy Farming?

Possible Answers

Look at the evidence from the previous page. **What possible answers to the question are presented?**

DIGGING DEEPER

Research to find out more about what farmers and individuals can do. Places to start:

- **Cow Burps Are Warming the Planet.** Curiosity Stream. PBS. This 3-minute video describes ways researchers are working to reduce the amount of methane cows emit. https://www.youtube.com/watch?v=MnRFUSGz_ZM
- **Methane: 4 Steps to Reduce this Greenhouse Gas.** Good Housekeeping. This article describes four steps individuals can take to reduce methane emissions. https://www.goodhousekeeping.com/institute/a20388/reduce-methane-greenhouse-gas/
- **The cows that could help fight climate change.** BBC. This article describes some wacky things people are exploring to reduce methane emissions from cows. https://www.bbc.com/future/article/20190806-how-vaccines-could-fix-our-problem-with-cow-emissions

Summarize what you learned. What positive and negative effects could these actions have?

WHAT DO YOU THINK?

Using the evidence from the preceding pages and your additional research, explain your answer or solution to the question.

Claim: Write a sentence stating your answer.

EVIDENCE

Data: Include data that supports your claim.

REASONING

Explanation: Share how your evidence supports your claim.

CENTER FOR ECOLITERACY

ABOUT THE CENTER FOR ECOLITERACY

The Center for Ecoliteracy is an internationally recognized leader in education for the sustainability of people and the planet. Since 1995, the Center has engaged with thousands of educators from across the United States and six continents. The Center offers publications, seminars, coaching for teaching and learning, in-depth curriculum development, keynote presentations, and technical assistance. Our California Food for California Kids® initiative connects public school districts as they advance their work in providing students with fresh, locally-grown food and reinforcing connections between the classroom, cafeteria, and garden. With a network of over 100 public school districts across the state, California Food for California Kids helps districts share the knowledge, experience, and caring of its participants to advance practical solutions that transform school food systems and how students learn about the food they eat.

CREDITS

Author Leslie Comnes

Designer Karen Brown

PHOTOS

Straus Family Creamery Photos courtesy Straus Family Creamery

Student activities Karen Brown

Stock photos milk bottle: iStock.com/EasyBuy4u; balloon: iStock.com/Anna Valieva; cow: iStock.com/GlobalIP; milk: IStock.com/Okea; cow digestion: Nicolas Primola/Shutterstock.com

Our deepest gratitude to Straus Family Creamery, who shared their stories, knowledge, and photos in the development of this lesson. Their generosity and wisdom will help students understand and adapt to the challenges they may face in the future of agriculture.