

Ruminating on digestion

Focus question	How does the cow's multi-chambered stomach allow for breaking down cellulose-rich plant material?
Vocabulary	Digestion chambers, ruminating, rumen, reticulum, omasum, abomasum

Cows and other ruminants (e.g., sheep, goats, and deer) have specialized digestive systems that extract nutrients from fibrous plant materials like grass and hay. Unlike monogastric animals such as humans, ruminants possess a four-chambered stomach designed to break down cellulose, a major component of plant cell walls, which is indigestible by most other species. This allows grazing animals to extract protein and other nutrients from grasses. See: [fda.gov/media/80784/download](https://www.fda.gov/media/80784/download) for more information about the enzymes and mechanics of cow digestive systems.

By knowing how the ruminant digestive system works, livestock producers can better understand how to care for and feed ruminant animals. In this activity, you will discover the functions of and create a model of one of the chambers of the ruminant stomach, and be able to explain how cows can digest their feed.

Materials

- Clear plastic containers or buckets to represent the four stomach chambers
- Additional materials to represent the physical characteristics of the chambers (honeycomb silicone trays, newspaper or pieces of dusters, microfiber towel pieces, etc.)
- Food items: hay or straw (dry, cut grass or leaves), green leafy vegetables, bread
- Plastic bags
- Water, vinegar, and baking soda (to simulate digestive fluids and enzymes)
- Cellulase enzyme, if available
- Blender or food processor or chopping items
- Paper and markers for labeling
- Gloves and aprons for students
- Large poster paper for creating a visual digestion process

Procedure

Day 1: Research

Research and begin to create a diagram or digital model of the cow's digestive system, focusing on each chamber's unique function and the microbial activity involved.

Name of chamber:

1. What is the structure?
2. What are the functions?
3. What enzymes or microbes are found there?
4. What should food look like when it leaves this chamber to enter the next?

Day 2: Lab

1. Create a model from a container that resembles the physical structure of the chamber and mimics the process that takes place in each of the chambers.
 - Rumen
 - Reticulum
 - Omasum
 - Abomasum
2. Collaborate with students working on each chamber to determine the relationships between each, making observations or drawing arrows on the diagrams they created on day 1 to follow the path of feed within the animal.
3. Hypothesize pH levels that may be found in each chamber.
4. Once models are constructed with "food," record pH levels, examine and record structural changes in food, and record overall observations of breakdown across chambers.
5. Prepare a detailed report or presentation covering the following:
 - Analysis of the digestive processes and biochemical changes in each chamber.
 - Explanation of how the cow's multi-chambered stomach is adapted for breaking down cellulose-rich plant material.
 - Discuss the role of each chamber in nutrient extraction and overall health impacts.
6. Present findings, using diagrams, pH data, and photos taken throughout the process to explain each chamber's role. Draw connections between ruminant digestion and how it differs from monogastric systems (e.g., human digestion).

Day 3

1. Finalize your diagram or digital model of the cow's digestive system, focusing on each chamber's unique structure, function, and the microbial activity involved.
2. Present your diagram or model to the class.

Reflection

1. How do the different chambers of the cow's stomach work together to ensure efficient digestion?
2. What happens to the molecules produced during digestion?
3. How are they used by the cow's body?
4. How does energy flow from the cow's food to its cells?

Rubric for self-assessment

Skill	Yes	No	Unsure
I can create a detailed and accurate model of the cow's digestive system that shows the process and all components.			
I can give a detailed explanation for how the structure of the cow's stomach impacts the functionality, using strong evidence.			
I can analyze data effectively and use it to explain and support my ideas with confidence.			
I can make a strong claim and use evidence effectively to support my argument.			
I can clearly explain the connections between the structure of the stomach and the function of digestion, with strong reasoning.			