The Digestive System

Dr. Dave's Teaching Manual

Second Edition

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Introduction

This manual will give you, the teacher, everything you need to teach a unit on the digestive system. From the first topic to the last class, it describes how to set up teaching presentations so that they are dynamic, exciting, and meaningful for students. You will see how easy it is to prepare for classes, and you will discover that this teaching approach allows students to experience real learning and real academic success.

Science is a wonderful topic to teach to children. Instead of lecturing for long periods or bogging students down with an avalanche of worksheets, this manual shows you how to make your presentations interesting and challenging to the mind of a child. This is easy to do—once you know how to do it. Children already possess a natural curiosity for science. This manual shows you how to take advantage of their curiosity and to present lessons in a way that creates an exciting learning environment in your classroom.

This manual describes easy teacher demonstrations that use basic materials such as crackers, construction paper, oil, and marshmallows. Most of them take only minutes to set up. Show the students a marshmallow starch molecule that you made using toothpicks as you teach about polymers and glucose, or display a baster as you teach about the secretion of digestive enzymes from the pancreas. You can be sure that the students will be watching you as stretch 30 feet of string across the room to show them the length of the small and large intestines.

Following the teacher presentations, you can run various student activities at levels that are appropriate for your students' abilities. This manual is flexible, and there are many opportunities for integration of core subjects. In addition, you can choose from many demonstrations, visual projects, experiments, group projects, and research projects. A unit on the digestive system offers opportunities for you to run several experiments that will allow students to explore the characteristics of digestive enzymes. These experiments engage students in hands-on, inquiry-based science and apply the scientific method, giving students the opportunity to discover and construct knowledge for themselves.

This unit is naturally rich in life science topics. As students learn about the structure of polymers, they understand that digestion is all about breaking these polymers down into their individual components. This manual will show you how to teach about the ways in which the stomach protects itself from its own acid, lactose intolerance, the impressive amount of digestive juices that the body produces, and the role of bile in the digestion of fats.

This manual also offers suggestions for assessment and shows examples of exemplary student work. In addition, it provides tips on classroom management, critical-thinking questions, modifications, clean-up, and safety. The Teacher Resources section contains a variety of downloadable worksheets that you can use as homework or as in-class assignments; these are available from the Royal Fireworks Press website (rfwp.com). Many of the images in this book can be projected for the students to see and will help them to understand and internalize the concepts being taught; these are available for download as well.

The internet is a rich source of animations and short video clips. If you have the technology available in your classroom, you can use the keywords provided to search the internet to find websites that you can project during your teaching presentations.

Digestion in the Mouth

Objectives

- Students will understand the general processes of the digestive system.
- Students will distinguish between mechanical and chemical digestion.
- Students will describe the role of saliva in digestion.

Key Points

- Chewing is a type of mechanical digestion.
- Saliva contains the enzyme amylase, which begins chemical digestion.
- Amylase breaks starch down into smaller fragments and glucose.
- Starch is a common nutrient found in a variety of foods.
- Iodine is a chemical that can test for starch.

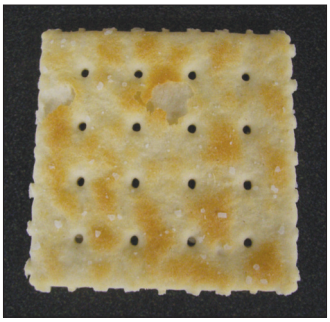
Vocabulary Words

Digestion	Saliva	Enzyme	Amylase
Mechanical Digestion	Starch	Polymer	Glucose
Chemical Digestion	Substrate		

Start the Class

A good way to begin this unit is to show the students a cracker, put it in your mouth, and start chewing. Explain to the students that *digestion* is the process of breaking food down into small, molecular pieces so that the nutrients in the food can enter the bloodstream. The bloodstream then takes these nutrients and feeds all of the cells in the body. Tell the students to think of the digestive system as one big tube that runs through the body. Food enters at the mouth and travels through the stomach and intestines.

Tell the students that digestion begins the moment you start chewing food—it starts in the mouth. The role of teeth in digestion is obvious: they break food down mechanically into smaller pieces. *Saliva* is the liquid that is present in the mouth. Its job is to lubricate the food to help it go down into the stomach. It also contains an enzyme called *amylase*.



Teacher Demonstration: The Role of the Teeth

Take another cracker, and gently break it into small pieces with a hammer. This illustrates how food is broken down into smaller and smaller pieces by the teeth. Tell the students that this kind of digestion is an example of *mechanical digestion*.

Scoop up the pieces of crushed cracker using an index card, and transfer them to a small, clear, plastic container. Explain to the students that, as your teeth chew, your mouth fills with saliva. Display a cup of water, and state that the liquid represents saliva.

Pour some water into the container, and let the crackers get soggy; you might even smash them a bit with a spoon. Tell the students that saliva isn't just water; it also contains an enzyme called amylase. Add a small amount of flour to the container, and mix it into the cracker slurry. The white powder represents amylase.

Review with the students what *enzymes* are. If this is the first time that the students are learning this word, then simply state that enzymes do many jobs for the body, and amylase is an example of such an enzyme. Its job is to help break down starch into glucose.

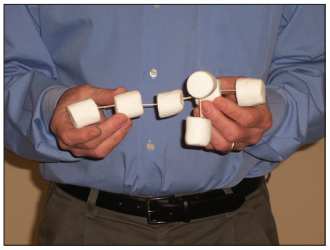
Teacher Demonstration: Starch

Explain to the students that *starch* is a common type of nutrient present in many foods. Show as many examples of these foods as you can. For example, you could display a cracker, a piece of bread, cereal, a bagel, and a cookie. Anything that is made of flour will contain starch. In fact, show the students a bag of flour or cornstarch, and identify it as containing a lot of starch.

> *Connections: Gluten is the substance in flour that makes it stick together when it gets wet. Help the students remember this by pointing out the word* glue *in its name. Individuals with certain diseases (such as Celiac disease) are unable to digest this protein and need to eat a gluten-free diet. You might have some of these children in your class.*

Teacher Demonstration: Polymers and Glucose

Polymers are an important topic for students to learn about; there are many significant examples of polymers in biology—proteins and DNA, for example. Tell the students that a *polymer* is any molecule that is made of the same repeating unit. Show the students a bag of marshmallows, and identify each individual marshmallow as representing a *glucose* molecule. Glucose is a type of simple sugar, so you might say that essentially you are holding a bag of glucose.



Connect a few marshmallows together using toothpicks, and identify this larger structure as a polymer. State again that polymers are repeating sequences of the same molecule. Tell the students that starch is a huge molecule and that it is actually made of hundreds, perhaps thousands, of repeating glucose molecules.

The Esophagus and the Stomach

Objectives

- Students will describe how food passes through the esophagus to the stomach.
- Students will describe the chemical digestion that occurs in the stomach.
- Students will understand how mucus protects the tissues that line the stomach.

Key Points

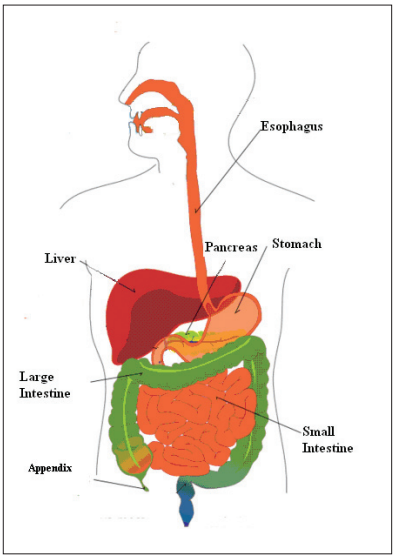
- Swallowing is a strong force that moves the food from the mouth to the stomach.
- The chemical digestion that started in the mouth continues with acid digestion in the stomach.
- The stomach contains strong hydrochloric acid.
- While amylase is specific for starch, stomach acid facilitates a more general type of digestion.
- The stomach is lined by mucus to protect it from its own acid.
- Ulcers are openings in the mucus lining of the stomach.

Vocabulary Words

Esophagus	Stomach	Peristalsis
Hydrochloric Acid	Slurry	Ulcer

Start the Class

It is helpful at this point in the unit to show the students an image of the entire digestive system. Project the image at right, and go over it briefly with the students. Remind them that the digestive system is essentially a tube that runs through the body.



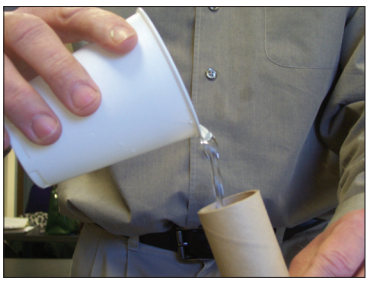
Mariana Ruiz

Tell the students that the *esophagus* is simply a tube that connects the mouth to the stomach. Food gets from the mouth to the stomach through the action of swallowing. Swallowing is such a strong force that you can swallow even when you are upside down.

Note that the liver and the pancreas are part of the digestive system but are not part of the tube that runs through the body.

Teacher Demonstration: The Esophagus and the Stomach

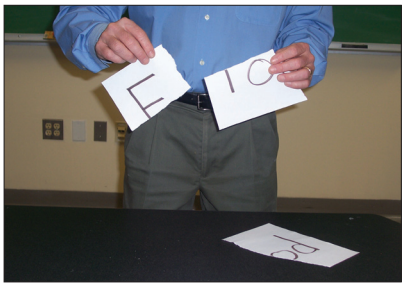
Quickly remake the cracker slurry, and pour it through a paper towel tube. Tell the students that the cardboard tube represents the esophagus. Make sure there's enough water in the mixture so that it pours easily. Aim the tube into a bowl, and state that the bowl represents the stomach.



Explain to the students that food does not drop straight down the esophagus as it does through the paper towel tube. Swallowing and a process called *peristalsis* move the food down to the stomach. Tell the students that they will learn more about peristalsis later, when you cover the small and large intestines. For now, simply explain that peristalsis is the contraction of muscles in the esophagus that push the food along.

Teacher Demonstration: Digesting Food in the Stomach

Once food gets into the stomach, digestion continues. A simple demonstration to review the overall purpose of digestion is to write the word *Food* a piece of paper and then tear the paper into progressively smaller pieces to simulate how food is broken down during digestion. Tell the students that once food reaches the stomach, acid is what breaks it apart. The acid in the stomach is a kind of acid called *hydrochloric acid.*



Project the images below for the students to see as you discuss the characteristics of the stomach. Explain that the stomach has two openings: one leading from the esophagus, and another leading into the small intestine. It takes about two to four hours for food to be digested in the stomach before it goes into the small intestine.

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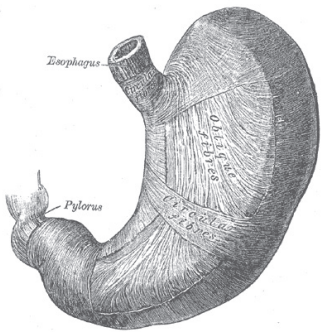


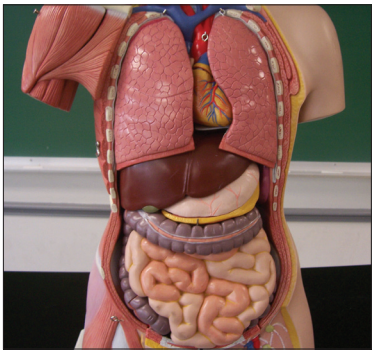
Gray's Anatomy

Project the image at right of the small intestine for the students to see, and reiterate how long the pathway actually is. Point out how folded and *convoluted* the intestines are; there are even sharp turns in some parts of the pathway. Tell the students that food moves slowly through the intestine, spending anywhere from two to six hours there.

National Cancer Institute

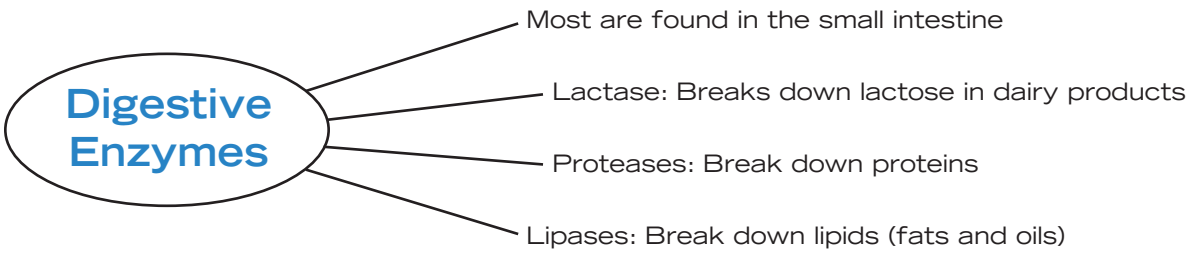
Extension: Interested students can learn that the small intestine is subdivided into three sections: the duodenum, the jejunum, and the ileum.

If you have one, human models of the digestive system are excellent visuals to show to the students. These models help students visualize the placement of the digestive organs within the scale of the whole human body. You can use the model as you progress through the lessons on the digestive system, showing the respective organs as you cover them. While many of these models are expensive, there are economical models available.



Teacher Demonstration: Digestive Enzymes in the Small Intestine

Explain to the students that the majority of chemical digestion occurs in the small intestine. The small intestine secretes several digestive enzymes to finish the chemical digestion of the food slurry that comes from the stomach. It is where food is completely broken down into small molecules. It is also where the majority of nutrients from food are absorbed into the bloodstream. Project the image below to introduce the students to these enzymes, and take this opportunity to review the names of enzymes and their substrates.

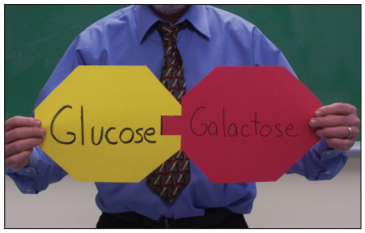


Fact: The human body produces more than 20 different digestive enzymes. Some of these are sold as supplements to treat digestive disorders.

Teacher Demonstration: Lactose and Lactase

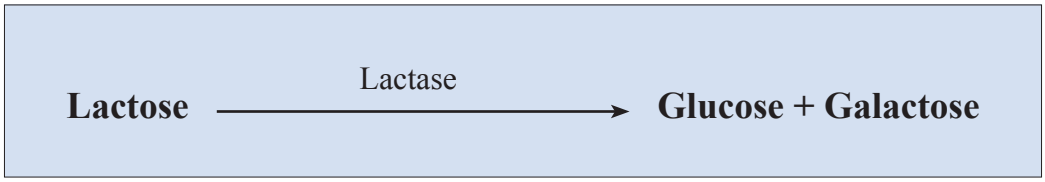
Many students will be familiar with lactose intolerance and will be interested in this topic. Display a small cup or carton of milk, and take a drink of it if you want to attract interest. Identify the sugar in milk as *lactose*, and state that there is an enzyme in our small intestine called *lactase* that breaks lactose down into simple sugars that can be absorbed into the bloodstream. Tell the students that many dairy products contain lactose, including milk, cheese, yogurt, and ice cream.

Show the students two pieces of paper labeled "Glucose" and "Galactose" (you may want to cut them into interlocking shapes, as shown in the images at right). Identify lactose as a molecule of these two sugars linked together. Lactose must be broken down into separate glucose and galactose molecules in order to be absorbed into the bloodstream. This is what lactase does.



If the students have not previously learned about disaccharides, don't worry about explaining the properties of galactose. Just make the point that *glucose* is a simple sugar that is absorbed into the bloodstream. It may be appropriate for some of the students to learn that galactose is an isomer of glucose.

Project the formula below for the students to see.



Technology Integration: Search the internet using the keywords "lactase" and "animation" to find websites that show animations of lactase breaking down lactose into glucose and galactose that you can project for the students.

Teacher Demonstration: Lactose Intolerance

Explain to the students that individuals who have difficulty digesting dairy products do not have lactase in their digestive system. As a result, they are unable to break down lactose, which produces symptoms of gastrointestinal distress. This condition is known as lactose intolerance. In fact, you may have students in your class who are lactose intolerant. Lactose intolerance is common among humans; millions of people lack this enzyme and are unable to digest dairy products fully. You might tell the students that this is a genetic trait and that some ethnic groups are more prone to lactose intolerance.

There are several brands of lactose-free milk available for people who are lactose intolerant. This milk has the enzyme added it is so that the lactose is already broken down into glucose. You can also buy lactase in the form of pills or tablets. Show the students a package of these, and describe how this enzyme replaces the enzyme that the body lacks. You can also tell the students that these enzyme tablets are useful in science experiments.

Proteases in the Small Intestine

Objectives

- Students will describe the structure of proteins.
- Students will understand how proteases break down proteins.
- Students will understand the role of the pancreas in digestion.

Key Points

- Proteins are polymers of amino acids.
- Proteases break down proteins present in food into amino acids.
- Amino acids are absorbed into the bloodstream.
- The pancreas makes digestive enzymes that are secreted into the small intestine.
- The pancreas produces a large quantity of digestive juice.

Vocabulary Words

Proteins	Polymer	Amino Acids	Proteases
Pancreas	Secretion	Hydrolysis	

Start the Class

Tell the students that *protein* is an important part of our diet. Just like lactose, proteins must be broken down into smaller molecules in the small intestine so that they can be absorbed into the bloodstream. Once again, marshmallows linked together with toothpicks make a good model.

Remind the students that a *polymer* is a repeating sequence of the same molecule. In the starch model, each individual marshmallow represented a glucose molecule. In a protein model, the marshmallows represent *amino acids*. Tell the students that proteins are polymers of amino acids. Most proteins are made of several thousands of amino acids linked together.

Fact: The largest human protein is titin, which is a giant, spring-like protein found in muscles. Titin is composed of anywhere from 27,000 to 33,000 amino acids.

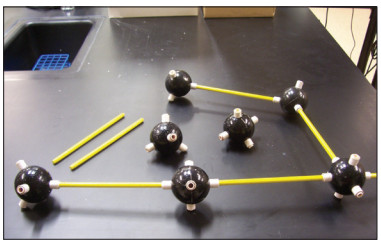
As you show this short marshmallow protein molecule to the students, explain that amino acids are an important nutrient for the body to absorb. Tell them that the marshmallows actually represent twenty different amino acids.

Teaching Tip: If the students have learned about amino acids, review their structure with them. If not, simply state that proteins must be broken down into amino acids.

Teacher Demonstration: Proteases

After discussing the structure of the marshmallow molecule, take it apart in front of the students to demonstrate the action of the enzymes that break down proteins. Tell the students that this is a perfect example of what digestion is all about—in this case, the breakdown of large proteins into molecular-sized amino acids that can be absorbed into the bloodstream. The enzymes that break down proteins are called *proteases*.

Demonstration Tip: You can buy molecular model kits that will enable you to build bead models of large polymers, but marshmallows or styrofoam balls work just as well.

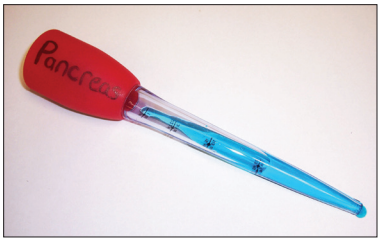


Technology Integration: Search the internet using the keywords "digestive enzyme" and "animation" to find websites that show digestion animations that you can project for the students.

Teacher Demonstration: The Pancreas and Secretion

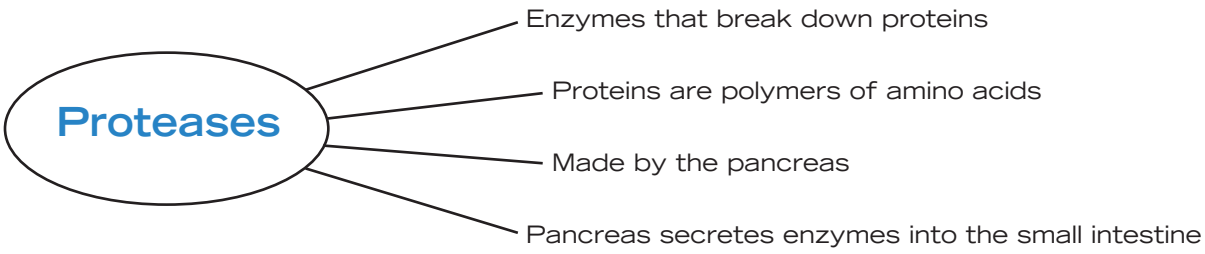
Now it is time to talk about the organ called the *pancreas*. Explain to the students that they can think of the pancreas as a protein factory where many of the enzymes involved with digestion are made. The pancreas then *secretes* these enzymes into the small intestine. A good demonstration for secretion is to get a baster and label it "Pancreas." Put some colored water into it, and squirt some "pancreatic juice" into a container that is labeled "Small Intestine."

Even though the container is a poor model for the small intestine, the baster is an excellent model for the process of secretion. For a more accurate representation, touch the tip of the baster to the container so that there is no air in the connection between the two. Interested students can learn the name of this connection as the pancreatic duct.



The students will be impressed by the amount of juices that the body uses for digestion. The average human produces about nine liters of digestive juices a day. That's nearly 2.5 gallons!

Project the image below for the students to see.



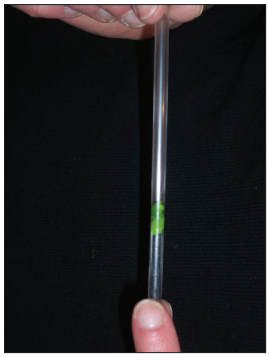
Student Activity: Proteases and Gelatin

There is an excellent experiment for the students to conduct to test for the presence of proteases. It involves adding fruit juices that may or may not contain proteases to gelatin. Gelatin is a pure protein, and its gelling characteristic makes it a useful protein to use in classroom experiments. If you add a protease to a gelatin solution, it will break the gelatin down completely into amino acids, and the gelatin will be unable to gel.

Teaching Tip: At this point, you must decide what you will call the substance that was food in the small intestine and is now waste in the large intestine. Stool *and* feces *are acceptable scientific names.*

Tell the students that the opening in the body through which the waste is excreted is called the *anus*, and the waste substance itself is called *stool* (or *feces*; use whatever term you have chosen). It takes an average of about 40 hours for the stool to pass through the large intestine and to exit through the anus. This means that the total amount of time it takes for the digestive process to work, from beginning to end, is approximately 48 hours, although this can vary significantly.

Teacher Demonstration: Peristalsis



Tell the students that muscles that line the small and large intestines move the food along. Place a small pea in a transparent straw, and explain that the straw represents the small intestine. Use your fingers to squeeze the straw little by little to move the pea slowly down the straw. Your fingers represent the contraction of muscles. This process is known as *peristalsis*.

These muscle contractions happen automatically. The brain doesn't have to think consciously about contracting the muscles, in the same way that it doesn't have to think about the involuntary beating of the heart and breathing. All of these functions occur automatically.

Teacher Demonstration: Peristalsis in the Large Intestine

This optional demonstration is sure to attract interest as a visual simulation of the peristalsis process. You will need wide dialysis tubing, some mud, and plastic wrap. Prior to class, cut a one- to two-foot-long piece of dialysis tubing, and soak it in water. Prepare the "stool" that will go into the tubing by tightly wrapping a small amount of mud with plastic wrap. Just be sure that you can fit the plastic-wrapped package into the dialysis tubing.

In front of the students, put the "stool" into the tubing, hold one end of the tubing with your hand, and propel the digestive mass through the tubing by squeezing it through with your other hand. This is a good—albeit mildly unappealing—simulation of peristalsis.

Teacher Demonstration: Diarrhea and Constipation

The key point to teach about the function of the large intestine is that this is where water absorption occurs. The body absorbs water that is in the large intestine into the bloodstream. If the body can't absorb enough water, the result is *diarrhea*, a condition in which there is too much water in the stool. If it absorbs too much water, the stool becomes dry and hard, making it difficult to pass. This is called *constipation*.

Be forewarned: many students find these topics hilarious. However, diarrhea in particular is a serious subject. Most students will be surprised to learn that diarrhea kills more than a million children worldwide every year. This makes it one of the leading causes of death in

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