GOAL STATEMENT:
Students will compare and contrast the digestive systems of ruminant (4 compartment stomach) and monogastric (single stomach) animals, observing how groups share differences and similarities which can be used to infer the degree of relatedness among organisms.

OBJECTIVES:
- Students will learn how the ruminant stomach functions.

REQUIRED MATERIALS:
- “Digest Digestion” worksheet (1 per student)
- “The Ruminant’s Digestive System” worksheet (1 per student)
- “Monogastric Digestive System Facts” (1 per student)
- “The Human Digestive System Facts” (1 per student)
- “Monogastric Digestive System” worksheet (1 per student)
- “Talk it Over” worksheet (1 per student)
- “The Ruminant’s Digestive System Teacher Key”
- Colored pencils
- Feedstuffs: grass, hay, corn, and soybeans (kit available)
- Rinsed out 20-ounce plastic water or drink bottle with cap
- Warm tap water
- Packet of active dry yeast or dry quick rise yeast (1 tablespoon if using yeast from a jar)
- Light-colored corn syrup
- 9” balloon (be aware of latex allergies)
- Funnel
- Measuring cup
- Tablespoon

AMOUNT OF TIME TO ALLOW:
Total Lesson Time: 50 minutes (not including extension)
Activity Time: 20 minutes for preparation, 10 minutes (or longer) to observe your bottles
On the farm, animals like cows, goats, and sheep are ruminants (cud-chewing animals). A ruminant’s stomach is divided into four sections: the rumen, reticulum, omasum, and abomasum. A ruminant first chews its food enough to moisten it, then swallows the food into the first and largest section of the stomach, the rumen. The rumen contains “rumen bugs” or microbes which are simply bacteria, protozoa, and fungi that aid in digestion. The rumen bugs ferment feed into volatile fatty acids, which the ruminant animal can use for energy. This process allows ruminant animals to get energy from fibrous feeds, like grass and hay, that are not well-digested by a simple gastric stomach.

Food is mixed and softened in the rumen before moving to the second section, the reticulum (nicknamed the hardware or honeycomb). Then the food returns to the mouth, via the rumen, and is thoroughly re-chewed. The animal re-swallows, and the food passes through the first two sections and into the third section of the stomach, the omasum (nicknamed the manyplies). Next, the food passes into the fourth section, the abomasum or true stomach. The abomasum is much like the human stomach as it produces gastric juices to aid in digestion.

The activity included in this lesson will simulate the digestion that occurs in the rumen, which is primarily fermentation of food by gut microbes.

Engagement

10 minutes

Show examples of several feeds, such as grains, hay, and pasture. Ask students why some livestock are fed different types of feed than other livestock? Allow students to share ideas. Lead the discussion to the concept that livestock are fed the feeds that they can digest to get the essential nutrients needed by their body and that the type of digestive system affects what can be eaten. As a result of class discussion, students will investigate the different types of digestive systems.
**Exploration**  
**20 minutes**

**Directions:**
Have students complete the activity as follows in small groups of 3 or 4.

**Steps to follow:**
1. Add 1 packet or three tablespoons of yeast to the bottle.
2. Add 3-4 tablespoons of corn syrup.
3. Add 8 ounces of warm water to your bottle so that it is about half full.
4. Replace the cap and shake to mix the contents.
5. Remove the cap and place a balloon over the mouth of the bottle and observe what happens.
6. Record the size of the balloon after 10 minutes, after 60 minutes, and after 1 day (if possible).

**Explanation**  
**20 minutes**

The activity in this lesson simulates the same fermentation process that occurs in the rumen. Just as the rumen bugs break down fibrous food materials, the yeast breaks down the processed corn sugars through fermentation. The yeast releases two waste products: carbon dioxide and ethanol. You can tell that fermentation is occurring in the bottle because the balloon expands as it fills up with carbon dioxide gas. Like the yeast in the bottle, the rumen is a very effective bioreactor. Rumen bugs take fiber, starch, sugar, and proteins and turn them into volatile fatty acids (VFAs). VFAs are processed by the body into glucose (energy) and methane (gas, which is expelled by burping).

The fermentation process within the stomach is unique to ruminant animals and allows them to digest fiber into energy. Animals with a monogastric stomach—like pigs—cannot utilize fiber for energy because the gastric digestion which occurs in a single stomach does not break down fiber.

**Extension**

Have each group of students create a display that could be exhibited in the school demonstrating what they learned. They can create a model of the different digestive systems.

Give students an opportunity to earn extra credit by giving a presentation to the class on how microorganisms are involved in the digestion of feed ingredients in the ruminant’s stomach as compared to a monogastric stomach.

Allow students to research digestive systems of a horse (hind gut fermenter) and chicken and in what way their digestive systems are similar to and different from a ruminant and monogastric digestive system.

Go to the computer lab and allow students to use a virtual pig dissection at [www.whitman.edu/content/virtualpig](http://www.whitman.edu/content/virtualpig) or allow students to conduct a real dissection.

Take students on a field trip to see a fistulated cow. University of Maryland, College Park owns a fistulated cow. A fistulated cow has a hole cut in her side, providing access to the rumen, one of the four chambers of her stomach. A fitting, known as a cannula, lines the hole and has a removable plug allowing access to the inside of the rumen.

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Career Connections

- **Animal nutritionist** — This person studies animal digestive systems and formulates feed mixtures to maximize growth, development and performance.
- **Veterinarian** — This person treats animals for digestive disorders and complications.
- **Feed mill worker** — This person mixes raw ingredients to make animal feeds and packages and sells them on a large scale.
- **Grain farmer** — This person produces the corn, wheat, barley, soybeans and other crops that feed mills use to create animal feeds.

Evaluation

A pre/post test should be completed with this lesson plan. Student understanding of concepts can also be evaluated through class discussion as well as through evaluation of completed activity data sheets. Analysis/conclusion questions that are answered incorrectly by a large number of students should be addressed in a follow-up discussion.

References


*National 4-H Project Activity Guide: Putting the Oink in Pig, Swine Level 2.* National 4-H Curriculum.

*National 4-H Project Activity Guide: Here’s the Beef, Beef Level 2.* National 4-H Curriculum.


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Digest Digestion

Goal:
Examine the similarities and differences of monogastric and ruminant digestion and how it controls the types of feeds consumed.

Materials:
- Diagrams
- Fact Sheets
- Talking it Over Questions
- Colored Pencils

Background:
Do you like to eat? Of course you do! Every form of life likes to eat, well, has to eat to live. But do we all eat the same things? In the animal world, they eat what their stomach compartments can digest. Animal digestion differs with each species because their digestive systems are not all the same.

For example, the pig is a simple stomached animal called a **monogastric**. The pig’s digestive system is very similar to our own single stomach compartment design. Both swine and humans start digesting their food in the mouth when they take in food.

So why can cows, goats, and sheep eat grass and other farm animals like pigs can’t? Did you know that beef cattle have a different type of digestive system than pigs or chickens? The answer lies in the difference in their digestive systems. These animals are called **ruminants**. Rather than a simple stomach like you have, these animals have a very large stomach with four compartments called the rumen, reticulum, omasum and abomasum. Each of these four compartments is responsible for helping to digest feedstuffs such as grass, hay, corn, and soybeans.

Directions:
1. Get into your lab groups.
2. Read the directions carefully to complete the activities.
3. Using the ruminant’s digestive system fact sheet, label the parts of a ruminant’s digestive system on the ruminant digestive system diagram.
4. Then, study the drawing of the swine digestive system and the monogastric digestion system fact sheet. Use colored pencils to draw the digestive system on the outlined pig and label the parts from the word bank.
5. Compare and contrast the human digestive system with that of the other animals studied using the fact sheets provided.
6. Prepare a presentation how feed moves through each species digestive system. Include a brief description of what happens as the feed moves through each part. Use the digestive system differences fact sheet for assistance.
The Ruminant Digestive System

Functions
- Food intake
- Storage
- Digestion
- Absorption
- Elimination of waste

As the food moves through the digestive tract, all feeds are broken down into smaller and smaller units so they can be used or eliminated. Much of this “breakdown” is done by microbes in the ruminant’s stomach. Normally about three to four days are required for feedstuffs to pass through the digestive tract of ruminants. Here are the four compartments of the ruminant’s stomach and what they each do.

- **Rumen** – Called the large vat, it functions as a storage area for food. In addition, the rumen aids in breakdown of coarse particles through bacterial action. The cow’s rumen can hold up to 40 gallons of liquid (think of 40 gallon milk jugs).
- **Reticulum** – Called the hardware stomach or honeycomb because of its honeycomb-like walls, this compartment helps to retains large particles and foreign materials that could injure the digestive system. The reticulum functions are similar to the rumen.
- **Omasum** – Called the many plies because it resembles pages in the book, it helps to remove liquid from the feed by muscle contractions. In addition it helps to breaks up coarse particles in feed.
- **Abomasum** - Called the true stomach because of its smooth lining structure and because contains digestive juices including hydrochloric acid, pepsin, rennin, and lipase, this compartment helps to break down food and its actions are similar to that of a single stomach animal.

When a cow eats, she swallows food, just like we do. They tend to chew their food less than we do so the food will not be ground (by teeth) and will appear to be rather course. The food is swallowed, then passes down the esophagus into the rumen. The food particles are exposed to the existing stomach contents, which exposes the feed to the microbes that live there. Unlike us, a cow will have a wide range of microbes that are used to help with the breaking down of the feed. The rumen microbes include bacteria, protozoa, fungi and bacterial viruses. These microbes that consume the feedstuffs produce volatile fatty acids which are used as a source protein for the cow.

Cows can graze for quite a while before they stop, lie down and begin ruminating or in other terms “chew their cud”. The cow is able to regurgitate its food, which is rechewed then swallowed again. This process of regurgitation, rechewing and swallowing will occur for a period of time.

The rumen composes the largest (75-80%) part of a cow’s stomach and is located on the left side of the animal. The reticulum is much smaller and is found in front of the rumen, its lining is very distinct with an appearance similar to a honeycomb. The omasum is located on the right side of the reticulum and its lining is often said to have “many plies” like pages of a book. The abomasum, which is also called the “true stomach,” sits below the omasum and connects to the small intestines.
The Ruminant’s Digestive System

Complete the diagram using the word bank.

Ruminant Digestive System Parts

Abomasum
Esophagus
Mouth
Omasum
Reticulum
Rumen
Small Intestine
The Ruminant’s Digestive System - Teacher Key

Ruminant Digestive System Parts

Abomasum
Esophagus
Mouth
Omasum
Reticulum
Rumen
Small Intestine
Monogastric Digestive System Facts

**Mouth** – the teeth break food into small particles, and an enzyme begins carbohydrate digestion.

**Esophagus** – muscle contractions move the food from the mouth to the stomach.

**Stomach** – the main function is to serve as a kind of vat where chemicals are added to the food to start digestion of fats, proteins, and carbohydrates. Some nutrients are absorbed through the wall into the bloodstream.

**Small Intestine** – in this very complex, very long tube composed of the duodenum and the ileum, digestion and absorption continue. More nutrients are absorbed here than anywhere else.

**Cecum** – often called the blind gut, this has very little function in the pig.

**Large Intestine** – the main function is to absorb water. It also adds mucous material to the remaining food to aid in the movement of the food through the tract.

**Rectum** – leads to the opening through which the undigested portion of the feed is eliminated.

A monogastric has a simple stomach, such as in swine and humans. Both humans and pigs begin digestion of the food in the mouth. The tongue and teeth gather feed and break it down into smaller pieces in order to make it easier for the animal to digest. Next the esophagus, a long tube, carries the feed from mouth to stomach.

The stomach serves as a reservoir for short-term food storage and digestion. In the stomach, digestive enzymes break down the feed components so that they may be absorbed into the bloodstream.

The next step in the digestive process takes the remaining undigested feed into the small Intestine, where it is broken down further for absorption into the body. After the small intestine has removed the available nutrients from the feed, the remaining material is passed into the large intestine and finally excreted from the body through the rectum.
The Human Digestive System

**Mouth** – Digestion begins way before food reaches our stomachs. When we put food into our mouths, we use our teeth to start breaking the food down (mechanical digestion), but that’s not all! Our salivary glands release saliva in response to food – or even thinking about or smelling food! Saliva softens food for chewing and also contains an enzyme called amylase which begins breaking down carbohydrates (chemical digestion).

**Esophagus** – After swallowing, the chewed up food travels down the esophagus to the stomach. Contractions of the muscles in the walls of the esophagus move the food down. This is called peristalsis.

**Stomach** – From the esophagus, the food passes into the stomach through a muscular ring called a sphincter. It squeezes shut so that food or fluid does not go back up into the esophagus. The stomach’s main job is to mix up the food and liquids with digestive juices using its strong muscles. These very acidic juices come from the stomach’s lining; they break the food up into smaller, more digestible pieces. The stomach then empties its contents slowly into the small intestines. The food no longer looks like food but is now a thick liquid called chyme.

**Small Intestine** – When ready and at the right consistency, chyme slowly enters the small intestine through a small tube called the pylorus. The intestine is a coiled up organ that is actually over 20 feet long! There are three sections: the duodenum, the jejunum, and the ileum.

Once in the intestine, many substances in the food we eat still need more digestion, and digestive juices from the liver, pancreas and intestine continue to dissolve the chyme into smaller sized nutrients (i.e. carbohydrates, proteins and fats) as it moves down the intestine.

The small intestine is where most of the absorption happens. The nutrients pass through the wall of the intestine through small finger-like projections called villi, into the bloodstream and on to all the cells and the organs of the body.

**Large Intestine** – After travelling through the entire small intestine, what remains includes the undigested parts of foods, such as fiber, some water, and older cells. By this time, most of the absorption is finished. The main function of the large intestine is to remove the water from the undigested food and form solid waste (feces) that can be excreted by a bowel movement.

**Human vs. Pig digestion?**

Humans are monogastric like pigs. Overall, the physiology of digestion is similar to humans; they are true omnivores. Humans have essentially the same digestive organs as a pig, except for the appendix. Additionally, the pig’s large intestine is coiled, rather than framed, like the human’s. However, the human diet varies greatly, and we need to take care to eat well to keep our digestive system and our overall health in good shape.
The Human Digestive System

What makes a healthy digestive system?
The kinds and amounts of food a person eats and how the digestive system processes that food play key roles in maintaining good health. As you can see, the body receives all of the nutrients we take in through the digestive system. Feeding our body the right amount and type of nutrients is important, and so is keeping our digestive system working its best! Eating a healthy diet is the best way to prevent common digestive problems, such as constipation, diarrhea, irritable bowel, and more. Two very important nutrients for digestion are fiber and water.

**Fiber** – The term fiber refers to carbohydrates that cannot be digested. Many foods contain both soluble and insoluble fiber. Soluble fiber dissolves easily in water and takes on a soft, gel-like texture in the intestines. Insoluble fiber, on the other hand, passes essentially unchanged through the intestines. Fiber helps move the food through the digestive system faster. This prevents constipation and keeps the whole system working better. It can also lower cholesterol and slow the absorption of sugars into the blood, which is important for those with diabetes. *Fiber comes primarily from whole grains, fruits, vegetables, and legumes – such as beans and lentils.*

**Water** – Water and other liquids help break down the food in your stomach and keep your digestive system working well. Fiber pulls water into the digestive system, so it is important to drink more water if you are eating more fiber. *The best way to get fluid is from water. Juices, milks and other non-caffeinated beverages also provide water.*

**More for healthy digestion?** *Eat plenty of fruits and vegetables. Keep physically active, and stay at a healthy weight.*

Is there a difference in how nutrients are digested and absorbed?
As food is broken down and digested, it is broken down into nutrients. Most are absorbed through the small intestine. Specialized cells allow the absorbed nutrients to pass through the walls into the blood where they are carried off to the parts of the body that need them, made into different nutrients, or stored. **The major nutrients are carbohydrates, protein and fats but vitamins, minerals and water are also absorbed through digestion.**

Digestible carbohydrates that we eat are starches and sugars. Starches are broken down into simple molecules by saliva and then into even smaller molecules now called glucose in the small intestine where they are absorbed. Glucose is carried through the blood into the liver where it is stored or used for energy. Sugars are dissolved in one step in the small intestine to glucose and fructose. Milk contains lactose, which is another type of sugar.

*Foods rich in carbohydrates are breads and grains, potatoes, rice, beans, pasta, fruits and vegetables.*

Protein consists of giant molecules that must be digested by strong enzymes before they can be absorbed.

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The Human Digestive System

Most protein digestion happens in the stomach and is then completed in the intestine. Once digested, they are called amino acids. Amino acids can be absorbed through the intestine wall into blood to be used in the body for building and for energy.

*Food rich in protein include meat, dairy, eggs, beans, and nuts.*

Fat is the slowest nutrient to be digested and absorbed. The first step is to break it up into tiny droplets in the intestine by mixing it with bile acids (produced by the liver). Then the enzymes in the intestine can digest the fat into smaller molecules of fatty acids and cholesterol. The bile acids help move the fat molecules into the intestinal walls where they are formed back into larger fat molecules again. They move through the lymphatic vessels to be transported to where it needs go for energy or storage.

**Resources:**

*Your Digestive System.* The Nemours Foundation. <kidshealth.org/teen/your_body/body_basic/digestive_system.html>


*Organ Systems: Digestive System.* The Partnership for Environmental Education and Rural Health (PEER) Texas A&M University. <peer.tamu.edu/curriculum_modules/organsystems/module_2/index.htm>
Refer to the labeled diagram to create your own swine digestive tract on the blank pig below.

Monogastric Digestive System Diagram

Name: ______________________
Date: ___________ Period:____}

Monogastric
Word Bank

Cecum
Colon
Duodenum
Liver
Pancreas
Rectum
Small Intestine
Stomach
Talk It Over

What are the major parts of a ruminant’s digestive system?

Why can a cow eat large amounts of hay and a pig can’t?

How does feed move through each species’ digestive system?

What differences are there between the two systems?

What similarities are there between the two systems?

What are the major parts of a monogastric digestive system?

How does a human digestive system compare to a monogastric digestive system?

What do you consider your strengths when giving presentations to others?

Besides using good public speaking skills, how could you improve your presentations to make them interesting and easy for listeners to follow?
PRE-Evaluation: Animal Digestion

1. How old are you? ______________

2. Are you... (Select one.)
   - A boy
   - A girl

3. Are you...(Select ALL that apply.)
   - African American/Black
   - Native American/Alaskan Native
   - White
   - Asian
   - Hispanic/Latino
   - Native Hawaiian/Other Pacific Islander

4. What type of school do you go to? (Select one.)
   - Public school
   - Private school
   - Religious school (Catholic, etc.)
   - Home school

Your Science and Agriculture Opinions and Knowledge

5. BEFORE going through the AGsploration Program, please circle the degree to which you agree or disagree with the following statements.

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<thead>
<tr>
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<th>Strongly Disagree</th>
<th>Disagree</th>
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<td>I like science.</td>
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<td>Science is useful for solving everyday problems.</td>
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<tr>
<td>Maryland agriculture is beneficial to me, my family, and my community.</td>
<td>1</td>
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<tr>
<td>When I graduate from high school, I would like to have a job in agricultural science.</td>
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POST-Evaluation: Animal Digestion

Your Science and Agriculture Opinions and Knowledge

7. AFTER going through the AGsploration Program, please circle the degree to which you agree or disagree with the following statements.

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9. As a result of participating in this activity, tell one new thing you will try or one thing you will find information about.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

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SUPPLEMENTAL-Evaluation: Animal Digestion

Directions: If you are teaching more than one lesson plan in one day, you may attach this to the pre/post evaluation form for the other lesson you are teaching. Please have the student fill out these during the pre and post evaluation times. In addition, only have the student fill out the post evaluation questions Q5 – Q7 at the completion of all lessons.

**PRE-Evaluation**

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**POST-Evaluation**

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