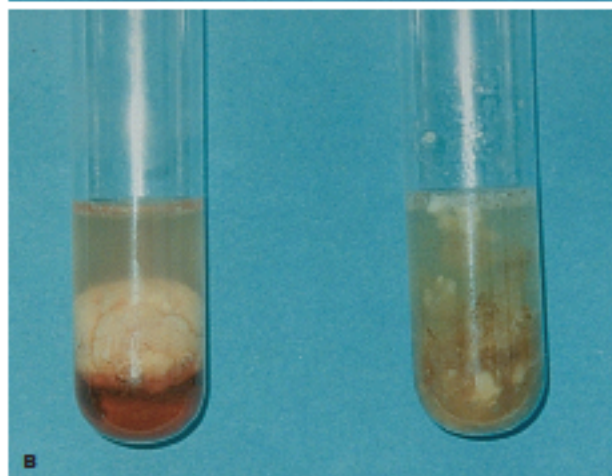
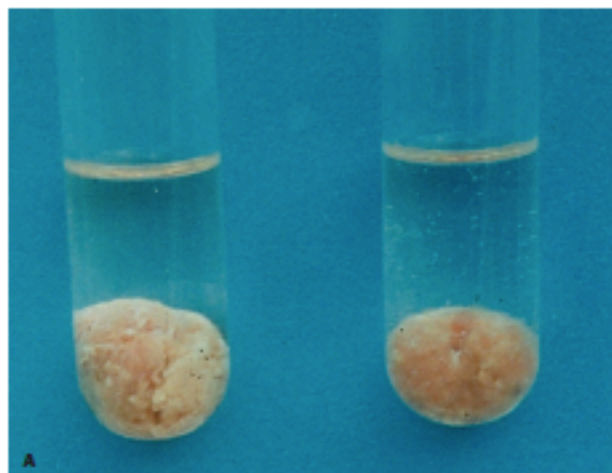


# Digestion in the Stomach



Both of these photographs show the same two test tubes. Each test tube contains a liquid and a small piece of ground beef. Photo B was taken 24 hours after Photo A. What do you think has happened to the contents of each test tube over the 24-hour period?

## INTRODUCTION

In Lesson 4, you discovered that the teeth and tongue have major roles in mechanical digestion. You also found out that starch is the only type of food that starts to undergo chemical digestion in the mouth.

In the stomach, as you will discover in this lesson, there is even more digestive action than in the mouth. Three layers of stomach muscles churn the food and continue the process of mechanical digestion. Chemical digestion becomes even more important as the stomach continues to break down foods into a form that the body can use.

What special features help the stomach break down protein, one of the three basic food types? You're about to find out!

## OBJECTIVES FOR THIS LESSON

Explore chemical digestion in the stomach.

Discover the roles of hydrochloric acid (HCl) and pepsin in chemical digestion in the stomach.

Explain why the human body needs protein.



Dr. William Beaumont

William Beaumont was a young frontier doctor living in northern Michigan in the early 1800s. Most of his work was fairly routine. Because he lived in a wilderness area where hunting was common, he had even gotten accustomed to treating gunshot wounds.

But the wound that Alexis St. Martin, a young fur trapper, had suffered was different. The shot blasted a deep hole in his stomach. Beaumont was convinced that St. Martin would not live through the night.

Much to Dr. Beaumont's surprise, his patient did live. The deep wound in his stomach, however, never healed over.

# Chance of a Lifetime

To keep food from leaking out of the wound, Beaumont covered it with a bandage.

Beaumont had always been interested in research, and he realized that St. Martin gave him a rare opportunity to study how the stomach works. So Beaumont persuaded St. Martin to stay with him and let him perform some experiments. Here's what he did.

He took samples of partially digested food from St. Martin's stomach and examined them. He tied threads around pieces of fresh food and dropped them into the stomach. After a while, he pulled out the pieces and observed the effects of the gastric juices. He measured the temperature of the stomach when it was empty and full. He even sent samples of St. Martin's gastric juices to Europe to be analyzed by a chemist.

Beaumont published his findings in a book called *Experiments and Observations*.

Doctors and scientists

around the world who read the book gained a new understanding of the stomach and how it digests food. □



Dr. Beaumont's desk and lab equipment might have looked something like this. What chemicals do you think are in the small bottles?

## QUESTIONS

1. What do you think Dr. Beaumont found out about digestive activity in the stomach? What food types are digested in the stomach? What types are not?
2. How do you feel about the way Dr. Beaumont used a human subject for his research? Do you think this could happen today?

# SPIES



## INTO THE BLENDER

Peppt and Bollo find themselves in a large, hollow area that looks like a J-shaped balloon.

"Just like folds of pink velvet," says Bollo.

"What's going to happen here?"

"First of all, we're in for a bath," says Peppt.

"You're right. What's all this liquid sloshing around?" asks Bollo.

"The digestive juices," says Peppt. "One of them is an acid, called hydrochloric acid. The other juice is an enzyme called pepsin. Together, these juices are called gastric juices. They begin the digestion of protein."

"Hydrochloric acid. That's pretty strong stuff, isn't it?" asks Bollo.

"Yes. Pure hydrochloric acid is extremely strong. But the hydrochloric acid in the stomach is weaker. In fact, in the stomach, it's actually the pepsin that does most of the work of digestion. The hydrochloric acid just gets things going."

### Three Types of Muscles

"The churning of the stomach helps the digestive juices do their job even better," Peppt continues. "It's caused by muscles. How many can you see?"

"There's one type of muscle that runs at an angle," says Bollo. "But where are the others?"

"Good for you, Bollo. That's one of the three. But there are two more layers of muscle on top of that one. One layer circles the stomach, and another runs from one end of the stomach to the other. All this action helps move the food around and helps break it into tiny pieces."

"It was about 12:30 P.M. when we arrived,"

says Bollo. "That pizza was part of Joanne's lunch. But her stomach wasn't empty. Was that her breakfast?"

"Yes, there are still some small pieces of food in here. Some things take longer for the stomach to process than others. But Joanne's breakfast is already well on its way to becoming digested. It has turned into a thick, creamy liquid called chyme. Chyme is spelled c-h-y-m-e. But remember, it rhymes with 'dime.'"

Peppt and Bollo keep an eye on the action. More food, as well as some liquid, enters. The stomach gradually expands. The thick folds that Peppt and Bollo saw when they entered the stomach are flattening out.

As time passes, the pieces of food get smaller and smaller. The sloshing continues.

### Slippery Stuff

"That gastric juice must be strong," says Bollo. "But why doesn't the juice attack the stomach itself? How does it know what's 'off limits'?"



Peppt and Bollo explore the stomach. What do you think is dripping from the top?

"The stomach is protected by an inner wall that is covered with a thick liquid called mucus," replies Peppi. "The stomach generally doesn't start producing digestive juices until food is present and the mucus is in place.

"As long as the stomach is coated with mucus, the gastric juice usually cannot do any harm. But if the juice finds a spot where there is no mucus, it can penetrate the stomach wall. It makes a small hole, called an ulcer."

"So here's a potential problem with this marvelous organ called the stomach," says Bollo, perking up his ears. "It can get ulcers. Something to report to our leader." He jots this down in his notebook.

"Yes. Ulcers have many causes. Scientists recently learned, for example, that they can be caused by certain bacteria as well as by too much gastric juice or too little mucus. But once a doctor has diagnosed an ulcer, it's pretty easy to treat.

"And while we're on the topic, there's another type of discomfort that's caused by gastric juice. The pain develops in the lower esophagus, just around the entrance to the stomach. It's called heartburn. It has nothing to do with the heart; the pain just happens to develop in the same area where the heart is located. Gastric juice backs up into the lower esophagus from the stomach and causes a burning sensation."

"Heartburn," writes Bollo.

"But don't get carried away thinking about the problems that can arise in the stomach. It's a very efficient organ. It even has a way of getting rid of things that don't agree with it. It reverses the normal digestive process, opens that sphincter between the esophagus and stomach, and sends them right back up and out! That action is called vomiting. It is not very pleasant, but absolutely necessary. Vomiting can be triggered by bad food, by some medications, or by poisons."

"I have another question," says Bollo. "Some of the foods seem to be disappearing faster than others. I don't see much pizza crust around

here anymore, but there's lots of sausage."

"Remember that there are three major food types—carbohydrates, fats, and proteins. Pizza contains all of them. The crust is mostly carbohydrate, and the sausage is fat and protein. All three food types undergo mechanical digestion in the mouth, but only carbohydrates begin to undergo chemical digestion in the mouth."



Why does mucus have to be so slimy? Bollo knows. Do you?

"So that's why I see less crust and more sausage in the stomach!" says Bollo.

"Right," Peppi replies. "Proteins begin to undergo chemical digestion in the stomach. The chemical digestion of carbohydrates continues for a short time in the stomach as well. Fats, on the other hand, are not chemically digested in the stomach at all. It all depends on enzymes. There is even a special enzyme called rennin that begins the digestion of milk. That is important, because when humans are born, that's all they eat for a while."

"But what happens now?" says Bollo. "We've been here for almost 4 hours!"

"Be patient, Bollo. Like the pizza that Joanne ate, we still have a long way to go!" □