# Do Dairy Cows' Burps and Farts Change the Climate?

**Suggested Grade Level:** 6-8

**Time:** 4 45-minute periods

**Subject:** Science, Biology, Chemistry, Environment, English Language Arts, Writing, Research, Health, Environmental Health, Personal Health, Social Studies, Climate Change and Global Warming, Agriculture, Dairy

**Overview:** In this four-day, cross-curricular lesson, students explore how dairy cows contribute to greenhouse gas emissions through digestion and manure, and what the dairy industry is doing to reduce its environmental impact. Through engaging experiments, interactive models, videos, and discussions, students learn about the science behind ruminant digestion, the chemistry of methane production, and the real-world innovations that help agriculture combat climate change.

**Objectives:**

1. Identify the two primary gases ruminants emit.
2. Describe the process of fermentation.
3. Demonstrate how gas is created.
4. Explain why greenhouse gases are detrimental to the environment.
5. List ways the dairy industry is decreasing greenhouse gas emissions

**Background Information**

Two of the world's most significant challenges are feeding a rapidly growing population and caring for our planet. In the United States, dairy farms play a significant role in meeting the need for nutritious food. In 2022, approximately 24,094 U.S. farms produced and sold $52.8 billion worth of milk, maintaining around 9.342 million milk cows. In 2016, the top 23 milk-producing states collectively produced 212.4 billion pounds of milk—about 24.7 billion gallons. That averages to roughly 72 gallons of milk per year for each of the 342 million people living in the United States at the time (National). Dairy farmers not only provide this vital food source, but also act as stewards of the environment. They care for the land, water, and air because they want their farms to thrive for future generations.

One primary concern in dairy production is reducing its environmental impact, especially concerning global warming. Global warming refers to changes in the Earth's temperature caused by greenhouse gases (GHGs), which include carbon dioxide, methane, nitrous oxides, and water vapor. Dairy farming contributes to GHG emissions through several direct sources: methane and carbon dioxide are released by the

digestive systems of cows, as well as from manure and soil. Additional emissions result from the use of fossil fuels and from decomposing organic matter like fertilizers.

However, reducing emissions without significantly decreasing production has been a constant challenge for the dairy industry. Some people have suggested eliminating dairy cows as a solution. Still, a study by researchers at Virginia Tech and the USDA found that doing so would reduce U.S. greenhouse gas emissions by only about 0.7%. Eliminating milk would also remove a key source of nutrients, requiring costly replacements. Milk production is responsible for about 1.3% of total U.S. GHG emissions. Still, few foods match milk's nutritional content—especially calcium, vitamin D, riboflavin, and alpha-linolenic acid—at the same calorie count and cost. Importantly, between 2007 and 2017, dairy farming in the U.S. became significantly more efficient, using 21% less land, 30.5% less water, 20% less fuel, and 17% less feed (U.S.). Today, the U.S. dairy industry accounts for approximately 2% of national greenhouse gas emissions and has set an ambitious goal to reach carbon neutrality by 2050 (McComb)

One primary source of emissions is methane, which dairy cows release as a natural part of digestion, like all ruminant animals. Methane is primarily emitted through burping and breathing, accounting for 90–95% of the total released by cows; the remaining 5–10% is emitted through manure and flatulence (Torgovnick). Each cow emits about three tons of carbon dioxide equivalent per year in the form of methane. To reduce this, scientists and farmers are exploring feed-based solutions. For instance, the Brazilian company DSM developed a feed additive known as 3-NOP. When applied at 60 mg/kg of the total mixed ration (TMR), it can cut methane emissions by 22–35% (DSM). Similarly, some Australian farmers have begun adding just 3% seaweed to cow diets and have seen methane emissions drop by more than 95% (Department). Researchers are also exploring methane-reducing forage crops such as plantains.

In addition to feed additives, selective breeding may be another long-term solution. Researchers have discovered that some cows naturally produce less methane. Breeding for this trait could potentially reduce emissions by 3–8% annually over 20 years. Another emerging approach is the development of a methanogen vaccine, which aims to reduce methane emissions from all ruminants by at least 30%. This vaccine works by targeting the methane-producing microbes (methanogens) in the cow's digestive system. It is currently undergoing laboratory testing (Beil). Although methane is more potent than carbon dioxide—trapping 28 times as much heat in the atmosphere—it breaks down much faster. Methane is naturally destroyed within about 10 years, whereas carbon dioxide can remain in the atmosphere for thousands of years (U.S.).

Each dairy cow eats about 90 pounds of food and drinks about 40 gallons of water daily. In addition to producing milk, cows also generate about 30 pounds of manure per day. This manure emits a mix of greenhouse gases, including carbon dioxide, methane, ammonia, and hydrogen sulfide. Rather than letting it go to waste, farmers often recycle it as fertilizer on crop fields. Manure is sometimes separated into liquid and solid

components. Manure storage and water management are regulated by local, state, and federal governments to ensure the safety of farmers and the environment. Some dairy farms use anaerobic digesters to turn manure into renewable energy. These systems convert manure into methane biogas, which can be used to generate electricity. If the farm produces more electricity than it needs, the excess can be sold to local utility companies. The remaining material, called digestate, has many uses. Its solid form can be dried and turned into pelleted fertilizer, renewable fuel, or even construction materials. Products like medium-density fiberboard and wood-plastic composites have already been created from digestate (AgSTAR).

Thanks to innovation and improvements in animal care, dairy farmers have significantly increased milk productivity while reducing their environmental impact. Between 1944 and 2007, the U.S. dairy industry reduced the number of cows needed to produce the same amount of milk by 79%, while total milk production increased by about 59%. As a result, methane emissions per unit of milk decreased by 57% (Capper, Cady, & Bauman, 2009). In 2007, the average cow produced about 20,261 pounds—or roughly 2,356 gallons—of milk annually (Capper). Beyond nutrition and sustainability, the dairy industry plays a significant role in the U.S. economy. Each gallon of milk supports jobs in transportation, veterinary care, nutrition, and manufacturing. Overall, the industry supports 3.05 million U.S. jobs and generates $779.45 billion in economic activity (International). Dairy is the largest segment of U.S. agriculture, which itself is the nation's largest industry. As of 2022, the dairy industry contributed $59 billion directly to the U.S. economy (Law).

**Kansas Industry Information:**

The dairy industry is an integral part of Kansas's agricultural economy, creating jobs and generating billions in economic activity across the state. With about 175,000 dairy cows on over 209 farms—ranging from small family dairies to large operations—Kansas ranks 17th in the nation for milk production and 15th for milk output per cow. In 2023, Kansas dairies produced 4.2 billion pounds of milk, valued at more than $1 billion. The average Kansas dairy cow produces approximately 7.56 gallons of milk per day, contributing around $15.80 in value daily. The industry supports more than 3,500 jobs when including direct, indirect, and induced impacts, and contributes over $1.4 billion to the Kansas economy. Kansas is also home to approximately 193 licensed dairy herds and seven processing plants, which helps keep more of the economic benefits within the state. Projects like the Dairy Farmers of America milk powder plant in Garden City help ensure that around 75% of Kansas milk is processed locally. Dairies provide jobs not only on farms, but also in areas such as transportation, veterinary care, nutrition consulting, and equipment services. Each dairy cow alone contributes more than $8,600 to the local economy annually, illustrating the significant impact dairies have on rural communities (Kansas).

**Materials:**

*Day 1: How Does Gas Build Up in a Cow's Stomach?*
(By group)

- How Does Gas Build Up in the Stomach Worksheet (provided)
- 4 Empty 20-oz water/soft drink bottles with caps
- 1 Tsp flour
- 6 Tsp sugar for each group
- 3 packets of active dry yeast or dry quick-rise yeast
- Warm tap water
- 4—9-inch latex balloon
- Funnel
- 250 ml measuring cup

*Day 2: How Does a Burp Occur?*


- Toilet tissue–one square per student or group
- 1 tablespoon baking soda
- Tape
- ½ cup Vinegar
- Small Ziplock sandwich baggie
- Large poster board or bulletin board paper
- Markers
- Scissors
- Glue
- How Does a Burp Occur? Activity (provided)
- Ruminant Stomach Activity (provided)
- Ruminant Stomach Activity Answer Key (provided)

*Day 3: Ruminant Digestion*

- 1 small Ziploc bag
- water
- A variety of food items: bread, cheese, chicken or other meat, grapes and other soft fruits, etc.
- Scissors
- ½ cup of ammonia, vinegar, cola, or orange juice
- ½ teaspoon of salt
- Matches (2 stick matches)
- Paper towel
- A bowl or tray to catch excess fluids
- 1 teaspoon yeast
- Group food slips (provided)
- Ruminant Digestion Experiment (provided)

*Day 4: Ruminant Digestion Continued*

- Ziploc bags from day 3
- Stick pin
- Ruminant Digestion Experiment (provided)
- Ruminant Stomach Activity (provided)

**Day 1: How Does Gas Build Up in the Stomach?**
**Instructional Format:**

1. Review background information.
2. Conduct engagement exercise.
3. Lead a class discussion.
4. Complete the activity.
5. Conduct assessment exercise.

**Engagement:**
Introduction: Play this video for your class. Note: These are middle school students, and the topic of burps and farts is inherently comical. So, asking them what they know about burps and farts, and allowing them to 'get them out of their system' for a minute or so, would be helpful in later work. Reactions: Cow Burps are Warming the Planet https://www.youtube.com/watch?v=MnRFUSGz_ZM.

**Procedures:**
*Discussion*

1. After playing the video, ask for a show of hands to summarize it.
2. Then, introduce the experiment. You will find the full step-by-step student instructions and experiment setup on a separate handout titled "How Does Gas Build Up in the Stomach? Experiment" (at the end of the lesson). Review it before class and gather the required materials listed.
3. Introduce the concept of ruminants and explain that cows don't have four stomachs, but one stomach with four compartments. Focus primarily on the rumen and its role in digestion and gas production.
4. Explain that the class will be creating a model of the rumen using bottles, yeast, sugar, and balloons to observe how gas builds up and forms a "burp."

*Activity*

1. Split the class into small groups.
2. Gather all materials before starting: four empty bottles with caps, four balloons, sugar, flour, yeast, warm and cold water, a funnel, and a measuring cup. Label the bottles 1, 2, 3, and 4.
3. Add ingredients to the bottles as follows:
   Bottle 1 – sugar, yeast, warm water
   Bottle 2 – sugar, warm water
   Bottle 3 – flour, yeast, warm water
   Bottle 4 – sugar, yeast, cold water
4. Put the caps on and shake each bottle gently to mix the contents. Then, remove the caps and stretch a balloon over the top of each bottle.
5. Ask students what they think will happen in each bottle. Let the bottles sit for at least three minutes.
6. Watch the balloons. Have students write down what they see. After a few minutes, swirl each bottle gently and observe any changes.

7. Ask which bottle has the biggest balloon and why. Talk about how this is like what happens in a cow's rumen, where microbes break down food and make gas. That gas becomes a burp.
8. Assess students based on their answers to the experiment.

**Day 2: How Does a Burp Occur and Ruminant Stomach Activity**
**Instructional Format:**

1. Lead a class discussion.
2. Complete Activity 1.
3. Complete Activity 2.
4. Conduct assessment exercise.

**Procedures:**

*Discussion*

1. Start by explaining to students that today's experiment will help them understand why burps happen. Inform them that both humans and cows produce gas during digestion, and when this gas builds up, it must be released. In cows, this can happen through frequent burping, and in humans, too much gas can cause discomfort. Let students know they'll use baking soda and vinegar to model how gas builds up and creates pressure, just like in a stomach.
2. Next, have students predict what they think will happen when they mix the materials. Ask them to write down their hypothesis.

*Activity 1: How Does a Burp Occur*

1. Have students work individually or in pairs.
2. Provide the materials listed and have them follow the step-by-step instructions on the student handout (provided)
3. Once they've sealed the bag, instruct them to toss it gently away from themselves and observe what happens.
4. After the reaction, lead a discussion. Discuss whether the experiment behaved as expected and why. Connect the experiment to real-life burping in humans and cows by explaining that gas builds up in the stomach or rumen and must be released to avoid discomfort.

*Activity 2: Ruminant Stomach Activity*

1. Review the four components of a ruminant's stomach by providing the Ruminant Stomach Activity. Have students complete steps one through four.
2. Place the last page of the 'Ruminant Stomach Activity' in a separate location for students to use after completing the stomach arrangement, but before they glue it down.

**Day 3: Ruminant Digestion**
**Instructional Format:**

1. Conduct engagement exercise.
2. Complete the activity.
3. Conduct assessment exercise.

**Engagement:**
Watch FOX 13 Tampa Bay: His job is to study cow burps
https://www.youtube.com/watch?v=xqi9aG-tLpc.

**Procedures:**
*Activity*

1. Complete Ruminant Digestion Experiment Day 1.
2. Give each group a small ziplock bag, scissors, water, yeast, salt, cut-up matches, an acidic liquid (like vinegar or cola), a paper towel, and a bowl or tray. Distribute the provided slips (at the end of the lesson).
3. Have students tear or cut their food into small pieces and put them in the bag. Explain this is like a cow's front teeth biting food. Add a little water to moisten and mash the food, mimicking the cow's molars and stomach muscles at work.
4. Next, add the acidic liquid and mix again. This represents the acid and enzymes in the cow's stomach.
5. Wrap the bag with paper towels and gently squeeze it for two minutes to mimic the action of stomach muscles. Press the liquid away from the solids over the tray, but keep the solids mostly together.
6. Pour out the liquid (this is like nutrients absorbed in the small intestine). Return the solids to the bag. Add yeast, salt, and cut-up matches to represent microbes and digestion. Seal and label the bag with the group name and food items.
7. Place the bag in a warm spot to sit overnight until the next day.

**Day 4: Ruminant Digestion Continued**
**Instructional Format:**

1. Complete Activity 1.
2. Lead a class discussion.
3. Complete Activity 2.
4. Conduct assessment exercises.

**Procedures:**
*Activity 1: Ruminant Digestion Continued*

1. Begin by reviewing Day 1. Remind students that they mixed food, liquids, and microbes in a bag to simulate the digestive process of a cow. The bags have been sitting in a warm place overnight.
2. Have each group pick up their labeled bag.
3. Instruct students to poke a small hole near the top of the bag and gently waft the smell from the bag toward their nose.
4. Explain that this model demonstrates the later stages of digestion, where gas is produced.
5. Have students rate the smell on a scale from 1 (least smelly) to 10 (strongest smell).

6. Complete the Ruminant Digestion Experiment and have students submit their completed forms.

*Discussion*

1. Lead a class discussion using these questions:
    - What happened to your bag overnight?
    - How does this experiment explain why cows and people fart?
    - Why do some farts have more odor than others?
2. Watch WMTW-TV: Cow farts and climate change: It's a real connection, scientists say https://www.youtube.com/watch?v=yimKVVCjqVk.

*Activity 2: Ruminant Stomach Continued*

1. Have students return to the 'Ruminant Stomach Activity' to complete steps 5-11.
2. Provide the article 'Can Cow Farts Cause Global Warming' for students to read.
3. Ask students to draw a simple cow around the stomach diagram, leaving the stomach parts visible.
4. Next, have them draw dotted arrows showing how food moves through the stomach.
5. Then, tell them to draw a burp from the cow's mouth and write: "Burps come from gas in the rumen."
6. Have them draw a fart at the back of the cow and write: "Farts come from gas in the large intestine."
7. Ask them to list the two gases: methane and carbon dioxide.
8. At the bottom, have them write a label: "Ways to Decrease Dairy Cow Gas Emissions." Have students add more ways to reduce GHG emissions from cow operations on their Ruminant Stomach Activity.
9. Tell students: "Scientists aren't the only people working to make dairy production safe and sustainable—another important role is the dairy inspector."
10. Briefly describe the dairy inspector's job (using the Career Information section below) and emphasize how inspectors ensure milk and dairy products are safe, properly labeled, and of high quality. Explain that safe, healthy cows produce better milk, and better milk production can reduce waste and improve efficiency—both of which help lower the environmental impact.
11. Wrap up by connecting the experiment to real digestion and gas production in animals. Alternatively, take a field trip to a college or research station where students can see a fistulated cow. A fistulated cow has a window surgically implanted in its side, allowing researchers to reach in and remove the contents of its rumen.

**Vocabulary:**

- **Greenhouse gases (GHG):** gases in the atmosphere that influence the Earth's energy balance.
- **Greenhouse gas emissions:** releasing chemicals that trap the sun's heat and warm up the Earth's atmosphere.

- **Global Warming:** gases in the atmosphere that affect the Earth's temperature and create temperature changes
- **Ruminant:** an animal that chews food that is partially digested in one of its stomach compartments and brought back to the mouth.

## Kansas Standards:

***Next Generation Science Standards***

Matter and Its Interactions

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

From Molecules to Organisms: Structures and Processes

MS-LS1-3. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

Ecosystems: Interactions, Energy, and Dynamics

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Biological Evolution: Unity and Diversity

MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

***Language Arts***

<u>6th Grade</u>

Writing

Text Types and Purposes

W.6.1 Write arguments to support claims with clear reasons and relevant evidence.

Research to Build and Present Knowledge

W.6.7 Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

Language in Writing

W.6.10 Demonstrate command of the conventions of standard English grammar and usage when writing.

W.6.11 Demonstrate command of the conventions of standard English capitalization, punctuation and spelling when writing.

Speaking and Listening

Comprehension and Collaboration

SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on sixth-grade topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

7th Grade
Writing
Text Types and Purposes
W.7.1 Write arguments to support claims with clear reasons and relevant evidence.
Research to Build and Present Knowledge
W.7.7 Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.
Language in Writing
W.7.10 Demonstrate command of the conventions of standard English grammar and usage when writing.
W.7.11 Demonstrate command of the conventions of standard English capitalization, punctuation and spelling when writing.
Speaking and Listening
Comprehension and Collaboration
SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on seventh-grade topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.7.2 Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text or issue under study.

8th Grade
Writing
Text Types and Purposes
W.8.1 Write arguments to support claims with clear reasons and relevant evidence.
Research to Build and Present Knowledge
W.8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
Language in Writing
W.8.10 Demonstrate command of the conventions of standard English grammar and usage when writing.
W.8.11 Demonstrate command of the conventions of standard English capitalization, punctuation and spelling when writing.
Speaking and Listening
Comprehension and Collaboration
SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on eighth-grade topics, texts, and issues, building on others' ideas and expressing their own clearly.

***History, Government, and Social Studies***

Standard 1: Choices Have Consequences
1.1 The student will recognize and evaluate significant choices and consequences that have impacted our lives and futures.
1.2 The student will analyze the context and draw conclusions about choices and consequences.
Standard 2: Individuals have Rights and Responsibilities
2.1 The student will recognize and evaluate the rights and responsibilities of people living in societies.

***Health***
Standard 1: Students will comprehend concepts related to health promotion and disease prevention to enhance health.
1.8.3 Analyze how the environment affects personal health
Standard 5: Students will demonstrate the ability to use decision-making skills to enhance health.
5.8.2 Determine when health-related situations require the application of a thoughtful decision-making process.
Standard 8: Students will demonstrate the ability to advocate for personal, family, and community health.
8.8.1State a health-enhancing position on a topic and support it with accurate information.

**National Agricultural Literacy Standards:**
***Agriculture and the Environment***
- Describe benefits and challenges of using conservation practices for natural resources (e.g., soil, water, and forests), in agricultural systems which impact water, air, and soil quality (T1.6-8 b.)
- Discover how natural resources are used and conserved in agriculture (e.g., soil conservation, water conservation) (T1.6-8 c.)
- Discuss (from multiple perspectives) land and water use by various groups (i.e., ranchers, farmers, hunters, miners, recreational users, government, etc.), and how each use carries a specific set of benefits and consequences that affect people and the environment (T1.6-8 d.)
- Recognize the factors of an agricultural system which determine its sustainability (T1.6-8 e.)

***Food, Health, and Lifestyle Outcomes***
- Identify the careers in food production, processing, and nutrition that are essential for a healthy food supply (T3.6-8 j.)

***Science, Technology, Engineering & Mathematics Outcomes***
- Describe how biological processes influence and are leveraged in agricultural production and processing (e.g., photosynthesis, fermentation, cell division, heredity/genetics, nitrogen fixation) (T4.6-8 b.)
- Identify science careers related to both producers and consumers of agricultural products (T4.6-8 g.)

## Supporting Resources:
Dairy Byproducts Poster
https://ksagclassroom.org/supporting-resources/dairy-byproducts/

Dairy Excellence Foundation: Discover Dairy in Our Environment.
https://www.youtube.com/watch?v=vaLLtaK2we0

Dairy Fun Facts Poster https://ksagclassroom.org/supporting-resources/dairy-fun/

Digest Your Food Activity:
https://www.teachengineering.org/activities/view/usf_biorecycling_lesson01_activity1

Kansas Dairy Poster https://ksagclassroom.org/supporting-resources/kansas-dairy/

Kids Connection Magazine More Than Milk
https://ksagclassroom.org/resource-center/connection/

**Career Information:** Diary Inspectors

Dairy inspectors license, inspect, and sample products at milk processing plants. They also monitor dairy products that are imported to other states. Dairy processing plants and milk transfer stations are inspected at least four times a year. Inspectors ensure compliance with cleaning and sanitation requirements. They verify that the pasteurization equipment's temperatures and holding times comply with federal requirements. All milk and dairy products sold at retail must be pasteurized to ensure public health protection. Each month, inspectors verify that all milk products meet bacterial limits, drug residue limits, coliform bacteria limits, phosphatase testing requirements, vitamin addition standards, and butterfat labeling specifications. All cartons, containers, and closures for dairy products are also inspected. Single-service dairy container manufacturers are also subject to inspection. These facilities produce cartons, containers, and closures for packaging dairy products.

**Assessment:** This lesson includes three built-in assessments: students will complete a drawing, labeling, and listing activity on the cow poster, and answer questions following each of the two experiments.

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**References:**

AgSTAR. (n.d.). *How does anaerobic digestion work?* U.S. Environmental Protection Agency. Retrieved July 31, 2025, from https://www.epa.gov/agstar/how-does-anaerobic-digestion-work

Beil, L. (2021, October 21). *Getting creative to cut methane from cows*. Science News. https://www.sciencenews.org/article/getting-creative-cut-methane-cows

Capper, J. L., Cady, R. A., Bauman, D. E. (2009, March 13). The environmental impact of dairy production: 1944 compared with 2007. *Journal of Animal Science*, 87:2160-2167. doi: 10.2527/jas.2009-1781

Department of Climate Change, Energy, the Environment and Water. (2021, April). *From beaches to burps: Native Australian seaweed key to reducing methane emissions from cows*. Australian Government. https://www.dcceew.gov.au/climate-change/publications/from-beaches-to-burps-native-australian-seaweed-key-to-reducing-methane-emissions-from-cows

DSM. (2019, August). *Taking action on climate change, together*. https://www.dsm.com/content/dam/dsm/corporate/en_US/documents/summary-scientific-papers-3nop-booklet.pdf

International Dairy Foods Association. (2025, June 9). *New report highlights dairy's deep economic impact in communities across America*. https://www.idfa.org/news/new-report-highlights-dairys-deep-economic-impact-in-communities-across-america

Kansas Livestock Association. (n.d.) *Kansas Dairy Facts*. Retrieved March 22, 2022, from https://www.kla.org/dairy/kansas-dairy-facts

Law, J. (2024, January 11). Value of U.S. milk production reaches $59 billion in 2022. Economic Research Service, U.S. Department of Agriculture. https://www.ers.usda.gov/data-products/charts-of-note/chart-detail?chartId=108228

National Agricultural Statistics Service. (2024). *Dairy cattle and milk production* (2022 Census of Agriculture Highlights No. ACH22-4). U.S. Department of Agriculture. https://www.nass.usda.gov/Publications/Highlights/2024/Census22_HL_Dairy.pdf

National Agricultural Statistics Service. (2017, October 20). *Milk Production* (ISSN 1949-1557). U.S. Department of Agriculture. nass.usda.gov/Publications/Todays_Reports/reports/mkpr1017.pdf

Torgovnick May, K. (2018, September 27). Methane isn't just cow farts; it's also cow burps (and other weird facts you didn't know about this potent greenhouse gas).*TED*. https://ideas.ted.com/methane-isnt-just-cow-farts-its-also-cow-burps-and-other-weird-facts-you-didnt-know-about-this-potent-greenhouse-gas/

U.S. Dairy. (2021, February 25). *Cows and climate change*. Undeniably Dairy. https://www.usdairy.com/news-articles/dairy-cows-and-climate-change

U.S. Dairy. (2020, October 12). *U.S. dairy advances journey to net-zero carbon emissions by 2050*. Undeniably Dairy. https://www.usdairy.com/media/press-releases/us-dairy-advances-journey-to-net-zero-carbon-emissions-by-2050

U.S. Environmental Protection Agency. (n.d.). *Understanding Global Warming Potentials.* Retrieved July 31, 2025, fromhttps://www.epa.gov/ghgemissions/understanding-global-warming-potential

# How Does Gas Build Up in the Stomach?

**For this activity, you will need:**

- 4 empty 20oz water bottles with caps (represents the cow's rumen. Real cows have a 35-50 gallon capacity, depending on their size)
- 6 tsp (or 6 packets) of white granulated sugar (represents grass or feed)
- 1 tsp of flour (represents non-microbes)
- 3 packets of active dry yeast or dry quick-rise yeast (represents microbes in the stomach)
- Water (represents saliva)
- 4-9 inch latex balloon (represents methane and carbon dioxide)
- Funnel (represents the mouth and esophagus)
- 250 mL liquid measuring cup

**Most people think cattle have four stomachs, but they actually have only one. Ruminants have four separate compartments, each with its own function. This experiment demonstrates how the rumen functions and how a burp is formed.**

1. Label bottles 1, 2, 3, and 4.
2. In bottle 1, add sugar, yeast, and 250 mL of warm water and screw on the cap.
3. In bottle 2, add sugar and 250 mL of warm water and screw on the cap.
4. In bottle 3, add flour, yeast, and 250 mL of warm water and screw on the cap.
5. In bottle 4, add sugar, yeast, and 250 mL of cold water and screw on the cap.
6. Add the packet of yeast and 3 tablespoons of sugar to the both empty bottles.
7. Shake each of the bottles for a few seconds to mix the ingredients.
8. Remove the cap and place a balloon over the open top of each bottle.

# How Does Gas Build Up in the Stomach?

9. What do you think will happen to each of the bottles?

   Hypothesis :

   Bottle 1 : _____

   Bottle 2 : _____

   Bottle 3 : _____

   Bottle 4 : _____

10. Observe. Let the mixtures sit for at least 3 minutes.

    What happened in each bottle? Record below.

    Bottle 1 : _____

    Bottle 2 : _____

    Bottle 3 : _____

    Bottle 4 : _____

11. Swirl each bottle again after a few minutes or when the balloons stop increasing in size. You will need to swirl the bottle to gently mix the contents.

    Are there any changes to the bottles? If so, what changes do you see?

    _____

    Which bottle has the largest 'burp' (most blown up balloon)? _____

    Why?_____

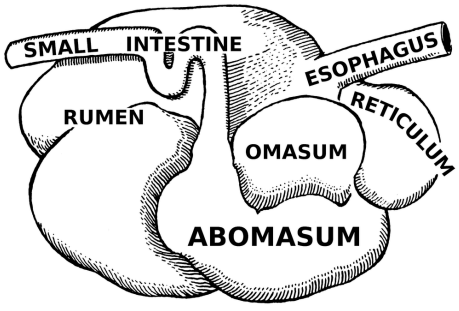
    Explain what is used in a cow's stomach for it to create a burp.

    _____

    _____

    _____

Rumen – This first compartment turns food (grass and feed) into nutrients and gas (methane and carbon dioxide). This process is called fermentation. It uses the bugs (microbes and bacteria) to break down the feed to create energy and gas. This represents a process called rumination – also referred to as "chewing cud." There are over 200 different bacteria in the rumen. After the food spends some time in the cow's rumen, it is sent back up to the cow's mouth for extra chewing. Every minute, rhythmic muscular contractions help move feedstuffs in and out of the rumen. The gas then gets expelled through burps, and the food goes into the next compartment of the cow's stomach. Cows will belch 30-50L of gas per hour to avoid bloating!



# How Does a Burp Occur? Activity

**For this activity, you will need:**

- Toilet tissue –1 square
- 1 tablespoon baking soda
- Tape
- ½ cup vinegar
- Small ziplock sandwich bag

Read through steps 1-6 and make a hypothesis of what might occur.

_____

_____

1. Lay the toilet tissue on a table.
2. Add one tablespoon of baking soda onto one square of the tissue.
3. Fold the tissue into a little bundle and tape it firmly.
4. Place the tissue into the ziploc bag and add the vinegar.
5. Zip up the bag.
6. Toss the bag away from you onto a tray or outside.

Did the experiment do what you expected? Why or why not?

_____

_____

How does this experiment relate to a human or cow's burp?

_____

_____

Why do we burp?

_____

_____

Why do you think we need to burp a baby?

_____

_____

Why do you think some foods make us burp more than others?

_____

_____

# Ruminant Stomach Activity

**For this activity, you will need:**

- Large poster board OR sheet of bulletin paper
- Markers
- Scissors
- Glue

**Follow the steps below.**

1. Cut out and label each of the stomach parts.
2. Lay them out as they are found in a cow's stomach.
3. Check with the answer key. Change the arrangement of the stomach compartments if necessary.
4. Glue the stomach pieces onto the paper. Be sure they are labeled.
5. Draw a cow around the stomach.
6. Draw dotted arrows to show how the cow's feed or grass moves through its system
7. Draw a burp from the cow and write what causes the burp below the word.
8. Draw a fart from the cow and write what causes it below the word.
9. List the two gases that are emitted from the burp and the fart on the paper.
10. Write a label on the paper that states 'Ways to Decrease Dairy Cow Gas Emissions.
11. List ways that gas emissions can be decreased under the label.

| | |
|---|---|
| Grapes and cheese | Bread only |
| Chicken and fruit | Your choice of two ingredients |
| Your choice of two ingredients | Your choice of two ingredients |
| Your choice of two ingredients | Your choice of two ingredients |
| Your choice of two ingredients | Your choice of two ingredients |

# Ruminant Stomach Activity

**Dairy cows and most mammals are ruminants. This means they have one stomach, but it includes four parts. Use the information below and the cutouts to recreate the cow's stomach. (The following parts are not in order.)**

The rumen is the site of fermentation. Fermentation is performed by microbes and bacteria that convert carbohydrates, such as starch or sugar, into alcohol or an acid. It is the first part of the stomach and the largest of the four chambers.

Rumen

The reticulum is the second compartment of the cow's stomach. The reticulum is responsible for separating feedstuffs to either be regurgitated or passed into the omasum. The larger particles return to the mouth to be broken down further, and the smaller particles travel to the omasum. The reticulum is lined with ridges that form a honeycomb-like structure, designed to capture large particles and undigested materials

Reticulum

The omasum is made of folds of tissue like a leaf. It has a large surface area that allows it to absorb water. This third stomach part also serves as a filter, allowing only small particles to pass to the abomasum.



Omasum

The abomasum is also called the true stomach. It kills the bacteria that pass from the rumen. The abomasum is where protein digestion begins. This part of the stomach is similar to a human stomach.

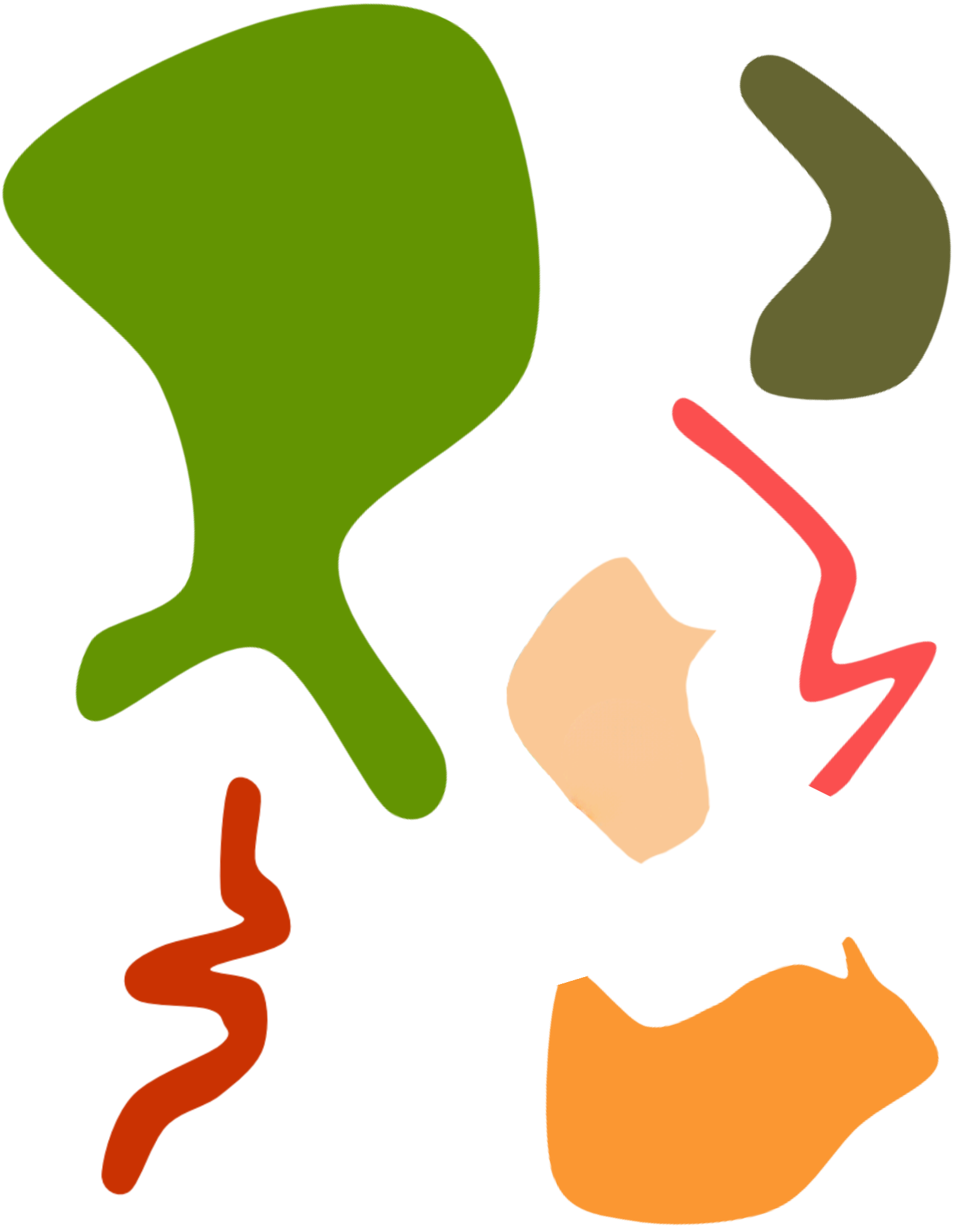
Abomasum

The large intestine is the primary site of mineral absorption, secondary site of fermentation. It also stores the waste product from the digestive system (manure).

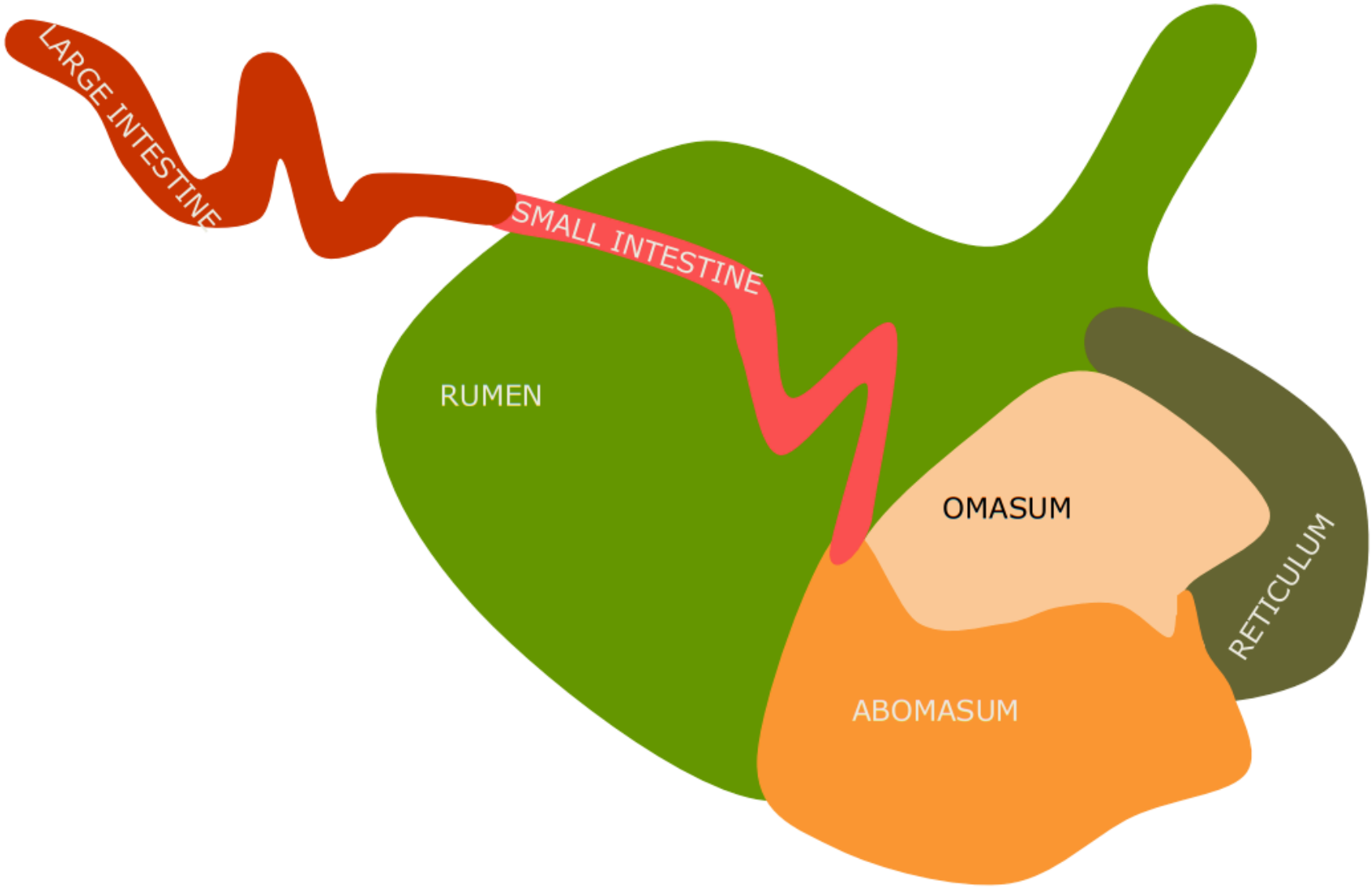
Large Intestine

The small intestine is where many of the nutrients are digested. The surface is covered with delicate villi (finger-like projections) similar to those in the human small intestine. These increase surface area, which helps in the absorption of nutrients, proteins, and fatty acids.

Small Intestine



# Ruminant Stomach Activity Answer Key



# Ruminant Digestion Experiment - Day 1

**For this activity, you will need:**

- 1 small Ziploc bag
- Water
- A variety of food items: bread, cheese, chicken or other meat, grapes, and other soft fruits, etc.
- Scissors
- ½ cup of ammonia, vinegar, cola, or orange juice
- Salt
- 2 stick matches
- Paper towel
- Bowl or tray to catch excess fluids
- 1 teaspoon of yeast
- Stick pin (for day 2)

1. Grab the materials from your teacher.
2. With your group, tear or cut your food items into bite-sized pieces and put them in the bag. (This is what the cow's front teeth would do. The bag represents the stomach.)
3. Then, add a small amount of water if needed to moisten the food and mush it together OR cut it into smaller pieces. This is similar to the molars on a ruminant. The stomach is a muscle that squeezes the food.
4. Add the acidic liquid and mix again. This acid is like the acid and enzymes in the cow's rumen.
5. Observe what is happening. A cow swallows some of the food, then regurgitates it to chew again. This is called 'chewing its cud.'
6. Wrap the bag in a paper towel and gently squeeze for 2 minutes. If the bag opens or pops, put the ingredients into a new bag.
7. Press the liquid away from the solids. You may need to quickly open the bag to perform this step. Place it over a bowl or tray. Use your hands to gather most of the solids and gently squeeze them. Do not squeeze all the fluid out of them, just enough to keep the solid together.
8. Pour all liquid out of the bag. These are nutrients absorbed into the small intestine.
9. Place the mostly solid part into the ziplock bag (large intestine), add one teaspoon of yeast (microbes in the rumen), cut up the matches, and add salt. Seal the bag. Food usually sits in the rumen for one to three days.
10. Label the bags with your group name and the two food items added to each bag. Set them in a warm place until tomorrow.

# Ruminant Digestion Experiment - Day 2

1. Get the Ziploc bag with your group's name on it and observe what has happened since yesterday.
2. Poke a small hole in the bag near the top and waft the smell.

We assume that the food (cud) has moved into the third and fourth stomachs —the omasum and abomasum —where it is fully digested. Some of this digested food enters the bloodstream and travels to the udder, where it is converted into milk.

| Group/Bag Number | Food Digestion | Wafting Score (1-10) |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

1. What happened to the bag overnight?

_____

2. What food items smelled the worst?

_____

3. Which food items had the least odor?

_____

4. Does the type of food make a difference in the smell?

_____

5. How does this experiment explain a fart?

_____

6. How does this experiment explain the odor of fart?

_____

# Why is Cow Gas a Problem?

In the past century, there have been more greenhouse gases in our air.
Some come from burning coal to produce electricity or gasoline in our cars.
Some are from the methane expelled by animals.

The average dairy cattle produces approximately 98kg of methane per year, the average beef cattle beast produces approximately 61kg per year, the average deer approximately 25kg per year, and the average sheep approximately 13kg per year.

About 90 to 95 percent of the methane released by cows comes out of their mouths, while 5 to 10 percent is released in the form of manure and farts. This is three tons of CO2 every year for every dairy cow. Farmers have added nitrogen to the soil, which creates a higher production of food; however, too much nitrogen emits nitrous oxide, another greenhouse gas, into the air.

Some scientists say that the climate on the planet is changing because of an extra layer of greenhouse gases around the Earth's atmosphere. So now, the blanket of greenhouse gases is thicker than at any other time during human existence. These greenhouse gases can trap extra heat and change the weather patterns. Summers become hotter, and winters become colder. Rain doesn't fall when farmers need it most, and droughts destroy entire crops.
One of the biggest risks for dairy farming is the increase in extreme weather events. The right amount of rainfall – at the right times – is important for optimal pasture management. Too much rain can cause a variety of problems, such as:

- loss of soil to erosion
- increased sediment in waterways
- loss of soil structure
- increased nitrous oxide emissions from saturated soils
- damage to infrastructure such as fences, bridges, and roads.

Not enough rainfall over a period of time can cause drought conditions, which can impact pasture growth and reduce the amount and quality of feed. Farmers need to buy supplemental feed to keep milk production going or dry off (stop milking) stock earlier than planned.