

Unit B: Understanding Animal Body Systems

Lesson 1: Understanding Animal Digestion

Student Learning Objectives: Instruction in this lesson should result in students achieving the following objectives:

1. Identify the various types of digestive systems found in animals.
2. Describe the functions of the major parts of the digestive systems.

Recommended Teaching Time: 4 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

Lee, Jasper S., et. al. *Introduction to Livestock and Companion Animals, 3rd Edition.*
Pearson Prentice Hall, Inc. 2004. (Chapter 3)

<http://www.wiziq.com/educational-tutorials/presentation/1912-MartinIntrotoRuminantDigestion>

List of Equipment, Tools, Supplies, and Facilities:

Writing surface

Projector

PowerPoint Slides

Materials and Equipment needed for LS: 1-1 **Fermentation During Ruminant Digestion Laboratory**

Terms: The following terms are presented in this lesson: (**PowerPoint Slide 2 and 3**)

Absorption

Amino acids

Anus

Avian

Bile

Cecum

Chyme

Crop

Cud

Digestion

Digestive system

Enzymes

Ervuctated

Feces

Gizzard

Intestinal juice

Monogastric

Omasum

Pancreatic amylase
Pancreatic juice
Pepsin
Polygastric
Pseudo-ruminant
Reticulum
Rumen
Ruminant
Rumination
Salivary amylase
Salivary maltase
Stomach
Trypsin

Interest Approach. Use an interest approach that will prepare the students for the lesson.

Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Ask students to make a list of what they have had to eat this week. Once students have compiled the list, have each one share their favorite food item for the week. Then, have them make a list of what they think is fed a livestock animal such as a cow. Ask the question “Why can they eat this type of food but we can not?” or “Why do animals have to eat different kinds of food than humans?” Use the responses to these questions to lead into Objective 1.

Summary of Content and Teaching Strategies

Objective 1: Identify the various types of digestive systems found in animals.

Anticipated Problem: What are the various types of digestive systems found in animals?

- I. Knowledge of the different types of digestive systems is critical in selecting the proper feeds for livestock. Understanding the chemical and physical changes that occur during the digestion process leads to more efficient livestock feeding. **Digestion** is the process of breaking down feed into simple substances that can be absorbed by the body. **Absorption** is taking the digested parts of the feed into the bloodstream. The **digestive system** consists of the parts of the body involved in chewing and digesting feed. This system also moves the digested feed through the animal's body and absorbs the products of digestion. Different species of animals are better able to digest certain types of feeds better than others. This difference occurs due to the various types of digestive systems found in animals. There are four basic types of digestive systems: monogastric (simple), avian, ruminants (polygastric), and pseudo-ruminants.

Lead students in a discussion about digestion. Where does digestion start? What is digestion?

Have students independently think of 3 questions they have about animal digestion and share them with the class. Also, use PowerPoint Slides 4, 5, and 6 to aid in note taking.

- A. A **monogastric** digestive system has a simple stomach. The **stomach** is a muscular organ that stores ingested feed and moves it into the small intestine. The stomach secretes acid. The acid results in a low pH of 1.5 to 2.5. The low pH destroys most bacteria and begins to break down the feed materials. Animals with this type of digestive system are

better adapted to the use of concentrated feeds, such as grains, than the use of large quantities of roughages. Examples of monogastric animals are dogs, cats, and humans.

Use PowerPoint Slides 7, 8, and 9 and TM: 1-1 and have students sketch the digestive system.

- B. The **avian** digestive system is found in poultry. This system differs greatly from any other type. Since birds have no teeth, there is no chewing. The esophagus empties directly into the crop. The **crop** is where the food is stored and soaked. From the crop the food makes its way to the gizzard. The **gizzard** is a very muscular organ, which normally contains stones or grit which functions like teeth to grind the food. Digestion in the avian system is very rapid.

Soak a whole apricot, halves of apricots, quarters of apricots, and diced apricot in a bowl of water. Have students predict which amount will be the easiest to crush using only 2 stones. After predictions have been made, let students crush the fruit. This will show how the gizzard works in poultry. Also, use PowerPoint Slides 10, 11, 12, and 13 and TM: 1-2 to help students visualize the avian digestive system.

- C. The **polygastric** or **ruminant** digestive system has a large stomach divided into compartments. The largest section of the stomach is the **rumen**. The rumen contains bacteria and other microbes that promote fermentation. The rumen is the first compartment of the stomach that food enters. This system is designed for food to be ingested, **eructated** (belched up), chewed, and swallowed again. The **reticulum** is the second segment of the stomach. Next is the omasum, followed by the **abomasum**. The **omasum** is a small compartment that acts as a filter of materials for the abomasum. The abomasum secretes gastric juices that kill the microbes that have passed with the food materials from the rumen. The juices and other substances in the abomasum digest the microbes. The polygastric system uses feed high in fiber. Thus, these animals make good use of roughage. Some examples of polygastric animals are cattle, sheep, and goats.

Ask students as a group to recite what are the four compartments of the ruminant digestive system? “Rumen, Reticulum, Omasum, Abomasum” Repeat. Also, use the websites under resources as well as worksheet WS: 1-1 to reinforce this topic. Use PowerPoint Slides 14 through-22 to show students the different compartments of the ruminant stomach. Students could independently create a pamphlet about the compartments of the ruminant stomach. Create this as a “Travel Guide” through ruminant digestion. Also use TM: 1-3.

- D. A **pseudo-ruminant** is an animal that eats large amounts of roughage but does not have a stomach with several compartments. The digestive system does some of the same functions as those of ruminants. They are able to utilize large amounts of roughages because of the greatly enlarged cecum and large intestine. These animals often eat forages as well as grains and other concentrated feeds. Examples of pseudo-ruminants are horses, rabbits, guinea pigs, and hamsters.

Use PowerPoint Slides 23, 24, and 25 and TM: 1-4.

Objective 2: Describe the functions of the major parts of the digestive systems.

Anticipated Problem: What are the major parts of the digestive system and their functions? (Use PowerPoint Slide 26 here).

- II. The digestive system is made up of a number of parts known as organs. The system begins at the mouth, where food enters the body, and continues until anus, where undigested material exits the body. The digestive systems of most livestock are very similar in terms of the organs they contain. Some of the major parts of the digestive system and their functions are:
- A. Mouth and esophagus—The chewing action of the mouth and teeth breaks, cuts, and tears up the feed. This increases the surface area of the feed particles which aids in the chewing and swallowing process. Saliva stimulates the taste of the feed but also contains

the enzymes, alivary amylase and salivary maltase. **Enzymes** are substances called organic catalysts that speed up the digestive process. **Salivary amylase** changes starch to maltose or malt sugar. **Salivary maltase** changes maltose to glucose.

Use PowerPoint Slides 27 and 28

B. Ruminant stomach—The four parts of the ruminant stomach are rumen, reticulum, omasum, and abomasum. Ruminant animals typically eat rapidly. They do not chew much of their food before swallowing. The solid part of food goes into the rumen. The liquid part goes into reticulum, then the omasum and on into the abomasum. In the rumen, the solid feed is mixed and partially broken down by bacteria. When the rumen is full, the animal lies down. The feed is then forced back into the mouth rumination occurs. **Rumination** is the process of chewing the cud. **Cud** is a ball-like mass of feed that is brought up from the stomach to be rechewed. On average, cattle chew their cud about six to eight times per day. A total of five to seven hours each day are spent in rumination. The rumen and reticulum contain millions of bacteria and protozoa. It is the bacterial action in the rumen that allows ruminants to use large amounts of roughage. These bacteria can change low-quality protein into the amino acids needed by the animal. **Amino acids** are compounds that contain carbon, hydrogen, oxygen, and nitrogen. These are essential for growth and maintenance of cells. Bacteria also produce many of the vitamins needed by the animal.

To help reinforce this topic, use PowerPoint Slides 29, 30, 31, and 32 and have students do lab LS: 1-1 and TS: 1-1 that will help explain the fermentation process. Also, have students go to the following websites to read more about ruminant digestion. Use WS: 1-1.

http://www.vivo.colostate.edu/hbooks/pathphys/digestion/herbivores/rumen_anat.html

<http://agriculture.kzntl.gov.za/portal/Publications/ProductionGuidelines/DairyinginKwaZuluNatal/RuminantDigestion/tabid/247/Default.aspx>

C. Monogastric stomach—When feed enters the stomach of monogastrics or the abomasum of ruminants, gastric juices begin to flow. The fluid comes from glands in the wall of the stomach. The juices contain from 0.2 to 0.5 percent hydrochloric acid. This acid stops the action of the amylase from the mouth. These gastric juices also contain the enzymes pepsin, rennin, and gastric lipase. **Pepsin** breaks the proteins in the feed into proteoses and peptones. The muscular walls of the stomach churn and squeeze the feed. Liquids are pushed on into the small intestine. The gastric juice then act on the solids that remain in the stomach. **PowerPoint Slides 33 and 34**

D. Small intestine—The partly digested feed that leaves the stomach enters the small intestine. It is an acid, semi-fluid, gray, pulpy mass. This material is called **chyme**. In the small intestine, the chyme is mixed with three digestive juices: pancreatic juices, bile, and intestinal juice. **Pancreatic juice** secreted by the pancreas, contains the enzymes trypsin, pancreatic amylase, pancreatic lipase, and maltase. **Trypsin** breaks down proteins not broken down by pepsin. Some of the proteoses and peptones are broken down by trypsin to peptides. Proteoses, peptones, and peptides are combinations of amino acids. Proteoses are the most complex compounds and peptides are the simplest. **Pancreatic amylase** changes starch in the feed to maltose. Sugar and maltose are then broken down even further by maltase. They are then changed into a simple sugar called glucose. Lipase works on fats in the feed. It changes them into fatty acids and glycerol. **Bile** is a yellowish-green, alkaline, bitter liquid produced in the liver. Bile is stored in the gall bladder in all animals except horses. Bile aids in the digestion of fats and fatty acids. It also aids in the action of the enzyme lipase.

Glands in the walls of the small intestine produce ***intestinal juice***. This fluid contains peptidase, sucrase, maltase, and lactase, all enzymes used in digestion. Proteoses and peptones are broken down by peptidase into amino acids. Starches and sugars are broken down by sucrase, maltase, and lactase into the simple sugars, glucose, fructose, and galactose. **PowerPoint Slides 35, 36, 37, 38, and 39**

- E. Cecum—The **cecum** or "blind gut" is found where the small intestine joins the large intestine. It is a small organ and has little function in most animals, except pseudoruminants. In these animals, roughage are digested by bacterial action in the cecum. **PowerPoint Slide 40**
- F. Large intestine—The main function of this organ is to absorb water. Material not digested and absorbed in the small intestine passes into the large intestine. Feed materials that are not digested or absorbed are called **feces**. This material moves through the large intestine by muscles in the intestinal walls. The undigested part of feed is passed out of the body through the **anus**, the opening at the end of the large intestine. **PowerPoint Slide 41**

Review/Summary: Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught again. Students can create review cards for each section of digestion to help them learn the different digestion systems. If possible see if the local person who processes animals could provide you with the digestive tracts of specific animals so the students can view the actual digestive tracts of these animals.

Application: Laboratory Exercise LS: 1-1 and Technical Supplement TS: 1-1.

Evaluation: Focus the evaluation of student achievement on mastery of the objectives stated in the lesson. Measure student performance on classroom participation, laboratory assignments, and written tests or quizzes.

Answers to Sample Test:

Part One: Matching

1 = h, 2 = e, 3 = j, 4 = f, 5 = b, 6 = i, 7 = d, 8 = a, 9 = g, 10 = c

Part Two: Completion

1. Digestion
2. gastric juices
3. fiber

WS: 1-1

A Closer Look at Ruminant Digestion

Name: _____

Use the following websites to take a closer look at the ruminant digestive system.

http://www.vivo.colostate.edu/hbooks/pathphys/digestion/herbivores/rumen_anat.html

<http://agriculture.kzntl.gov.za/portal/Publications/ProductionGuidelines/DairyinginKwaZuluNatal/RuminantDigestion/tabid/247/Default.aspx>

Answer these questions on another sheet of paper. Be sure to explain your answers and use full sentences!!

- Where do foreign objects collect in the digestive system?
- What triggers frothy bloat to occur? List the production losses caused by bloat.
- What are the folds in the Omasum called?
- In adult cattle how many liters can the rumen hold?
- In which part of the digestive system does bloat occur?
- How does the ruminant animal symbolize a symbiotic relationship between mammals and micro-organisms?
- What is the majority of dietary protein broken down into?
- What are the by-products called of bacterial fermentation?
- What compartments of the digestive system absorb the by-products of bacterial fermentation?
- What do the folds in the Omasum assist with?
- Which compartment of the digestive system is the most similar to the stomach of a non-ruminant animal?
- What is unique about the digestive system of a newborn calf?
- How do ruminants digest cellulose?
- How much food energy is lost as methane gas during digestion?
- Why can producers switch from a grain to a roughage ration rapidly, but not from a roughage to a grain?
- What causes free gas bloat?
- What are the projections called that line the rumen?

Sample Test 1-1

Name_____

Test

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

- | | | |
|--------------------|--------------|---------------------|
| a. Pseudo-ruminant | b. Omasum | c. Digestive system |
| d. Reticulum | e. Rummation | f. Amino acids |
| g. Avian | h. Cecum | i. Monogastric |
| j. Ruminant | | |

- _____ 1. Small organ and has little function in most animals, except pseudo-ruminants
- _____ 2. The process of chewing the cud
- _____ 3. Digestive system that has a large stomach divided into compartments
- _____ 4. Compounds that contain carbon, hydrogen, oxygen, and nitrogen
- _____ 5. A small compartment that acts as a filter of materials for the abomasum.
- _____ 6. Digestive system that has a simple stomach
- _____ 7. The second segment of the ruminant stomach
- _____ 8. An animal that eats large amounts of roughage but does not have a stomach with several compartments
- _____ 9. Digestive system found in poultry
- _____ 10. Parts of the body involved in chewing and digesting feed

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

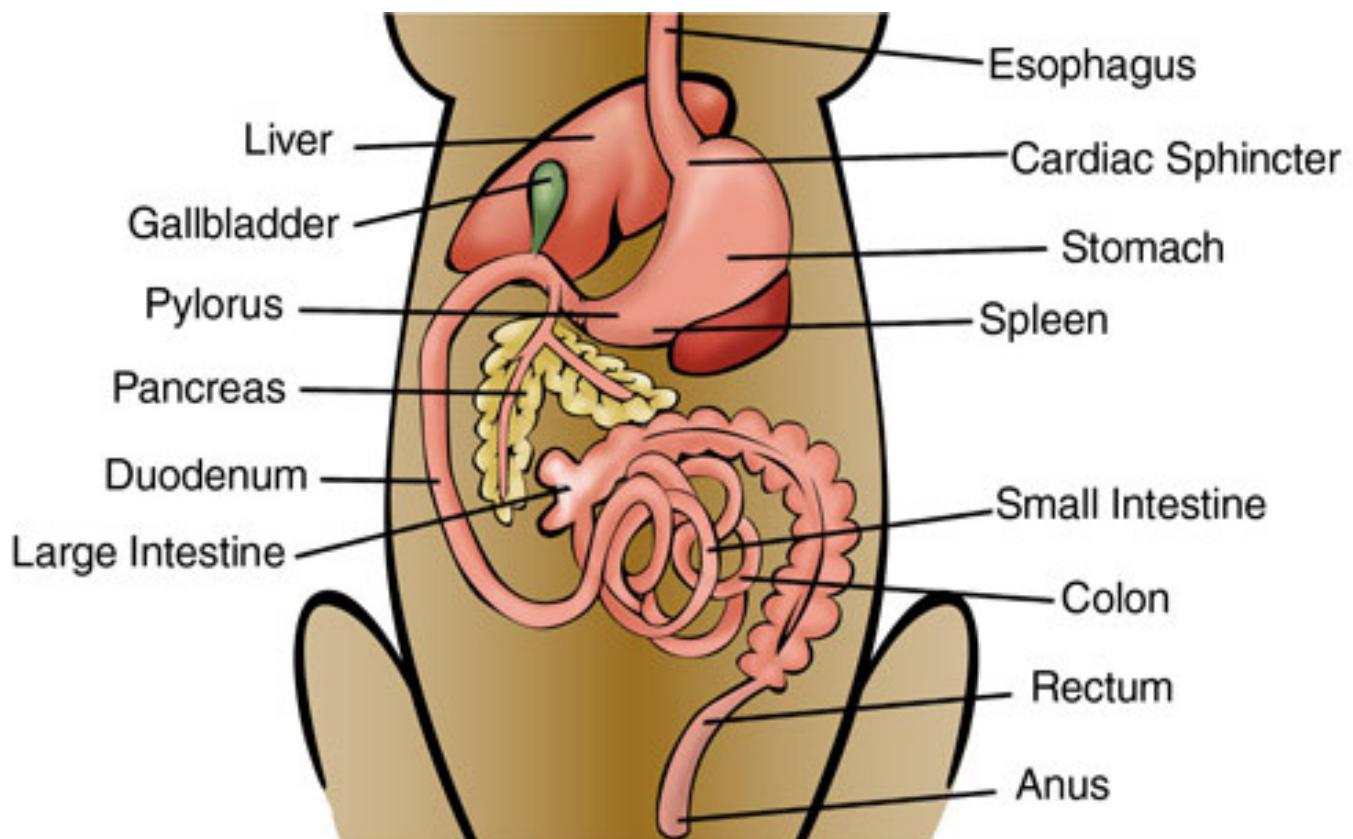
1. _____ is the process of breaking down feed into simple substances that can be absorbed by the body.
2. The abomasum secretes _____ that kill the microbes that have passed with the food materials from the rumen.
3. The polygastric system uses feed high in _____.
4. Salivary amylase changes starch to _____.
5. On average, cattle chew their cud about _____ to _____ times per day.

Part Three: Short Answer

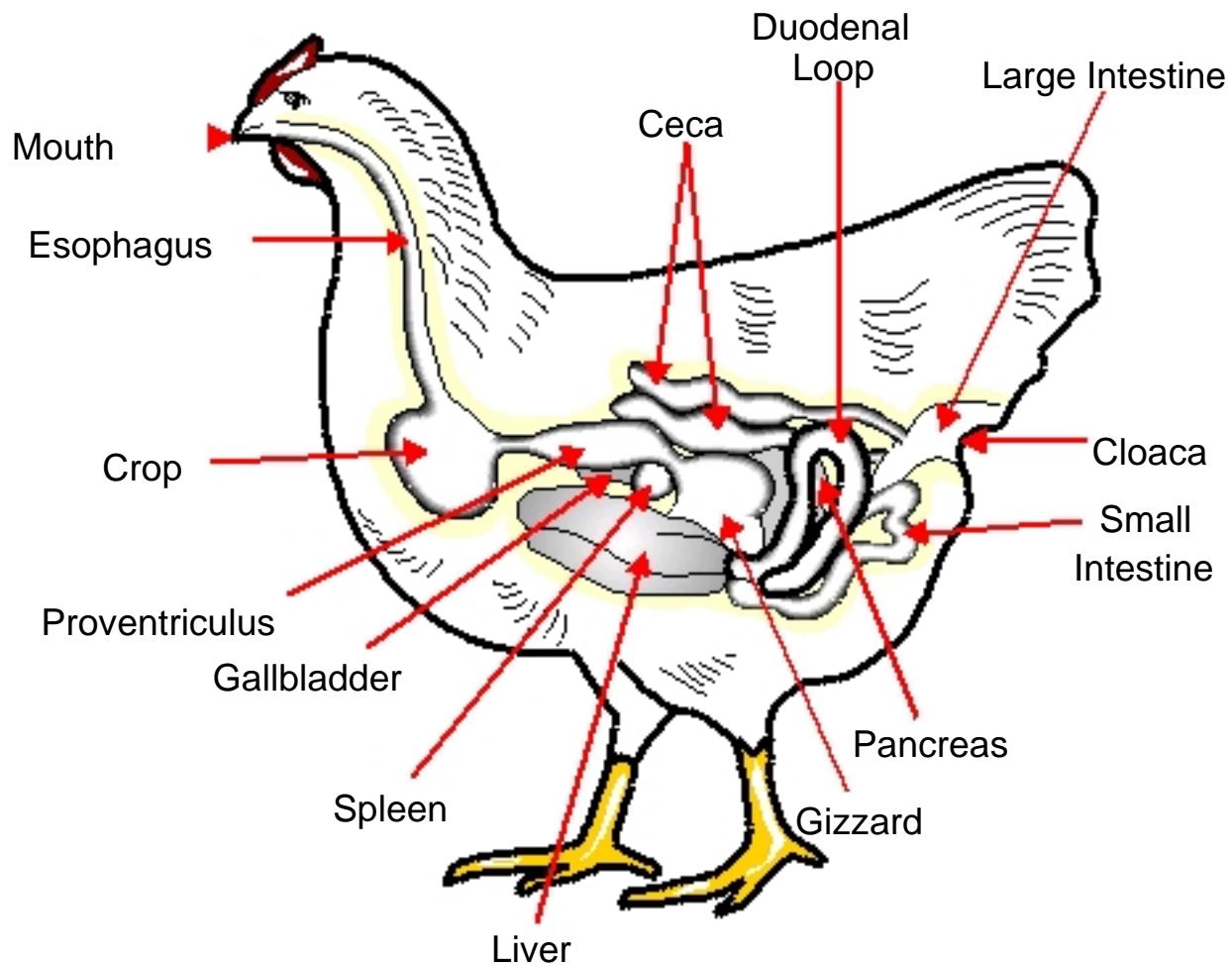
Instructions. Provide information to answer the following question.

Briefly describe digestion in ruminant animals.

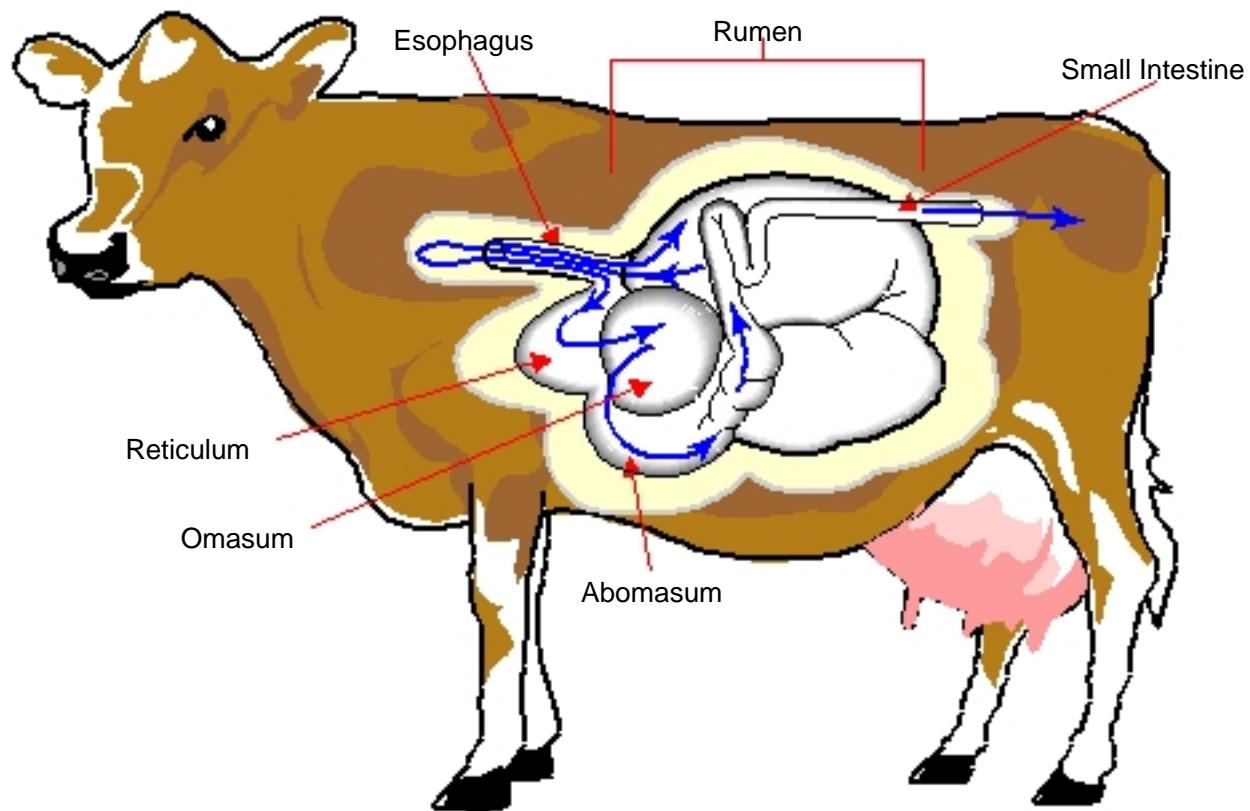
SCHEMATIC DIAGRAM OF DOG DIGESTIVE SYSTEM



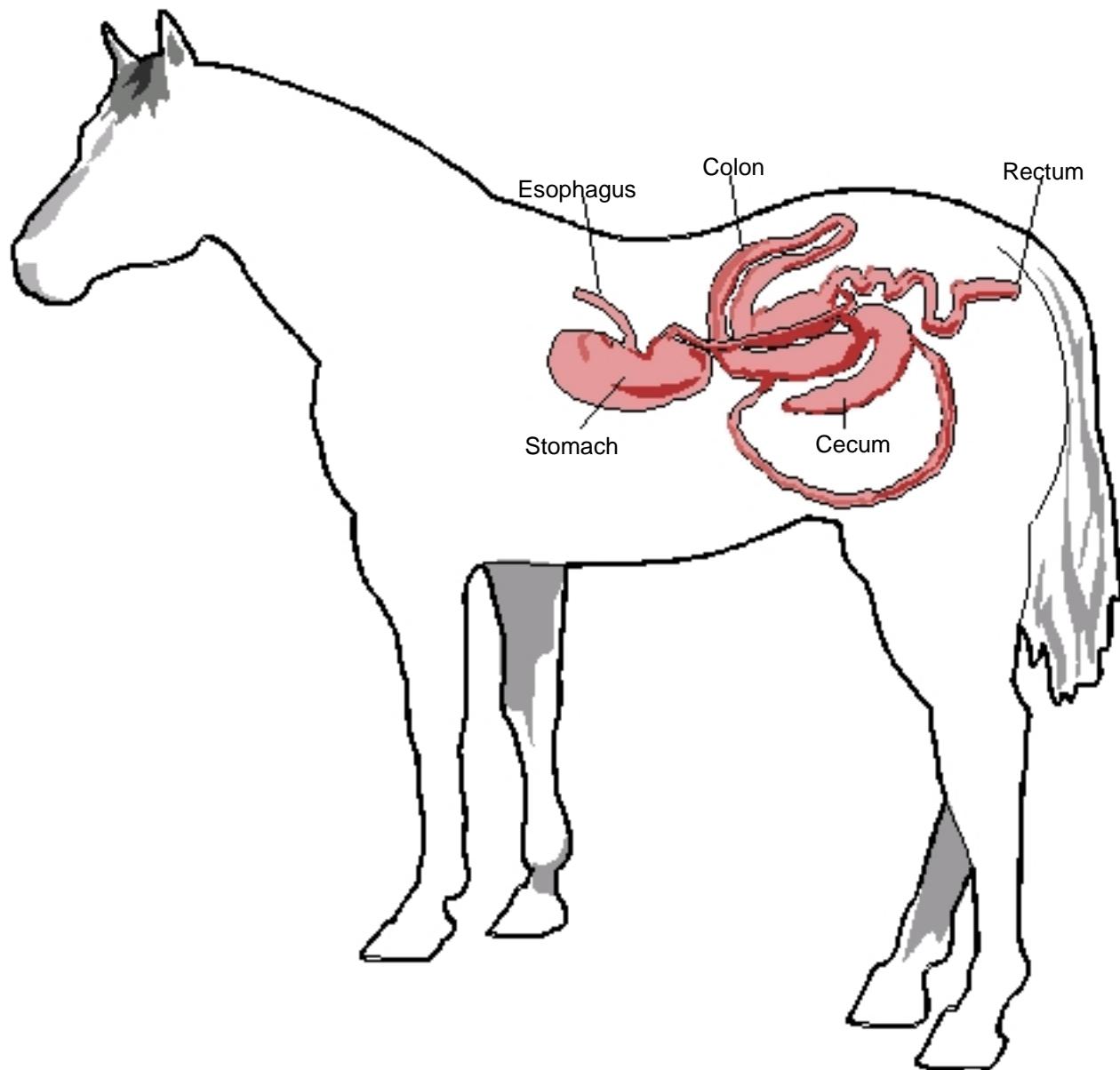
SCHEMATIC DIAGRAM OF CHICKEN DIGESTIVE SYSTEM



SCHEMATIC DIAGRAM OF COW DIGESTIVE SYSTEM



SCHEMATIC DIAGRAM OF HORSE DIGESTIVE SYSTEM



Fermentation During Ruminant Digestion Laboratory

And

Student Performance Objectives

Upon completion of this investigation, students will be able to:

1. Explain how the fermentation process occurs.
2. Describe how what is happening relates to what occurs in the digestive tract of ruminant animals.

Materials and/or Equipment

- 1 package yeast (1/4 oz or 7 g)
- water—500 mL
- corn syrup (1/4 c or 50 mL)
- 2-liter plastic bottle
- balloon
- funnel
- measuring spoons
- measuring cup
- sink

Procedures

1. Give each student or group of students a copy of the **LS: 1-1 Fermentation During Ruminant Digestion** Laboratory Worksheet to perform the activity.
2. Be cautious—the 2-liter bottle or balloon could burst and cause a mess. However, this is an easy way for students to visually see that carbon dioxide is being produced through fermentation similar to what happens in the digestive tract of ruminant animals.

Anticipated Findings

The balloon will gradually grow larger. The yeast in the bottle will break down the sugar from the corn syrup due to fermentation. Gas bubbles and foam should be observed in the mixture; this is carbon dioxide. Ethyl alcohol is created, but stays in the liquid mixture. About 13% of the liquid is ethyl alcohol and most of the rest of the liquid is water. As an extension have students use 1 T of sugar; similar results should be observed.

Fermentation During Ruminant Digestion

Laboratory Worksheet

Procedures

1. Pour 500 mL of water into the 2-liter bottle. Add one package (7 g) of yeast. Carefully swirl the mixture to mix the ingredients.
2. Design a data table and record what you observe happening. (i.e. What color is the mixture? Are gas bubbles present? Is the mixture translucent, opaque, or transparent?)
3. Place the funnel into the mouth of the bottle and add 50 mL of corn syrup. Mix again.
4. Carefully blow up the balloon to stretch it out and to check for holes. Stretch the deflated balloon over the top of the bottle.
5. Place the bottle in a sink or bucket.
6. Check the bottle and balloon after one hour and record your observations.
7. Check the bottle and balloon later in the day if possible (about 2 hours) and record your observations.
8. Check the bottle and balloon after 24 hours and record your observations.
9. When finished, throw away the contents in the bottle and wash out the bottle.

Technical Supplement

Fermentation During Ruminant Digestion

1. What is fermentation and how does this process occur?

Cellular respiration is the process of breaking down molecules of food (i.e. glucose) to release energy. The first step of cellular respiration is the process of glycolysis. Glycolysis is the first in a series of reactions during respiration in which a sugar molecule is degraded to pyruvic acid. Fermentation is one process that occurs after glycolysis. Fermentation causes energy to be released from molecules of food to furnish energy for metabolism and growth of microorganisms. Fermentation changes the chemical environment of a food. Before man knew much about fermentation, they simply used a small portion of food to add to new batches. This ensured that the microorganisms that are needed were included in the recipe. Fermentation is an important process in the preparation of foods for human consumption and in the digestive tract of ruminant animals.

2. What products are created through fermentation?

Foods that undergo fermentation include yogurt, cheese, cider, bread, sauerkraut, flavorings, candy, fruit juice, and silage. Pickling involves fermentation. Foods that are frequently pickled include beans, onions, cauliflower, cucumbers, tomatoes, and cabbage. Non-food items that undergo fermentation include ethanol, biodiesel, antibiotics, laundry detergent, insulin, growth hormone, cellulose, monoclonal antibodies, compost, medicine to dissolve tumors, and medicine to clot blood.

3. Where does fermentation occur in the digestive tract?

The rumen is a large fermentation chamber (in adult cattle its volume is about 125 liters) which has a very high population of micro-organisms, mainly bacteria, but also protozoa. It is because the bacteria secrete the enzymes necessary for cellulose degradation that ruminants are able to utilize roughage.