A Stomach At Work

Skill Level:
- Beginner to intermediate

Life Skills:
- Critical thinking, decision-making and problem-solving

Setting:
- An outdoor or indoor space with a supply station and an easy to clean floor; seating is optional.

Time:
- 20–30 minutes

Materials:
- ❑ Resealable plastic sandwich bags (one per participant plus one for demonstration)
- ❑ Sliced white bread (one piece per participant plus one for demonstration)
- ❑ 2-liter bottles of orange juice or cola (about one bottle per 15 participants)
- ❑ 3-ounce disposable cups (one per participant)
- ❑ Paper towels (one sheet per participant and enough for clean-up)
- ❑ Flipchart or other large paper
- ❑ Markers
- ❑ Easel or display space
- ❑ Masking tape
- ❑ Clock or stopwatch
- ❑ Large trash bag (one or more depending on the size of your group)
- ❑ "The Basics of the Ruminant Digestive System" resource sheet (one per participant, optional)

Overview:
The *Animal Digestion – A Stomach At Work* lesson is designed to teach young people about animal digestion. Participants will complete an activity in which they "digest" a slice of bread the way their stomachs would. They'll also discuss the basic differences in how various species of livestock digest feed. In the interactive lesson, they'll also learn the importance of acids to the process of digestion.

Objectives:
After completing this activity, participants will be able to:
- Discuss how digestive acids break down carbohydrates.
- Explain the difference between monogastric and ruminant animals.

PROCEDURE:

Before the meeting:

1. Review the lesson and gather any supplies you will need. Make one copy of "The Basics of the Ruminant Digestive System" resource sheet per person (optional).

2. Place one piece of white bread in a resealable plastic sandwich bag and fill one 3-ounce cup with orange juice or cola for each participant. Set the sandwich bags and filled cups out on the supply station.

3. Write the following definition of the word "digestion" on a sheet of flipchart paper and display it where everyone can see it, but keep it covered until the appropriate point in the lesson.

   Digestion is the process of breaking down food in the mouth, stomach, intestines and other organs so that it can be used by the body.

4. (Optional) On a sheet of flipchart paper, sketch a sandwich bag, a slice of bread and a bottle of juice or cola. Label them "stomach," "food" and "stomach acid," respectively, then hang the paper up where the group can see it.

5. Recruit one or more teen or adult volunteers to help with the activity.

During the meeting:

1. Introduce the activity by pointing out to the group the [optional] flipchart paper with the labeled sketches of the sandwich bag, slice of bread and bottle of juice or cola on it, then reading aloud or paraphrasing the following:

Today we're going to make model stomachs and "digest" slices of bread in them so we can observe the digestion process. A little later we'll also learn about the two main digestive systems of livestock animals: the monogastric or simple digestive system and the ruminant or complex digestive system.

2. Ask for volunteers to explain what the word "digestion" means. Record the answers on flipchart paper, then display the paper where everyone can see it. After everyone has had a chance to answer who wants to, uncover and discuss with the group the definition of "digestion" that you wrote on the flipchart sheet before the meeting.

3. Now ask the group why the digestion process is important to animals. *(So they can absorb and use the nutrients in the food they eat to build blood, bone, muscles, organs, nerves and other cell types. So they can maintain or increase their weight. So they can use the nutrients for energy to move and think and perform other tasks.)* Discuss and record their answers on flipchart paper and display the sheet where everyone can see it.

4. Give each person one of the bags with a piece of white bread in it. Explain to the group that in this activity, the bag will act like a stomach – a muscle that contains and squeezes the food (in this case, the bread) to break it down.

5. Now have them take turns bringing their plastic bag stomachs to the supply station to pick up a cup of orange juice or cola to pour into their bags. Explain that the liquid will play the part of the digestive juices in their model stomachs – that is, the stomach acid and enzymes that react chemically with the food in the stomach.

6. Once they've all combined the bread and the fluid in their plastic bag stomachs, tell them to carefully observe what is starting to happen to the bread.

7. Have the adult or teen volunteers you recruited earlier work with the participants to ensure that all of the plastic bag stomachs are tightly sealed. If the seal on any bag seems questionable, or if a bag has a hole in it, have them seal the entire bag (with its contents still inside) into another plastic bag.

8. Now ask the group the following questions:
   - What is happening inside of your model stomach? *(The bread is absorbing the liquid, turning color and getting mushy. It may be breaking apart.)*
   - What do you think might happen if you squeezed your model stomach for a little while? *(The bread will break into smaller pieces. The bread will be squished.)*

9. Give one piece of paper towel to every participant. Tell them to wrap the paper towel around their model stomachs so that they cannot see what is happening inside.

10. Now tell them that on your signal, they will act as the muscles for their model stomachs by gently squeezing their towel-covered bags for 2 minutes. Emphasize that they need to keep the towels wrapped around their bags and be gentle to avoid poking holes in them. Have a volunteer keep track of the time.

11. While the participants are using their model stomach muscles, ask them the following questions:
    - **Do humans have monogastric or ruminant digestive systems? *(Monogastric or simple.)***
    - **What does monogastric mean? *("Mono" means "one" or "single," and "gastric" means "stomach" or "related to the stomach," so "monogastric" means "one stomach" or "one stomach compartment.")***
    - **Name one livestock species that has a stomach that is similar to the human stomach. *(Swine and rabbits.)***
    - **Do sheep have monogastric or ruminant digestive systems? Cows? *(Ruminant.)***
    - **What does "ruminant" mean? *("To chew over again.")***
    - **What is the biggest difference between the ruminant and monogastric digestive systems? *(Ruminant stomachs have four compartments, and monogastric stomachs have only one compartment. Ruminants are able to digest grasses and other fibrous feeds better than animals with monogastric systems can. Ruminant animals are able to do this because they chew their food several times through a process of regurgitation and rumination that is more familiarly called "chewing their cud.")***

12. When the timekeeper indicates that the participants have been squeezing their model stomachs for 2

minutes, tell them to remove the paper towels and – without opening the bags! – observe the changes to the contents. After they've had a moment to observe and think about the changes, ask the group the following questions:

- What caused the changes to the bread? *(The mechanical action of squeezing and the chemical breakdown of the bread fibers by the acids in the liquid.)*
- Would the change have been different if the liquid we added was just water? Why or why not? *(Yes, because it is the acids in the orange juice or cola that accelerate the breakdown process.)*
- How is animal digestion similar to what we did with our model stomachs? *(An animal's stomach churns and squeezes and breaks down its contents in nearly the same way that we churned and squeezed and broke down the bread in our model stomachs. The acidic fluid – the orange juice or cola – we added to our model stomachs reacted chemically with the bread in them, just as real stomach acid reacts chemically with the contents of the stomach.)*

13. Now have a volunteer collect the sealed model stomachs in a trash bag. Have other volunteers clean up any other messes.

14. Next have the group stand in a straight line facing you. Tell them they're going to review the basic steps in the digestion process in monogastric animals. Ask them to imagine that a pig has just eaten a mouthful of grain, then ask the first person in the line "What happens to the food next?" (**Note:** You may want to record their answers for each step on flipchart paper to help the group keep track of where they are in the process.)

15. Move down the line, asking each person in turn "What happens to the food next?" (**Note:** The rough outline of the digestion process that follows will help you prompt any participant who isn't sure.)

a. The animal takes a bite of food.

b. The food mixes with saliva in the animal's mouth and is chewed by the teeth until is in small enough bits to be swallowed.

c. The food then moves down the esophagus to the stomach, where it is churned and digestive acids begin to break it down.

d. Then the food travels to the small intestine, which absorbs most of the nutrients in it.

e. Next the food enters the cecum, a sac between the small and large intestines that contains enzymes that help break down plant material. (**Note:** Younger and less experienced groups probably won't be familiar with the cecum, so you'll most likely have to tell them about this step.)

f. Next stop is the large intestine, which absorbs most of the water in the food.

g. Finally, what's left of the food moves through the rectum and exits through the anus.

16. Once the group has reached the end of the line, so to speak, read aloud or paraphrase the following:

The process of digestion in ruminants is similar to the process in monogastric animals. As we learned before, though, ruminant stomachs have four compartments, which helps ruminants digest plant material much more efficiently than monogastric animals can.

Another interesting difference is that ruminants chew their cuds. Does anyone know what it means when someone says a ruminant like a cow is "chewing its cud"? **(It means the cow has belched up a clump of food called a "bolus," from the first stomach compartment, the rumen, and is chewing it again to break apart the plant fibers some more.)**

After the food leaves the rumen, it moves to the other chambers, which are, in order, the reticulum, the omasum and the abomasum.

17. Refer to the "Basics of the Ruminant Digestive System" resource sheet for explanations of the functions of each of the ruminant stomach compartments. Share the level of information from the resource sheet that you feel is appropriate for the ages and experience levels of your group.

18. Next divide the group into four equal teams, then assign each team a compartment of the ruminant stomach. Tell the teams they'll have 30 seconds to come up with the word or phrase that is most representative of the stomach compartment they were assigned.

19. After 30 seconds, or when the teams seem to have settled on their descriptive words, tell them you're

going to point to each team in the order of where their assigned stomach compartment falls in the digestion process. Explain that when you point to a team, you want them to yell the name of their stomach compartment and the word or phrase they chose to describe it. For example:

- Rumen = fermentation
- Reticulum = honeycomb
- Omasum = many folds
- Abomasum = mixes

20. Rotate through the teams three times to help everyone remember the information.

21. Finally, challenge the group to think about how their own livestock animals digest food. Ask for volunteers to name an animal species they're raising and a type of food that is relatively easy for that species to digest. Do the same for food types that are harder for their animals to digest.

ADAPTATIONS & EXTENSIONS:

- **Older or More Advanced Participants:** If your group includes a mix of ages and experience levels, have the older or more experienced members partner with the younger or less experienced participants.
- **Older or More Advanced Participants:** Challenge the group to write out each stage of the ruminant digestion process from the perspective of a piece of grass being eaten by a cow.
- **Younger or Less Experienced Participants:** Make a card to represent each organ or step in the digestive system of a monogastric animal. Have each participant choose a card and then have the group work together to arrange themselves and their cards in the correct spots in line in the digestive system.
- Use an app such as Nearpod to create brief interactive mobile presentations that participants could use anywhere they have Internet access. You could tailor presentations to supplement the work the group is doing during meetings or to prepare background information on specific topics for the group to review before a meeting. (**Note:** "Apps" are small computer programs that are usually optimized for use on mobile devices such as smart phones and tablets that have relatively small screens.)
- Distribute copies of "The Basics of the Ruminant Digestive System" resource sheet for participants to take home with them.
- Adapt the lesson to focus on other types of animal digestive systems, such as hindgut fermenters (horses and guinea pigs) and avian (poultry) digestive systems. You could use many of the same steps with only limited adjustments.
- Have the stomach compartment teams build models of their compartment using only objects they can find in the room or area. Give them 1 minute to plan, 2 minutes to find materials and build their models, and 30 seconds per team to present their models and explain to the whole group what their stomach compartment does.
- Adjust how quickly the digestive process happens in the participants' model stomachs by altering the bread that is being "digested."
  - To speed up the process, remove the bread crust from the white bread before placing it in the plastic bag.
  - To slow down the process and give yourself an opening to talk about the food types that are harder to digest, such as roughages, consider using whole wheat or other whole grain bread.
  - Divide the larger group into three teams of equal sizes and give the members of each team one type of bread. That is, one team would have white bread with crusts, another white bread without crusts and another whole wheat or other whole grain bread. After the 2 minutes of "digesting" (squeezing) the bread, lead a discussion comparing the results of the action on the different types of bread.
- Arrange a group field trip to the Michigan State University Dairy Teaching and Research Center to examine the rumen of a fistulated cow. (A fistulated cow has had a "window" surgically implanted in its side to allow researchers to reach in and remove some of the contents of its rumen for study.)

ALIGNMENT TO SCIENCE & ENGINEERING PRACTICES:

How 4-H Increases Science Literacy

Nationally and in Michigan, 4-H has long enjoyed a reputation for engaging young people in positive, experiential (hands-on), and nonformal activities that are inquiry based. The activities in the *4-H Animal Science Anywhere* series can be used to enhance classroom science education. The activities are aligned with the eight Scientific and Engineering Practices from *A Framework for K–12 Science Education* (National Research Council, 2012, p. 42).

The activities in *4-H Animal Science Anywhere: A Stomach at Work* were evaluated for their alignment with the Science and Engineering practices by Michigan State University (MSU) Extension Educator Tracy D'Augustino in 2016.

Table 2. How This Lesson Aligns With the Science and Engineering Practices (National Research Council, 2012, p. 42)

Science & Engineering Practices	Action	Activity Step
▸ Asking questions and defining problems	▸ Participants brainstorm what digestion means and why it is important. ▸ Participants discuss how well their model stomach would work with water instead of acid.	2–3, 12
▸ Developing and using models	▸ Participants use bags, bread and acid to discuss how a stomach functions. ▸ Participants discuss the difference between the monogastric and ruminant digestive systems.	5–11, 12
▸ Planning and carrying out investigations	Participants carry out the investigation of how a stomach functions.	1–12
▸ Analyzing and interpreting data	Participants make and discuss their observations.	8 & 12
▸ Using mathematics and computational thinking	Participants explain the sequence of steps for digestion.	11
▸ Constructing explanations and designing solutions	▸ Participants explain the difference between the monogastric and ruminant digestive systems. ▸ Participants discuss the mechanical and chemical processes involved in digestion.	11–12
▸ Engaging in argument from evidence	▸ Participants discuss the parts and functions of the digestive system. Participants explain how food moves through the digestive system. ▸ Participants discuss how well their model stomachs would work with water instead of acid.	14–16, 12
▸ Obtaining, evaluating, and communicating information	▸ Participants learn the parts and functions of the two types of digestive systems. ▸ Participants use a model to explain how the stomach functions. ▸ Participants discuss and share information about digestive systems.	Whole lesson

REFERENCES & RESOURCES:

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ACKNOWLEDGMENTS:

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Thank You

Thank you to Dr. Karen E. Petersen, Senior Lecturer, Department of Biology, University of Washington, for permission to reprint the stomach compartment photos in the resource sheet.

Thank you to the Oklahoma Department of Career and Technology Education, Curriculum and Instructional Materials Center, for permission to reprint the hog and calf digestive system diagrams from *Agriscience Principles and Applications, Unit 1: Animal Nutrition and Digestion*.

This bulletin was produced by ANR Communications and Marketing (*anrcom.msu.edu*) for MSU Extension (*msue.anr.msu.edu*).

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The Basics of the Ruminant Digestive System

Digestion

The process of breaking down food in the mouth, stomach, intestines and other organs so that it can be used by the body.

Introduction

In general, livestock animals have one of two major types of digestive systems: monogastric or simple (see fig. 1) and ruminant or complex (see fig. 2). Monogastric animals include swine, horses, chickens and other poultry. Ruminant animals include cattle, sheep and goats. Table 1 lists a few of the major differences between monogastric and ruminant digestive systems.

Table 1. Major differences between monogastric and ruminant digestive systems

Difference	Monogastric digestive system	Ruminant digestive system
Number of stomach compartments	1	4
Number of times food is chewed	Once	Several times
Efficiency in digesting plants and plant byproducts	Limited	Highly developed

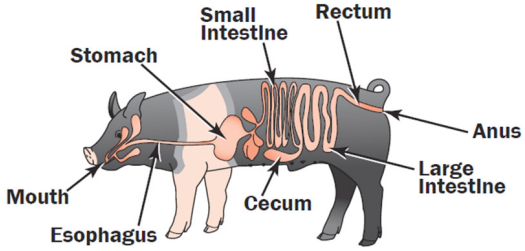

Figure 1. A diagram of the monogastric digestive system of swine. *(Courtesy of the Oklahoma Department of Career and Technology Education, Curriculum and Instructional Materials Center)*

Ruminant animals chew their food several times through a process called "rumination" or "chewing the cud." When a ruminant animal such as a cow takes a bite of grass or other food, the animal chews the food just enough so it can be swallowed. The food then travels from the mouth down the esophagus to the rumen (the first and largest stomach compartment). From there, it moves to the second compartment, the reticulum. Later, the cow can regurgitate the food (now called a "bolus" or "cud") to chew it again to continue breaking down the plant fibers.

The stomach compartments of a ruminant animal are much larger than the stomach of a monogastric animal because it takes ruminants longer to ferment, mix and digest the roughage they've eaten. They need plenty of room in their stomachs for all of that to happen.

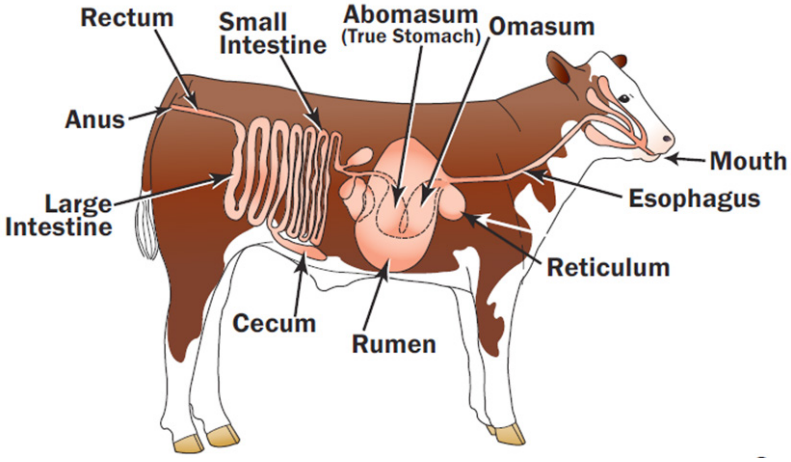

Figure 2. A diagram of the ruminant digestive system of cattle. *(Courtesy of the Oklahoma Department of Career and Technology Education, Curriculum and Instructional Materials Center)*

Four Stomach Compartments

The stomach of a ruminant animal has four compartments. In the order that food travels through them, they are the rumen, reticulum, omasum and abomasum. Each compartment has a distinct function and appearance. They're described here.

The Rumen

The rumen (see fig. 3) is the largest compartment of the ruminant stomach – it can store up to 50 gallons of digested materials. Food is fermented in the rumen, because the environment is anaerobic (has no oxygen). That allows for increased microbial action and high concentrations of bacteria ("rumen bugs"). The rumen is capable of changing poor-quality protein (such as the nitrogen in grass) to a good-quality microbial protein. To aid in this process, the rumen is very selective about how quickly particles can move from one stomach compartment to another. If a roughage is difficult to digest, the rumen will extend fermentation time to allow for further mechanical breakdown through the process of cud chewing. The rumen has fingerlike projections called "papillae" that increase the surface area on which microorganisms do their work. When a cow eructates (belches), it's releasing fermentation gas (mostly carbon dioxide and methane).

Figure 3. A close-up of a rumen. *(Photo: Dr. Karen E. Petersen, Department. of Biology, University of Washington.)*

Figure 4. A close-up of a reticulum. *(Photo: Dr. Karen E. Petersen, Department. of Biology, University of Washington.)*

The Reticulum (Honeycomb)

The reticulum (see fig. 4) is attached to the rumen and consists of bands of smooth muscle. The walls of the reticulum look like honeycombs, which give it the nickname "the honeycomb." Its main functions are to first detect large feed particles that need to be broken down further, and second to regurgitate or force those particles back up the esophagus to the mouth so they can be chewed and then swallowed again. Cows have an unfortunate habit of accidentally ingesting hardware such as nails and bailing wire. These foreign objects usually wind up in the reticulum and sometimes have to be surgically removed.

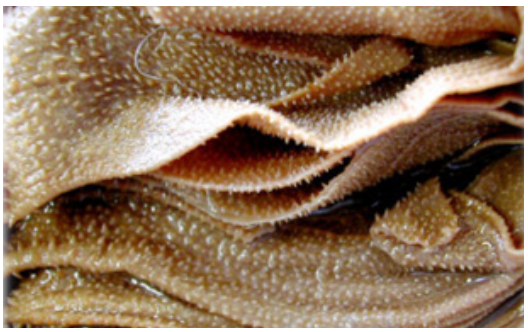

Figure 5. A close-up of an omasum. *(Photo: Dr. Karen E. Petersen, Department. of Biology, University of Washington.)*

The Omasum

Many folds or layers of muscle (called "plies") make up the omasum (see fig. 5). These folds increase the compartment's surface area, which helps it absorb nutrients from feed and water. The omasum squeezes water from the feed particles and continues to break them down into smaller particles.

Figure 6. A close-up of an abomasum. *(Photo: Dr. Karen E. Petersen, Department. of Biology, University of Washington.)*

The Abomasum (True Stomach)

The abomasum (see fig. 6) is called the "true stomach" because it's the equivalent of the stomach of a monogastric animal. This is where acids and enzymes (digestive juices) mix with and prepare feed for enzyme breakdown and absorption in the small intestine. It has a very low (acidic) pH. This is the feed's last stop before entering the small intestine where most nutrient absorption will take place.