U.S. Food and Drug Administration

How Cows Eat Grass

Exploring Cow Digestion

Adam I. Orr, Ph.D., P.A.S.

FDA Center for Veterinary Medicine

Digestion

Digestion is the process our bodies use to break down and absorb nutrients stored within food, but the ability to digest food is not the same for all animals. Cows, for example, have a very different digestive system than our own, and this allows them to thrive on a menu predominantly made up of grass.

Let's explore how cows are able to eat grass. The key to this ability lies in the stomach. After we chew and swallow our food, the stomach serves as a holding tank where digestion begins and food starts being separated into individual nutrients. Next, food passes into the small intestine where the breakdown continues and where the body absorbs nutrients. This basic digestive process is also true of cows, but there are a few extra steps along the way.

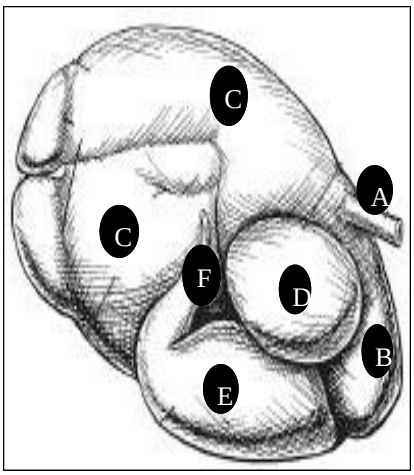

Diagram 1. Stomach of the Cow.
A = Esophagus; **B** = Reticulum; **C** = Rumen; **D** = Omasum; **E** = Abomasum; **F**

Eating

Cows are unique in that they have fewer teeth than other animals. In the front of the mouth, teeth (known as incisors) are only located on the bottom jaw. In place of the top incisors, there is a hard leathery pad (known as the “dental pad”). In addition, cattle have a relatively immobile upper lip (compared to goats and sheep). Because of this unique oral anatomy, a cow uses its tongue to grasp a clump of grass and then bite it off. Teeth in the back of the mouth (known as molars) are located on the top and bottom jaws. Plant materials sometimes contain tough stems, but because a cow chews food in a side-to-side motion, the molars shred the grass into small pieces that are more easily digested.

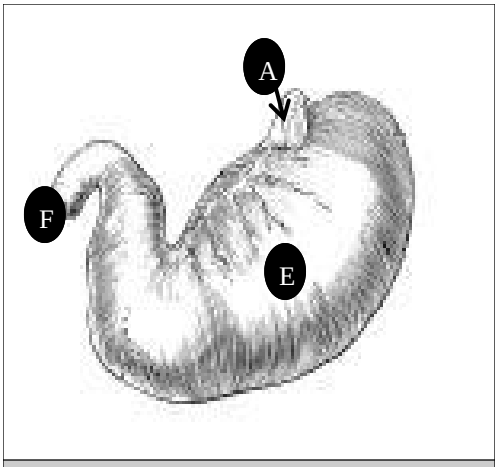

Diagram 2. Stomach of the Dog.
A = Esophagus; **E**= Stomach Body; **F** = Small Intestine begins
Diagram courtesy of Sudz Publishing

The Stomach

On the right, a cow’s stomach is shown in Diagrams 1 and 3, and a dog’s stomach is shown in Diagram 2. Use the letters that label the stomach parts in Diagrams 1 and 2 to identify the similarities and differences between the two stomachs. Notice that the letters do more than identify the structures; they also map the path food travels on its digestive journey. The dog’s stomach is a lot like our own. See how many more structures there are in the cow’s stomach? In the cow, rather than having a single pouch, there are four interconnected pouches, each with a unique function.

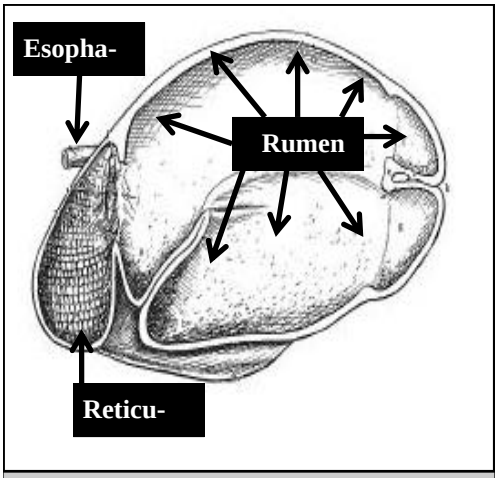

Diagram 3. The Reticulo-rumen.
Diagram courtesy of Sudz Publishing

When a cow first takes a bite of grass, it is chewed very little before it is swallowed. This is a characteristic feature of the digestion in cows. Cows are known as “ruminants” because the largest pouch of the stomach is called the rumen. Imagine a large 55-gallon trashcan. In a mature cow, the rumen is about the same size! Its large size allows cows to consume large amounts of grass. After filling up on grass, cows find a place to lie down to more thoroughly chew their food. “But they have already eaten,” you might be thinking. This is true, but cows are able to voluntarily “un-swallow” their food. This process of swallowing, “un-swallowing”, re-chewing, and re-swallowing is called “rumination,” or more commonly, “chewing the cud.” Rumination enables cows to chew grass more completely, which improves digestion.

The reticulum is directly involved in rumination. The reticulum is made of muscle, and by contracting, it forces food into the cow's esophagus which carries the food back to the mouth . The reticulum (letter B, Diagram 1) is sometimes called the "honeycomb" because of its distinct honeycomb-like appearance. See Figure 1 for a close-up look.

With a simple stomach, the dog, and even man, cannot digest many plant materials. A cow's rumen is different because it functions like a large food processor. In fact, millions of tiny organisms (mainly bacteria) naturally live in the rumen and help the cow by breaking down plant parts that cannot be digested otherwise. These tiny organisms then release nutrients into the rumen. Some nutrients are absorbed right away; others have to travel to the small intestine before being absorbed.

Figure 1. The Reticulum.
Photo courtesy of Dr. Karen Petersen, Univ. of Washington, Dept. of Biology

Figure 2. Rumen Papillae.
Photo courtesy of Dr. Karen Petersen, Univ. of Washington, Dept. of Biology

To help the cow's body capture and absorb all these nutrients, the inside of the rumen is covered by small finger-like structures (called papillae). In Figure 2, notice that the rumen wall resembles a shag carpet or the imitation wool on the inside of a winter coat. The papillae give the rumen wall this texture.

There is little separation between the first two sections of a cow's stomach, the reticulum and the rumen (Diagram 3), so food and water pass back and forth easily. The next pouch in the stomach is the omasum (letter D, Diagram 1). This pouch acts like a giant filter to keep plant particles inside the rumen while allowing water to pass freely. By keeping grass pieces and other feed inside the rumen, bacteria have more time to break them down, providing even more nutrients for the cow. Figure 3 shows the multiple layers of the omasum.

After the grass pieces and other feed are broken down to a small enough size, they eventually pass through the omasum and enter the abomasum (letter E, Diagram 1). The prefix “Ab-,” means from, off, or away from. The abomasum, then, is located just beyond the omasum. Refer back to Diagrams 1 and 2 and notice that the center of the dog’s stomach and the abomasum of the cow’s stomach are both labeled with the letter “E”. This illustrates a similarity in function. You see, the abomasum has the same basic function as the stomach of the dog, man, or other mammal, which is the production of acids, buffers, and enzymes to break down food. After passing through the abomasum, partially digested food enters the small intestine where digestion continues and nutrients are absorbed.

Figure 3. The Omasum.
Photo courtesy of Dr. Karen Petersen, Univ. of Washington, Dept of Biology

The Benefits

The rumen efficiently extracts nutrients from food other animals cannot digest. For this reason, cows can eat plant materials (such as seed coats, shells, and stems) that remain after grains are harvested for human consumption. These remaining materials are sometimes called “by-products.” Feeding by-products helps farmers and businesses save money by not having to pay to dispose of these extra materials and make money by selling the by-products as animal feed.

When oil is extracted from grains (for example, soybean oil from soybean seed and canola oil from rapeseed), or grains are used to brew alcohol or make fuel-ethanol, plant by-products are made. Although key nutrients (like fat, sugar, and protein) are removed from the plant materials during processing, when used properly, these by-products can be fed to cows. The complex nature of their four-compartment stomachs and their rumen bacteria allow cows to eat and thrive on plant by-products that other animals cannot digest.

The better we understand the cow’s digestive system, the better we are able to formulate diets and manage our herds for the optimal production of the nutritious meat and milk we routinely enjoy. So, the next time you have a cool glass of milk, a cup of ice cream, or a juicy hamburger, you will know that these products came from cows fed grass, grain, or by-products, and you will know, *How Cows Eat Grass*.

Name: _____

ACTIVITY: How Cows Eat Grass Knowledge Check

1. What is the definition of digestion?

2. List the four main parts of a cow's stomach.

3. Create a LABELED diagram of a cow's mouth anatomy using the information from the "Eating" paragraph.

4. Diagram 2 displays a dog's stomach. Dogs are "monogastric." Name three other monogastric animals.

5. List three examples of other ruminant animals.

6. What is the most common microorganism found in the rumen?

7. Summarize in 3-4 sentences, using information from the article, why cattle can digest materials and by-products that aren't suitable for humans.

Name:_____

Inside the Lab: Ruminant Stomachs

During this lab, you will construct a model of the “rumen,” which is one of the four parts of a ruminant animal’s stomach. Be sure to complete the *How Cows Eat Grass* worksheet on page 3 of the Reader before this Lab.

Rumen: The first large compartment of the stomach of a ruminant in which cellulose is broken down by the action of symbiotic microorganisms

Pre-Lab Questions:

1. Ruminant animals have bugs in their stomachs just like us. What are those “bugs” called?

2. What might happen if those bugs were not in their stomach?

3. Why do you think ruminant animals need four different parts for their stomach?

4. How are ruminant stomachs alike and different compared to the human stomach?

Materials:

- Bottle, recyclable water bottles or soda bottles
- Balloon
- 3 tablespoons of white granulated sugar
- Packet of active dry yeast or dry quick rise yeast (2 ¼ teaspoons)
- Warm tap water

Procedure:

1. Begin by receiving a cow outline and spend around ten minutes drawing the stomach system. If needed, you can use a computer as a reference.
2. Once your group finishes the outline, gather the necessary supplies from your teacher.
3. In the bottle, add one yeast packet and 3 tablespoons of sugar.
4. Fill the bottle halfway with very warm tap water. It’s crucial to ensure that the water is VERY warm; otherwise, the reaction may not occur.
5. Secure the lid tightly and shake the bottle to mix the yeast and sugar for approximately 10-15 seconds.
6. Remove the lid and place a balloon over the open top of the bottle.
7. Be prepared to observe the reaction; this will take a few minutes.
8. After 2-3 minutes, record your observations and draw your results.

Observations	

Draw Your Results

BEEF. IT'S WHAT'S FOR DINNER.®
Funded by Beef Farmers and Ranchers