Digestive System: Where does food go?
Teacher Version

In this lab you will learn about your digestive system. We will use everyday objects like yarn and a ziplock bag to understand how long our digestive system is and how it breaks down all of the tasty food you eat.

California Science Content Standards:

- **1. Cell Biology: The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells.**
- 1b. Students know enzymes are proteins that catalyze biochemical reactions with altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings.
- **9. Physiology: As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment.**
- 9a. Students know how the complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide.
- **9f. Students know the individual functions and sites of secretion of digestive enzymes (amylases, proteases, nucleases, lipases), stomach acid, and bile salts.
- How each section of the digestive tract contributes to the processing of the food you eat

Prerequisites:

- Good for most students
- Some basic multiplication required
- Concept questions require critical thinking about the functions of the digestive system. More challenging questions can be skipped with younger students.

Complete list of Materials:

- 5 different colors of yarn (white, yellow, pink, red, purple)
- Scissors
- Ruler
- Calculator
- 1 cup corn flakes (cereal)
- 1 tsp lemon juice
- Food coloring
- 1 quart ziplock bag
- Water
- Measuring spoons (1 tablespoon, 1 cup)
- 1 large width straw
- 1 gallon ziplock bag
- 1 empty paper towel roll
- 1 plastic cup
- Gloves
- 1 leg of pantyhose
- Small tub (or towel to put over table)

Key Concepts:

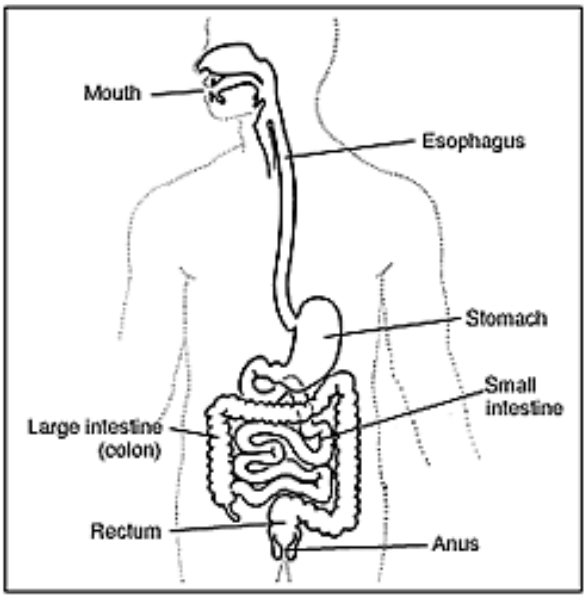
- The digestive system is very long and contains multiple organs to help break down food and adsorb nutrients from the food we eat. This requires both **chemical digestion**, when chemicals and enzymes break the food down into its nutrient components, and **mechanical digestion**, when food is physically broken into smaller pieces.
- The **mouth** is the first organ in the digestive system. Both chemical digestion and physical digestion occur in the mouth.
- The **esophagus** connects the mouth to the next organ in the digestive system, the stomach.
- The **stomach** contains hydrochloric acid which helps to chemically digest proteins. Mechanical digestion also occurs in the stomach due to the churning motion.
- The **small intestine** is the longest part of the digestive system, and most of the nutrients are absorbed here.
- In the small intestine, other digestive juices from the **pancreas** and the **liver** are added. These digestive juices help to continue the chemical digestion of food.
- In the **large intestine**, water is removed from the food, and the final nutrient absorption occurs.

Introductory Mini-Lecture:

Why do we eat food? Because it gives us the energy we need to do everything including growing and repairing our cells. How do we get this energy from our food? We need to break it down. This doesn't just mean breaking it down into smaller chunks of food, this means breaking it down into its building blocks – proteins into amino acids, complex carbohydrates into sugars, and fats into fatty acids and glycerol. In order to break down our food into these basic units, our digestive systems use two broad categories of digestion: mechanical digestion and chemical digestion. Mechanical digestion involves physically breaking the food down into smaller pieces without any chemical changes to the food. Chemical digestion involves breaking chemical bonds to split the food into simpler nutrients. As you work through this lab you will see both mechanical and chemical digestion at work.

Part 1: How long is YOUR digestive system?

Look at the picture to the right of your digestive system. This system is one long tube that contains many parts that are folded up inside your body. If you were to take your digestive system out of your body and lay it out flat, it would surprise you how long it is. In this lab you will make models of your own digestive system by measuring & cutting yarn to represent lengths of different parts of the system, and knotting (or taping) the pieces of yarn together to form one long string.



Procedure:

1) Digestion begins in the **mouth**, so measure and cut a piece of **white yarn** from the front to the back of the mouth. (You can do this by stretching the yarn from the front of your lips to the back of your jaw along your cheek).

   This is a great place to ask students what type of digestion occurs in the mouth. Both physical and chemical digestion take place in the mouth. The mechanical digestion comes from chewing the food and the chemical digestion comes from an enzyme in saliva called amylase which begins to break down carbohydrates.

2) *Record this length of this "mouth" yarn in centimeters (cm) in the data table on the next page.*

3) The **esophagus** is a tube that connects the mouth and stomach. Measure & cut a piece of **yellow yarn** the length of the esophagus. (Measure from the back of your jaw to just below your rib cage).

   No digestion occurs in the esophagus. It simply connects the mouth and the stomach.

4) *Record the length of this "esophagus" yarn in centimeters (cm) in the data table on the next page*. Tie or tape the esophagus yarn to the mouth yarn.

5) In the **stomach**, gastric juices break down solid food into a liquid. Find the length of the stomach by spreading the fingers of your hand and measuring the span from the thumb to the little finger. Measure and cut a piece of **pink yarn** to match this length.

   Again, ask about what type of digestion occurs in the stomach. Both chemical and mechanical digestion occurs in the stomach. The chemical digestion comes from enzymes and hydrocholoric acid which break down proteins. The mechanical digestion comes from the churning of the stomach.

6) *Record the length of this "stomach" yarn in centimeters (cm) in the data table on the next page*. Tie the stomach yarn to the esophagus yarn.

7) The **small intestine** is the longest part of the digestive system. It is folded up inside of you so it fits. Food is further digested and absorbed here. Measure your height in inches and ***multiply it by four***. Use the **red yarn** to represent the length of the small intestine.

   Why do you think the small intestine is so long? It is where most of the nutrients from your food are absorbed! If it is so long, why do they call it the small intestine? It has a smaller diameter than the large intestine.

8) *Record the length of this "small intestine" yarn in centimeters (cm) in the data table on the next page.* Tie the small intestine yarn to the stomach yarn.

9) Last is the **large intestine**. It is much wider than the small intestine but much shorter. It is about as tall as you are. Undigested material from the small intestine moves to the large intestine before it leaves your body. Use **purple yarn** to represent the length of your large intestine.

   The large intestine is where remaining nutrients and the water from food are absorbed.

10) *Record the length of this "large intestine" yarn in centimeters (cm) in the data table on the next page*. Then tie the large intestine yarn to the small intestine yarn.

11) Finally, add up each length to get the total length of your digestive tract in centimeters (cm).

DIGESTIVE ORGAN	LENGTH (CM)
Mouth	*≈ 10 cm*
Esophagus	*≈ 38 cm*
Stomach	*≈ 18 cm*
Small Intestine	*≈ 650 cm*
Large Intestine	*≈ 163 cm*
TOTAL	*≈ 879 cm*

Convert this to meters using the formula: (total # of centimeters) multiplied by (0.01 meters/centimeter)

Length of your digestive tract in meters: ≈ 8.8 m

Questions:

Q1. How does the length of your digestive system compare to your height (if you know your height in feet and inches, convert your height to inches knowing that there are 12 inches in a foot, then multiply it by 0.0254 meters/inch to get your height in meters)? How do you think your digestive system is able to fit inside your abdomen?

The length of the digestive system is approximately 5 times greater than one's height. The digestive system is able to fit inside the abdomen by being coiled up.

Q2. Why do you think your digestive system is so long? How do you think this helps digestion? What is the longest section of your digestive system? What important processes do you think happen to the food in this section?

The digestive system is so long to be able to digest food. This helps digestion by allowing time and space to break down food, absorb nutrients, and absorb water. The longest section of the digestive system is the small intestine. In the small intestine, the nutrients from the food are absorbed.

Q3. How long do you think it takes (on average) to digest food?

The time it takes to digest food from the time you eat it to the time you excrete it is about one to three days.

Q4. What percent of your entire digestive system is the small intestine?

length of small intestine / length of entire digestive tract = (650 cm/879 cm) x 100% ≅ 74%
The small intestine makes up about 74% of your entire digestive system.

Part 2: What happens to the food you eat?

Introduction:

In this part of the lab, you will work in groups and use real food to simulate what happens to the food you eat as it travels along your digestive system. We will pause at each section of the digestive system to identify any unique features and to try to better understand how these features contribute to the digestive process.

Procedure:

1) **The quart ziplock bag represents your mouth.** Put 1 cup of corn flakes into the quart ziplock bag. Add 2 tablespoons of water, representing your saliva. Close the bag tightly. Let each person in your group crush the corn flakes in the bag for 5 seconds.

   Remind students about the mechanical and chemical digestion taking place in the mouth.

2) **The straw represents your esophagus.** Try to "swallow", or pass the corn flake mixture through the straw esophagus by cutting a small hole in one corner of the bag and squeezing the mixture into the straw. Hold the gallon ziplock bag under the straw to catch anything that comes through the straw. *This is really hard to do, so just do a little to demonstrate peristalsis (muscles squeezing the food down into the stomach).*

   Q5. What do you have to do to get the mixture through the straw?

   You have to squeeze the mixture to get it through the straw.

   Q6. Do you think gravity is necessary for food to pass through the esophagus? (optional) Have one person in your group try to chew and swallow a cracker laying down flat on the ground. Were they able to do it?

   No, gravity is not necessary for food to pass through the esophagus. Yes, if someone tries to swallow a cracker lying down they should be able to do it.

   Q7. What is this movement of your real esophagus called?

   This movement of your real esophagus is called peristalsis.

3) **The gallon ziplock bag represents your stomach.** Move all of the corn flake mixture into the gallon ziplock bag. Add 1 cup of water and 1 teaspoon lemon juice to your bag. This

represents the gastric juices in your stomach. Close the bag tightly. Let each person in your group squish around the mixture for 30 seconds.

Remind students about the mechanical and chemical digestion occurring in the stomach. Why doesn't the acid in our stomachs burn through our stomachs? There is a mucous membrane (very similar to mucous, or snot, in your nose) which protects our stomach from the acid.

Q8. What kind of digestion occurs in your stomach?

In the stomach, food is broken down by acid and mashed up by the churning.

Q9. Your real stomach secretes hydrochloric acid (not lemon juice), which has a very low pH. What is the purpose of this acid? What other key ingredient in digestion is our simulated system missing?

The purpose of this acid is to make enzymes work (the missing key ingredient).

4) **The paper towel roll represents your small intestine.** Have someone in your group hold the roll at a 45 degree angle over the plastic cup. Before pouring the mixture through the tube, add some food coloring to your gallon ziplock bag. This food coloring represents other digestive juices from the liver, gallbladder, and pancreas that are required to complete chemical digestion of food. Once you've added food coloring, pour your corn flakes mixture from the 1 gallon ziplock bag into the top end of the roll.

The other digestive juices are bile (produced in the liver and stored in the gallbladder) and enzymes produced in the pancreas. Remind students about the important nutrient adsorption occurring in the small intestine. If we couldn't absorb the nutrients from our food, digestion would be a futile endeavor.

Q10. What do you notice about the food that emerges from the other end of the paper towel roll?

It is not quite as watery.

The small intestine has some interesting features which make it highly specialized for maximizing nutrient absorption. Although our paper towel roll intestine has smooth walls, your real small intestine has many folds, big folds you can see, and tiny folds that are only visible under the microscope. Let's calculate the surface area of your small intestine! The formula we will use is for calculating the surface area of a tube is: 2 x π x radius x length. Let's simplify by approximating π with 3, and the radius as 2 cm, which makes the formula: 2 x 3 x 2 cm x length.

Q11. Using the length of your small intestine you just calculated, what is the surface area of your small intestine?

≈ 7,800 cm^2

*Q12. The large folds increase the surface area of the small intestine by **three** times. What is the surface area of your small intestine now?*

≈ 23,400 cm^2

*Q13. The microscopic folds (called villi) increase the surface area further by another **ten** times. What is the final surface area of your small intestine? (This is approximately the size of a tennis court!)*

≈ 234,000 cm^2

5) The pantyhose represents your large intestine. Have everyone in your group put on a pair of gloves. Pour the cornflake mixture that you collected in your cup (after being passed through the paper towel roll) into the pantyhose (on the open end). Make sure that you are holding the pantyhose over the plastic tub. Let everyone in your group squeeze the corn flake mixture part of the way through the pantyhose. Continue squeezing trying to get out as much liquid as possible. Cut a small hole (representing the anus/rectum) to release the corn-flake mixture.

What happens if your large intestine isn't working to absorb the water from your food? You'll get dehydrated and have more diarrhea-like bowel movements!

Q14. What is the consistency of your mixture now?

The consistency should be solid but squishy and holds its shape (like stool).

Concept Questions

Q15. Why do you think different animals have different digestive systems?

Different animals eat different types of food (meat, plants, etc.) so they need a digestive system that will properly digest the types of foods they eat. Some animals eat all at once (lions) and some animals eat a little bit throughout the day (cows) and the different digestive systems accommodate this.

Q16. Why can some animals survive eating only plants and some can survive eating only meat?

Their bodies are designed to use the nutrients they get (from plants or meat) to make energy, build muscle, etc.

Q17. Why are some things very high in calories and other things very low in calories? Are foods that are higher in calories healthier for you and foods that are lower in calories less healthy for you?

Some things are very calorie dense (for example with low water content) and some things are not very calorie dense (for example high water content). The number of calories does not correlate to how healthy or nutritious the food is (think of a Twinkie versus lettuce).

Q18. How many calories do you think you need everyday? Why do some people need more or less calories than others?

The number of calories you need everyday depends on your size, how much exercise you get, your metabolism, and your age. The number of calories you need everyday is somewhere between 1,500 and 3,000 calories.

Q19. There are other parts of your digestive system that food doesn't pass through, such as the liver, the gallbladder, and the pancreas. What functions do you think these organs perform?

The liver processes the nutrients that are absorbed by the small intestine. The gallbladder stores bile that is then released into the small intestine. The pancreas makes enzymes for digestion.

Q20. Can you survive without any of the digestive organs you have learned about?

You can survive without your entire gallbladder and large intestine. You can survive without part of your liver, stomach, and small intestine. Although some people survive without other organs, these people need other forms of nutrition (such as tube feeding or TPN).