TEACHER GUIDE

DIGESTION

MATERIALS PER GROUP:

- Potato masher
- Sealable quart-sized plastic bag
- 1 Knee-Hi panty hose
- 2 Paper towels
- Trash bag (4 gallon)
- Bowl
- Funnel with a large-diameter opening at bottom or a large diameter piece of tubing or pipe.
- Various food products for digestion (bread, bananas, juice, coffee, cereal, etc.)
- 7 100 mL Beakers or 7 Test tubes with test tube rack
- Liquid to simulate enzymes (see below) (optional)
- Large trash bag to protect work surface

SAFETY PRECAUTIONS:

- Do not eat or drink in the laboratory.
- Wear safety glasses, lab coat and gloves when performing the experiments.

TOTAL DURATION:

20 min. pre-lab prep time;
40-50 min. class time

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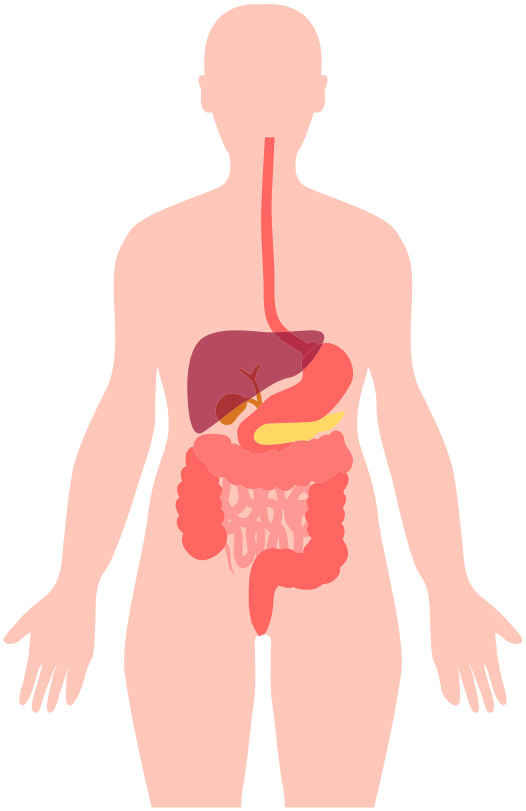
LESSON OVERVIEW:

The energy to keep our bodies functioning comes from the food we eat. This food provides us with nutrients our bodies then break down into smaller components for use as fuel and as building blocks to create other compounds needed for life functions. Nutrition is defined as the ingestion, digestion and absorption of nutrients from food. There are six classes of nutrients our bodies need: carbohydrates, proteins, fats, vitamins, minerals and water.



ESSENTIAL QUESTION:

How does the digestive system function?

TOPICAL ESSENTIAL QUESTION:

How is food broken down by the body to provide energy and building materials for life functions?

LESSON OBJECTIVES:

Students will be able to:

1. Discuss how the parts of the digestive system function independently and as a system.
2. Explain the types of nutrients needed by the body and how they are broken down and absorbed in the body.

STANDARDS:

MS-LS1-3

Students who demonstrate understanding will be able to: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

MS-LS1-7

Students who demonstrate understanding will be able to: Develop a model to describe how food is rearranged through chemical reactions, forming new molecules that support growth and/or release energy as this matter moves through an organism.

HS-LS1-2

Students who demonstrate understanding will be able to: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Science and Engineering Practices:

1. Asking questions
2. **Developing and using models**
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. **Engaging in argument from evidence**
8. Obtaining, evaluating and communicating evidence

Crosscutting Concepts:

1. Patterns
2. Cause and Effect: Mechanisms and explanations
3. Scale, Proportion and Quantity
4. **Systems and System Models**
5. **Energy and Matter: Flows, cycles and conservation**
6. Structure and Function
7. Stability and Change

NOTE TO THE TEACHER:

- Prepare the simulated enzymes prior to class by mixing different food colors and water to create the following compounds:
  - Salivary enzymes (amylase)
  - Protease
  - Hydrochloric acid (HCl)
  - Sodium bicarbonate (NaHCO3)
  - Lipase
  - Protease
  - Bile
- Cut out the digestive system parts cards and the digestive system functions cards for each student group, and be sure they are not in order.

KEY VOCABULARY:

Accessory organs
Lipase
Absorption
Mechanical Digestion
Chemical Digestion
Nutrition
Enzymes
Protease

LAB BACKGROUND INFORMATION:

NOTE: This is background information for the teacher to assist in facilitating learning and will be explained to the students after the Explore section.

The energy to keep our bodies functioning comes from the food we eat. This food provides us with nutrients our bodies then break down into smaller components for use as fuel and as building blocks to create other compounds needed for life functions. Nutrition is defined as the ingestion, digestion and **absorption** of nutrients from food. There are six classes of **nutrients** our bodies need: carbohydrates, proteins, fats, vitamins, minerals and water.

Many of the foods we eat are made up of large molecules that the body cannot absorb without help. Think of eating a hamburger; your body doesn't absorb the hamburger whole, it must be broken down into smaller parts. The body can do this in several ways. First through **mechanical** (or physical) **digestion** – tearing, biting, chewing and muscular contractions. The second method is through **chemical digestion** – the use of biological chemicals produced within the human body to further break the bonds between the nutrients in food into its smallest form which the body can then absorb. One such type of chemical are **enzymes**. Enzymes are chemicals produced within the body that speed up the digestion process. There are different types of enzymes for different types of food. For example amylase digest only carbohydrates while protease only digests protein. You can tell an enzyme by the suffix –ase. Without these enzymes, the human body would not be able to function.

Carbohydrates are one of the most abundant chemical compounds on the planet. They include sugars and starches. Some carbohydrates are simple sugars, meaning they are made up of one or two sugar molecules linked together; or they can be complex starches in that they are made up of multiple sugar units linked together to form a long chain. Carbohydrates can be found in foods like bread, pasta, potatoes, corn and even milk. The body begins to digest carbohydrates in the mouth with an enzyme called amylase to provide quick energy. After swallowing, carbohydrates continue to digest in the stomach through further enzyme action.

Proteins are necessary for building and repairing tissues. Proteins can be obtained from both plant and animal sources including meats, nuts, dairy products, eggs, beans and legumes. They are made up of long chains of amino acids; the body must break these apart in order to absorb the amino acids. Often proteins are so large that they must be broken down as the proteins travel through both the stomach and small intestines. Proteins can only be absorbed by the body as amino acids. **Protease** is only one example of enzymes that aid in this process.

Fats, or lipids, are an important component of the diet and are essential for good health. Fats are a source of energy provide the body with twice as much energy as carbohydrates and are required for vitamins A, D, E and K absorption. Additionally, fat is needed to synthesize or create hormones in the body. Fats are found in oils, nuts, meat, and some plant products like avocados and coconuts. Lipids are long molecular chains that cannot be absorbed without being broken down into smaller units. In the digestive system, the enzyme

lipase is produced by the pancreases and excreted into the small intestines to break down the large lipid chains into smaller units called fatty acids and glycerol.

Vitamins and minerals have similar functions as they often act as catalysts to speed up functions in the body. Vitamins are organic, meaning they come from living materials. The human body can produce four vitamins (B5, B7, K and D); the other nine must be consumed in the food we eat. Plants and animals make other vitamins in their bodies which are transferred to us when we eat them. Minerals are inorganic substances and come from nonliving materials or rocks. The human body does not produce any minerals on its own, so they must be consumed. Sixteen minerals are needed by the human body. Some, like calcium and sodium, are needed in larger quantities and are called macrominerals; others, like selenium and fluoride, are needed in smaller quantities and are called trace minerals.

Water is the last nutrient and is vital to the health of all animals. As the largest component of the body, all cellular functions rely on water. Without water, none of the above nutrients would make it from the digestive system to the other parts of the body to provide the energy necessary for life!

Different animals eat different types of foods, and their digestive systems have evolved over time to best utilize specific types of foods. There are four basic types of digestive systems: monogastric, modified monogastric, polygastric or ruminant, and avian. Humans, dogs, cats and pigs are examples of a monogastric digestive system as will be demonstrated in this lab.

Modified monogastrics have an additional structure called the cecum located between the small and large intestines. The cecum contains beneficial microbes that break down the cell walls of plant material and allow the animal to gain nutrients from this source of food. Horses, rabbits and guinea pigs are examples of modified monogastric digestive systems.

A ruminant digestive system has several differences, including a lack of top teeth in the front of the mouth, no enzymes in saliva, a four-chambered stomach that contains beneficial microbes for the breakdown of plant material, and regurgitation of food for more thorough digestion (called chewing the cud). Cattle, goats and sheep are examples of ruminant digestive systems.

Lastly, the avian digestive system is the most different from the other systems. Birds do not have teeth, so they pick up food and swallow it to be stored in a structure called the crop. The food then enters the proventriculus, which bathes the food in acids, beginning chemical digestion before it enters the gizzard. The gizzard is a muscular organ containing pebbles and rocks that the bird has eaten. As the gizzard contracts, the food grinds against the pebbles and is further broken down. After this point, the digestive system is similar to the others.

ENGAGE:

Ask students what they had for breakfast. Where do they think that these foods are in their digestive system right now? How long does food take to get through your digestive system?

Show students a nutrition label. Which of the ingredients are carbohydrates? Fats? Proteins?

EXPLORE:

For this procedure, it is best for the teacher to walk the students through each of the parts and discuss what is added and why, then students can follow along.

I. **Make certain that a variety of items are added to discuss different types of nutrients.**

a. Types of nutrients:

1. **Carbohydrates**
   a. Provide energy
   b. Starches and sugars (glucose, fructose, galactose)
   c. Foods containing grains, fruits, vegetables
2. **Fats**
   a. Provide energy (two times that of protein and carbs), store energy
   b. Necessary to absorb vitamins A, D, E, K
   c. Protect and cushion organs
   d. Nuts, seeds, meat
3. **Proteins**
   a. Build tissues (muscle, skin, hair, etc.)
   b. Animal and plant sources (meat, nuts, eggs)
4. **Vitamins**
   a. Organic materials present in living things
   b. Necessary for many chemical reactions that occur in the body
   c. Found in most foods
5. **Minerals**
   a. Inorganic, nonliving rock
   b. Necessary for many chemical reactions that occur in the body
   c. Found in most foods

II. **Ask students what happens in the mouth.**

a. Teeth are used to grind food. (Physical digestion, mastication)

i. Incisors are sharp teeth found in the front of the mouth that are used for biting and tearing.
   1. Use hands or scissors to mimic the biting and tearing of food.

ii. Molars are broad flat teeth found in the rear of the mouth that are used for grinding.
   1. Use the potato masher to mimic grinding food.

b. Saliva is released to begin **chemical digestion** of food through **enzymes**.

i. Add the salivary enzymes to the bowl (mouth).
   1. Amylase is the enzyme that begins the digestion of starches into simple sugars. It prefers a neutral pH and so only works in the mouth and esophagus.

ii. Thoroughly mix and mash the contents of the bowl until they are in small pieces.

III. Ask students what happens to food after it leaves the mouth.

a. The esophagus is a hollow tube that connects the mouth to the stomach.

i. Have student scoop out the contents of their bowl into the sealable plastic bag.

IV. What happens to food in the stomach?

a. The stomach is a hollow, muscular organ that continues the digestive process through chemical and physical digestion.

b. Chemical Digestion:

a. Add the hydrochloric acid (HCl) to the bag.
i. The stomach has a very acidic environment that allows the enzymes to function properly and kills foreign microbes.
1. Enzymes are chemicals that are used to begin or speed up a reaction.

b. Add **protease** to the bag.
i. Proteins cannot be digested by the body so the enzyme protease is used to break them down into smaller units that can be digested by the body.

c. Physical Digestion

a. The stomach is a muscle that contracts and relaxes repeatedly to mix the contents to ensure that all food is exposed to the enzymes for breakdown.
i. Seal the bag and mix the contents by gently squeezing.

V. Ask students what happens to food after the stomach?

a. A sphincter muscle at the bottom of the stomach opens and releases the contents into the small intestine.
i. Pour the contents of the bag into the panty hose.

b. The small intestine is where most of the nutrients are absorbed. Many millions of villi, finger-like projections, line the small intestine to increase the surface area for the **absorption** of nutrients across the lining and into the bloodstream.

c. The **accessory organs** (pancreas, liver and gallbladder) are important for the continued digestion of food in the small intestine.
i. The pancreas is a very important organ as it produces digestive juices containing the enzymes needed to complete the breakdown of nutrients into their smallest units so the body can absorb them and use them for fuel. The pancreas is also important in producing insulin which the body uses to control blood sugar.

1. Add sodium bicarbonate to the panty hose (small intestine).
a. While the stomach is very acidic, the enzymes in the small intestine can't work in such an acidic environment. The sodium bicarbonate raises the pH to be more neutral.

2. Add **lipase** to the panty hose (small intestine).
a. Fats are too large to be absorbed by the body and must be broken down into smaller molecules.

3. Add **protease** to the panty hose (small intestine).
a. Protein digestion continues into the small intestine.

ii. The liver is responsible for producing bile, an enzyme that continues the breakdown of fat molecules. The bile is stored in the gallbladder until it is needed.

1. Add bile to the panty hose (small intestine).

VI. Ask students what follows the small intestine?

a. Large Intestine

i. The large intestine, or colon, is the site of water absorption. At this point, salts will also be absorbed.

1. Hold the panty hose over the bowl and squeeze out as much water as possible.

2. Wrap the panty hose in paper towels and squeeze so remaining moisture is extracted from the contents and absorbed by the paper towel (large intestine/colon).

ii. Anything making it to the large intestine, other than water and salt, is not digestible.

VII. What follows the large intestine?

a. Rectum

i. The rectum is a temporary storage area for indigestible material.

1. Place the panty hose contents (large intestine/colon) into the small trash bag (rectum).

VIII. What follows the rectum?

a. Anus

i. The anus is the exit from the digestive system

1. Cut a hole in the bottom corner of the trash bag and push out the contents to simulate the passage of feces from the body.

EXPLAIN: (SEE LAB BACKGROUND)

The Lab Background Information from the Teacher Guide is repeated in the Explain section of the Student Guide.

ELABORATE:

There are many beneficial lab activities that can be done to build on the simulation of digestion. The Noble Research Institute lesson: Milk's Macromolecules focuses on identifying simple and complex carbohydrates, fats, and proteins in various types of milk. This lesson is available by electronic download from our website: www.noble.org/education/noble-academy/lessons/

Flinn Scientific has several labs that focus on how enzymes function in digestion including:
Lactose Intolerance (FB1570)
Digestive Enzymes at Work (FB1862)

EVALUATE:

1. Draw an image to represent the monogastric digestive system. Label the parts of the system, and provide a brief description of the function of each part.
   - **Mouth – physical and chemical digestion, chews and tears food, saliva moistens and starts to break down carbohydrates**
   - **Esophagus – connects mouth to stomach**
   - **Stomach – hollow, muscular organ that continues digestion through chemical and physical means**
   - **Small intestine – nutrients are broken down into their smallest parts and most absorption into the bloodstream occurs here**
   - **Liver – produces bile**
   - **Gall bladder – stores bile and releases it into the small intestine**
   - **Pancreas – produces sodium bicarbonate, lipase, pancreatic amylase and protease**
   - **Large intestine – absorbs water and salts**
   - **Rectum – undigested materials are temporarily stored**
   - **Anus – exit opening from the digestive system.**

2. Why have different types of digestive systems evolved?
   Organisms eat different types of foods that require different types of digestion.

3. Why is it important to include a variety of foods in your diet?
   It is important to eat a variety of foods to be sure that all of the nutrients we need are available to the body.

4. What is the main purpose of digestion?
   Digestion breaks down food so that our body can absorb the nutrients essential for it to function. Digestion also releases energy contained in food. Our bodies use this energy for essential life functions.

5. Why is the digestive tract so long and compartmentalized?
   The digestive tract is long and compartmentalized to allow different types of nutrients the correct time and conditions to be fully broken down and absorbed.

6. Where does digestion begin, and what type of molecules are broken down first?
   Digestion begins in the mouth with the breakdown of carbohydrates.

7. What happens to the digestive processes when someone has diarrhea?
   Diarrhea is the result of decreased water absorption in the large intestine, which causes the feces to contain more water and have a more liquid consistency. This can be caused by microorganisms, diseases and/or dietary issues which affect the cells lining the large intestine.

8. In the space provided below, write the name of the organ in the digestive system that is responsible for each function.

Esophagus	Food travels down this structure into the stomach.
Small Intestines	Nutrient absorption occurs here.
Mouth	Physical and chemical digestion occur here as food is torn and ground into smaller pieces and moistened with saliva.
Rectum	A storage area for materials that cannot be digested by the body.
Stomach	Physical and chemical digestion occur here and nutrients are broken down into smaller units.
Large Intestines	Water and salts are absorbed.
Anus	The exit of the digestive system.
Accessory Organs	The pancreas, liver and gall bladder, which produce and secrete digestive juices that aid in digestion.

Noble Research Institute would like to thank the following people for their contributions to this lesson:

- Quentin Biddy
- Janie Herriott
- Susie Edens
- Fiona McAlister
- Kay Gamble

STUDENT GUIDE

DIGESTION

MATERIALS PER GROUP:

- Potato masher
- Sealable quart-sized plastic bag
- 1 Knee-Hi panty hose
- 2 Paper towels
- Trash bag (4 gallon)
- Bowl
- Funnel with a large-diameter opening at bottom or a large diameter piece of tubing or pipe.
- Various food products for digestion (bread, bananas, juice, coffee, cereal, etc.)
- Enzymes (optional)
- Large trash bag to protect work surface

SAFETY PRECAUTIONS:

- Do not eat or drink in the laboratory.
- Wear safety glasses, lab coat and gloves when performing the experiment.

TOTAL DURATION:

20 min. pre-lab prep time;
40-50 min. class time

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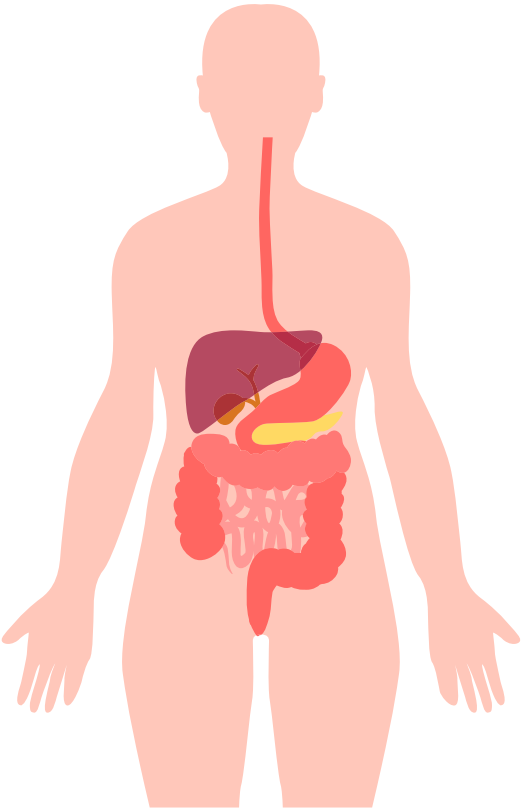
LESSON OVERVIEW:

The energy to keep our bodies functioning comes from the food we eat. This food provides us with nutrients our bodies then break down into smaller components for use as fuel and as building blocks to create other compounds needed for life functions. Nutrition is defined as the ingestion, digestion and absorption of nutrients from food. There are six classes of nutrients our bodies need: carbohydrates, proteins, fats, vitamins, minerals and water.



ESSENTIAL QUESTION:

How does the digestive system function?

TOPICAL ESSENTIAL QUESTION:

How is food broken down by the body to provide energy and building materials for life functions?

LESSON OBJECTIVES:

Students will be able to:

1. Discuss how the parts of the digestive system function independently and as a system.
2. Explain the types of nutrients needed by the body and how they are broken down and absorbed in the body.

KEY VOCABULARY:

Accessory organs
Lipase
Absorption
Mechanical Digestion
Chemical Digestion
Nutrition
Enzymes
Protease

ENGAGE:

Look at the nutrition label provided by your teacher to answer the questions below.

1. Which of the ingredients do you think are carbohydrates?
2. Which of the ingredients do you think are fats?
3. Which of the ingredients do you think are protein?

Introduction

In this lab you will be simulating what occurs in the digestive system of the human body as food is broken down and absorbed into the body.

EXPLORE:

1. The digestion process begins in the mouth. In this simulation, a bowl will represent the mouth. Add all food and drink products to the mouth. If you have large pieces of food, use the scissors to "bite and tear" as your front teeth would do as you eat. Then use the potato masher to grind the food products as your molar teeth would do.
2. The esophagus is a long hollow tube that connects the mouth to the stomach. The funnel or tubing will represent the esophagus. The quart-sized plastic bag will represent the stomach. With the plastic bag under the funnel/tubing, pour the contents of your "mouth" into the funnel/tube and into the plastic bag.
3. Physical and chemical digestion continue in the stomach. The stomach is a muscle that will contract to help mix the food contents with the hydrochloric acid and enzymes. Seal your bag and use your hands to knead your bag to replicate this process. After food leaves the stomach it is now referred to as chine and no longer resembles the original food products.
4. Chemical digestion continues in the small intestines. Enzymes from the accessory organs including the pancreas, liver, and gallbladder are secreted into the small intestines to finish breaking down the protein and fat molecules into their individual parts. The small intestines are the site of nutrient absorption. The small intestines are a narrow tube-like structure. The panty hose will serve to simulate the small intestines. Use the scissors to cut a small hole in the bottom corner of the "stomach" and, holding the panty hose over the bowl that served as the mouth, pour the stomach contents into the panty hose. Notice that there is liquid coming from the holes in the panty hose. This represents the fact that nutrients pass through the lining of the small intestines into the blood stream and will continue to the liver to be used to feed the body.
5. By the time the chine makes it to the large intestines, digestion has finished. Anything that makes it to the large intestines is indigestible and will pass from the body. However, there are two things left in the chine that the body needs to absorb from the chine: water and salt. These pass through the lining of the large intestines into the blood stream. For this activity, we will assume the panty hose represents both small and large intestines as they are connected. Take several paper towels and wrap them around the panty hose to absorb remaining liquids to simulate the absorption of water.

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6. Indigestible materials are stored in the rectum until a time in which they can be evacuated from the body. Cut a hole in the bottom of the panty hose and push the chine into the small trash bag. This will represent the rectum.
7. Waste must eventually leave the body. Cut a hole in the bottom of the small trash bag and "poop" the waste out. While it isn't polite to discuss poop, it can tell a lot about the health of a person. For example, if a person has diarrhea this means the lining of the intestines is inflamed or otherwise cannot absorb water, so the water passes through and is evacuated from the body.

EXPLAIN:

The energy to keep our bodies functioning comes from the food we eat. This food provides us with nutrients our bodies then break down into smaller components for use as fuel and as building blocks to create other compounds needed for life functions. Nutrition is defined as the ingestion, digestion and **absorption** of nutrients from food. There are six classes of **nutrients** our bodies need: carbohydrates, proteins, fats, vitamins, minerals and water.

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Proteins are necessary for building and repairing tissues. Proteins can be obtained from both plant and animal sources including meats, nuts, dairy products, eggs, beans and legumes. They are made up of long chains of amino acids; the body must break these apart in order to absorb the amino acids. Often proteins are so large that they must be broken down as the proteins travel through both the stomach and small intestines. Proteins can only be absorbed by the body as amino acids. **Protease** is only one example of enzymes that aid in this process.

Fats, or lipids, are an important component of the diet and are essential for good health. Fats are a source of energy provide the body with twice as much energy as carbohydrates and are required for vitamins A, D, E and K absorption. Additionally, fat is needed to synthesize or create hormones in the body. Fats are found in oils, nuts, meat, and some plant products like avocados and coconuts. Lipids are long molecular chains that cannot be absorbed without being broken down into smaller units. In the digestive system, the enzyme

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Different animals eat different types of foods, and their digestive systems have evolved over time to best utilize specific types of foods. There are four basic types of digestive systems: monogastric, modified monogastric, polygastric or ruminant, and avian. Humans, dogs, cats and pigs are examples of a monogastric digestive system as was demonstrated in this lab.

Modified monogastrics have an additional structure called the cecum located between the small and large intestines. The cecum contains beneficial microbes that break down the cell walls of plant material and allow the animal to gain nutrients from this source of food. Horses, rabbits and guinea pigs are examples of modified monogastric digestive systems.

A ruminant digestive system has several differences, including a lack of top teeth in the front of the mouth, no enzymes in saliva, a four-chambered stomach that contains beneficial microbes for the breakdown of plant material, and regurgitation of food for more thorough digestion (called chewing the cud). Cattle, goats and sheep are examples of ruminant digestive systems.

Lastly, the avian digestive system is the most different from the other systems. Birds do not have teeth, so they pick up food and swallow it to be stored in a structure called the crop. The food then enters the proventriculus, which bathes the food in acids, beginning chemical digestion before it enters the gizzard. The gizzard is a muscular organ containing pebbles and rocks that the bird has eaten. As the gizzard contracts, the food grinds against the pebbles and is further broken down. After this point, the digestive system is similar to the others.

EVALUATE:

Name: _____

1. Draw an image to represent the monogastric digestive system. Label the parts of the system, and provide a brief description of the function of each part.

2. Why have different types of digestive systems evolved?

_____

_____

_____

3. Why is it important to include a variety of foods in your diet?

_____

_____

_____

4. What is the main purpose of digestion?

_____

_____

_____

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5. Why is the digestive tract so long and compartmentalized?

_____

_____

_____

6. Where does digestion begin, and what type of molecules are broken down first?

_____

_____

_____

7. What happens to the digestive processes when someone has diarrhea?

_____

_____

_____

8. In the space provided below, write the name of the organ in the digestive system that is responsible for each function.

_____ Food travels down this structure into the stomach.

_____ Nutrient absorption occurs here.

_____ Physical and chemical digestion occur here as food is torn and ground into smaller pieces and moistened with saliva.

_____ A storage area for materials that cannot be digested by the body.

_____ Physical and chemical digestion occur here and nutrients are broken down into smaller units.

_____ Water and salts are absorbed.

_____ The exit of the digestive system.

_____ The pancreas, liver, and gall bladder which produce and secrete digestive juices that aid in digestion.