

Diffusion and Active Transport



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*How does the fragrance of flowers reach your nose?
You are about to find out!*

INTRODUCTION

You've explored the digestive processes that take place in the mouth and stomach. Now it's time to see what happens in the small intestine. Even though a great deal of digestive activity has already taken place, there is a lot more to come. In fact, it's in the first section of small intestine where most chemical digestive activity takes place. As digestive products continue to move through this important digestive organ, most of them are absorbed into the bloodstream.

The activities you will perform in this lesson will help you understand how the process of absorption occurs. First, you will set up an experiment that will show whether sugar and starch can pass through a membrane. While you're waiting to perform the sugar and starch tests, you will do another quick activity that is related to absorption. You will put some anise

OBJECTIVES FOR THIS LESSON

Use models to show how substances tend to spread.

Determine whether certain substances can pass through a membrane by diffusion.

Construct a definition of the word "diffusion."

Explain the difference between diffusion and active transport.

Indicate why both diffusion and active transport are necessary for the absorption of nutrients.

Summarize the digestive processes that take place in the small intestine.

seeds in a balloon and inflate it. Your nose will be your guide to interpreting the results of this test! You'll then put some anise extract in a balloon. Sniff, sniff. Smell the difference!

Getting Started

1. Your nose is going to have an important role in this inquiry! You probably already noticed a strong aroma as soon as you entered the room.

2. Listen as your teacher presents some introductory information. Now discuss the following questions with the class:

A. How do you think the scent reached your nose?

B. Was the aroma stronger at one place than another? If so, why?

3. Do you think that substances can move through solids as easily as they pass through a gas such as air? For example, could you detect an odor through plastic or rubber? Write down your thoughts in your notebook.
4. Before you begin your inquiry, turn in the summary box on which you have recorded the digestive processes that occur in the mouth.

MATERIALS FOR LESSON 6

For you

- 1 copy of Student Sheet 6.1: Diffusion and Cell Membranes
- 1 pair of safety goggles

For your group

- 1 plastic box
- 1 dropper bottle of Benedict's solution
- 1 dropper bottle of Lugol solution
- 1 bottle of sugar solution
- 1 bottle of starch solution
- 1 dropper bottle of distilled water

- 1 plastic pipette
- 1 250-mL beaker
- 1 50-mL graduated cylinder
- 1 plastic funnel
- 1 test tube clamp
- 2 large test tubes
- 1 medium test tube
- 1 test tube rack
- 2 membranes
- 4 pieces of string
- 1 dropper bottle of anise extract
- Anise seeds
- 2 balloons
- 2 plastic resealable storage bags
- 1 black marker

SAFETY TIPS

Always wear safety goggles when you are handling chemicals.

The chemicals you will be using are poisonous. Do not put them in or near your mouth.

Do not get the chemicals on your skin or clothing. Lugol solution will leave a stain on skin and clothing.

If Benedict's solution comes in contact with your eyes or skin, rinse it off thoroughly with water.

If you spill a chemical, tell your teacher immediately.

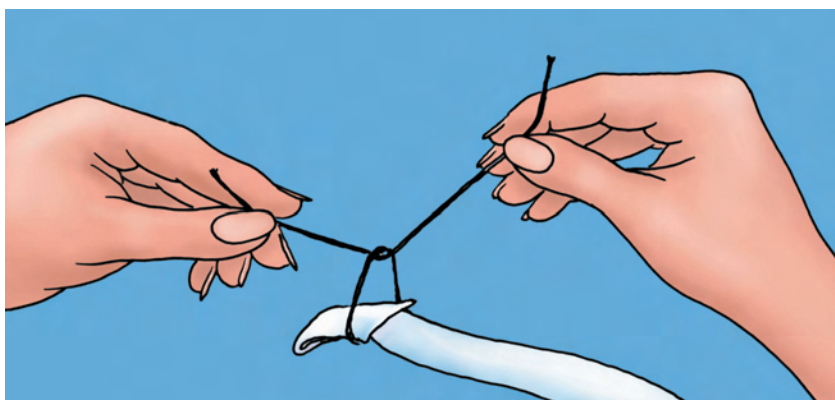
If you are allergic to latex, notify your teacher.

Inquiry 6.1

Spreading Out and Through

PROCEDURE

- 1.** Have a student from your group pick up a plastic box of materials. You will work with your group for this inquiry. With the class, go over the Procedure.
- 2.** Before you begin the inquiry, review the Safety Tips.
- 3.** Set up your materials as follows:
 - A.** Label one of the large test tubes "Sugar Solution."
 - B.** Remove a membrane from the beaker. Fold one end of the membrane back about 1.5 cm, as shown here. Make a loop with one end of the string and tie it securely around the folded end of the membrane.



- C.** Make sure the untied end of the membrane is wet. Then rub it between your thumb and forefinger until it opens, as shown.

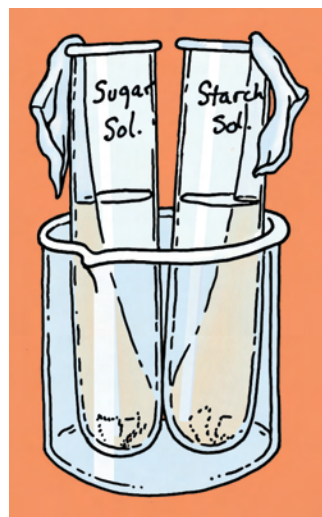


- D.** Use the graduated cylinder to measure 13 mL of sugar solution. Insert the end of the funnel through the open end of the membrane. Then, as shown in the figure, pour the sugar solution from the graduated cylinder into the membrane.



- E.** Rinse the outside of the membrane thoroughly to remove any trace of the sugar solution.
- F.** Place the membrane into the test tube labeled “Sugar Solution.” Hang the excess membrane over the top and down the side of the tube.
- G.** Rinse the graduated cylinder. Measure 8 mL of distilled water and pour it into the test tube.
- H.** Place the test tube in a beaker or test tube rack. The top of the membrane should still hang over the test tube.
- 4.** Label the other large test tube “Starch Solution.” Then use steps B through H as a guide in setting up the test tube for the starch solution.

- 5.** Allow both test tubes to sit in a beaker or test tube rack for about 15 minutes, as shown here.



- 6.** While you are waiting, complete this short activity.
 - A.** Remove a balloon from the bag.
 - B.** Open the container of anise seeds. Smell them. What do they smell like?
 - C.** Put about 10 seeds into the balloon. Blow it up. While one person pinches the neck of the balloon to keep air from escaping, have a second person tie the balloon securely with the string. Pass the balloon around. Let everyone in your group sniff it (see Figure 6.1). Can you smell the seeds through the walls of the balloon? Why or why not?
 - D.** Put 5 drops of anise extract into the other balloon. Inflate the balloon, tie it securely, and pass it around to let everyone sniff it. Can you smell the anise extract through the wall of the balloon? Why or why not?
 - E.** How does the strength of its aroma compare with that of the seeds in the balloon? What might explain the difference? Discuss these questions with your group.
- 7.** Now it is time to turn your attention back to the sugar and starch tests. Perform a chemical test for sugar on the water from the test tube with the membrane containing sugar solution.
 - A.** Use the dropper pipette to add 20 drops of the water in which the membrane is soaking into a test tube.
 - B.** Add 8 drops of Benedict's solution to the test tube.
 - C.** Place the test tube in the hot water bath for 2 minutes.

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Figure 6.1 Do you think that this student can smell the scent of anise seeds through the balloon? What about anise extract?

- 8.** Perform a chemical test for starch on the water from the test tube with the membrane containing starch solution. Put 10 drops of Lugol solution directly into the water in the large test tube and observe what happens. There is no need to heat the tube.
- 9.** Record your results on your student sheet.
- 10.** Follow your teacher's directions for cleanup.

REFLECTING ON WHAT YOU'VE DONE

1. Use your findings from this inquiry and the information in the two reading selections at the end of this lesson to answer the questions on Student Sheet 6.1. With your class, review Student Sheet 6.1 and clarify the concepts of diffusion and active transport.
2. Suppose someone dropped a small, uncapped bottle of red food coloring into a swimming pool. In terms of diffusion, what would happen?
3. In your science notebook, summarize the steps involved in the completion of digestion in the small intestine. After reviewing Figure 6.2 with your teacher, explain how the accessory organs of digestion aid in the completion of digestion.

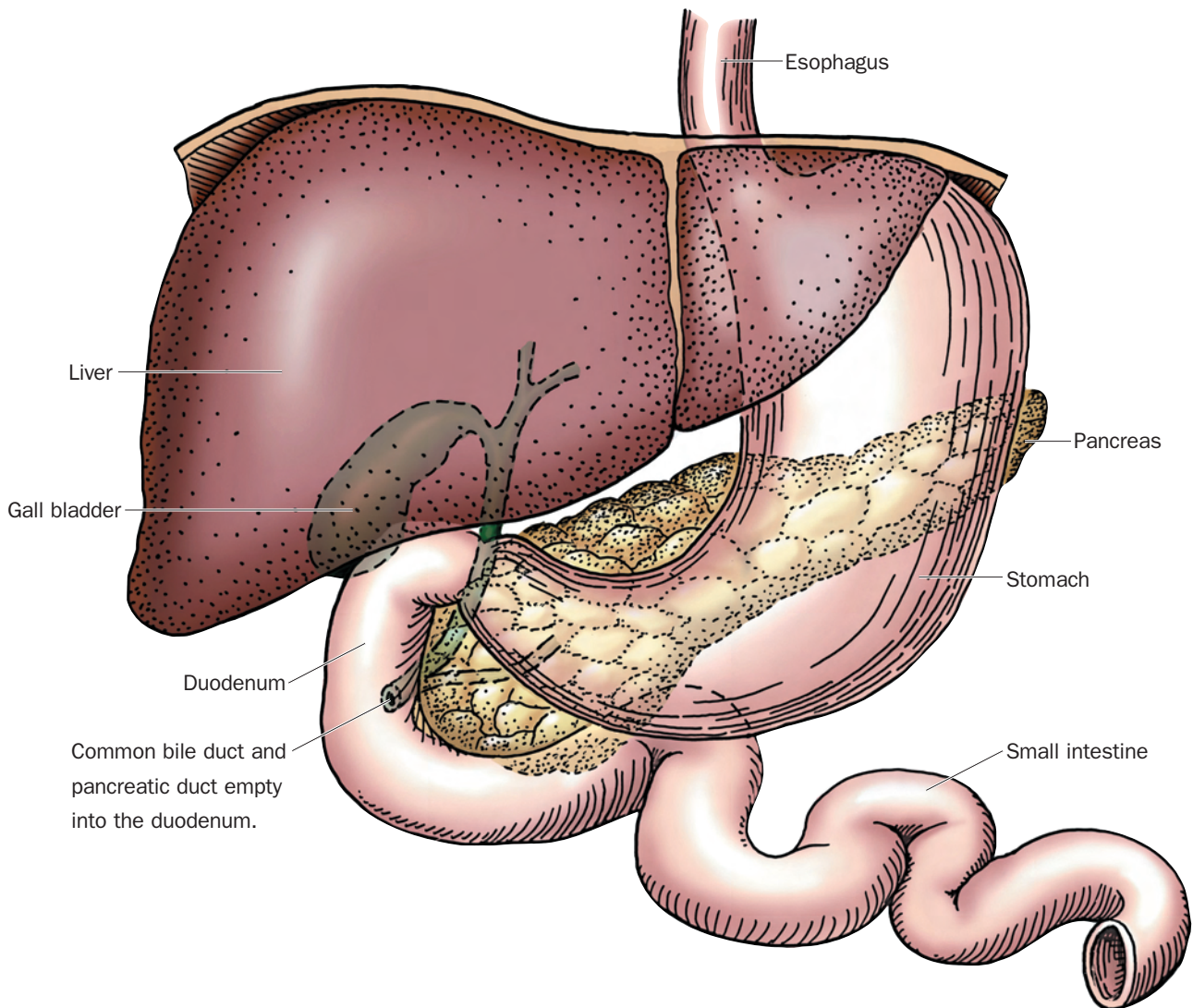


Figure 6.2 *The accessory organs of digestion*

Diffusion and Active Transport: Getting From Here to There

A lot of traveling goes on inside your body. Your blood is carrying nutrients and oxygen to every cell. But your cells are surrounded by membranes, and your blood is confined within blood vessels.

How do nutrients get past these barriers? There are two ways to do it: just go with the flow or hitch a ride.

Diffusion: Going With the Flow

What happens when you put a tea bag in a cup of hot water? At first, the tea is concentrated in one spot. But it soon spreads out. You can tell by the color change. The “wall” of the tea bag, however, keeps the tea leaves inside.

The particles that you taste when you sip the tea are so

small they pass through the bag. The process that moves the tea particles and the water back and forth through the tea bag is called diffusion.

Inside your body, diffusion works much the same way. Digested nutrients dissolve and move through the walls of your small intestine and blood vessels. The blood then carries the

nutrients throughout your body.

Diffusion that does not require any energy from cells is sometimes called passive transport.

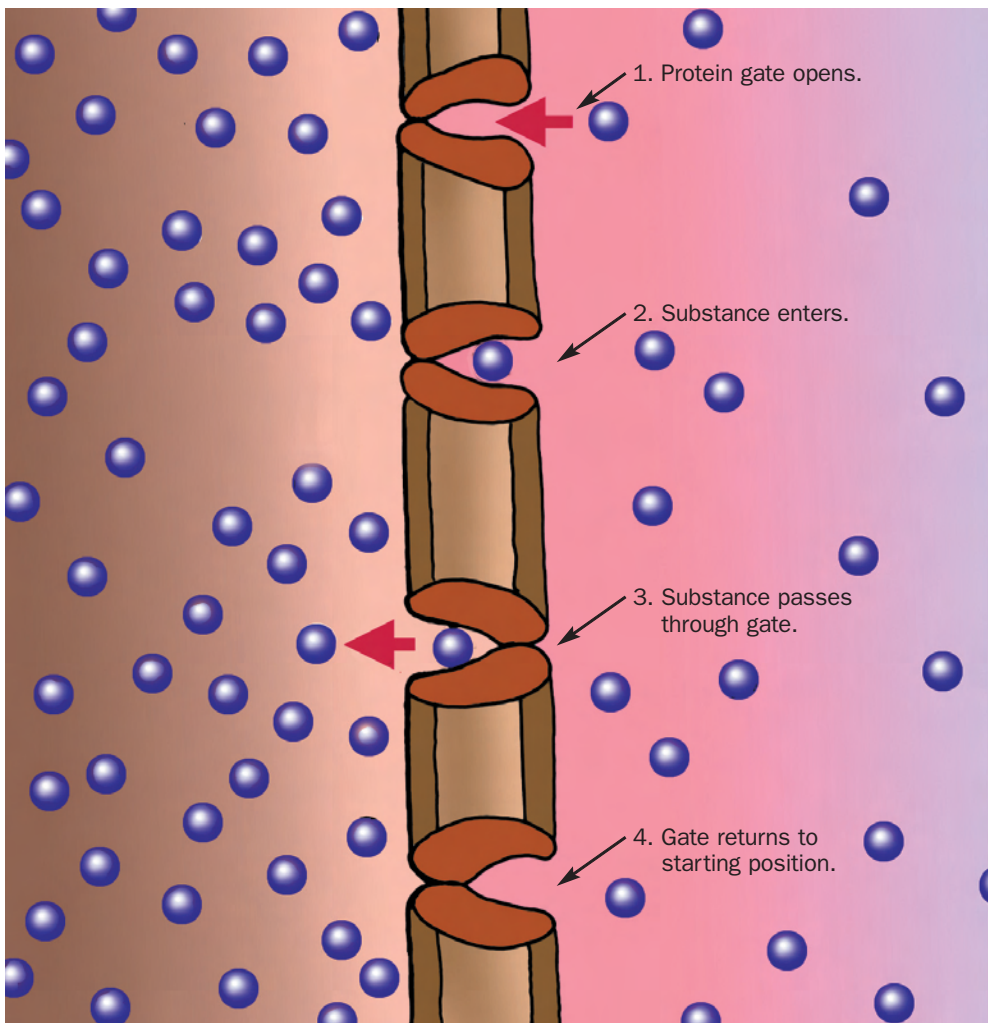
Active Transport: Hitching a Ride

Your cell membranes let some things get through by passive transport. In that case, they are working in the same way that the tea bag does.

For some nutrients, getting through a cell’s protective membrane is tougher. The membranes are choosy about what gets through and what does not. Because of this, they are sometimes referred to as “selectively permeable” or “semipermeable.” In some cases, it takes energy from the cells to move nutrients from one side of the membrane to the other. The process that allows this to happen is called active transport.



If it weren't for diffusion, tea bags would be useless!



Model of active transport

During active transport in the human body, substances use energy from the cell to move through the cell membrane. The energy comes from a substance called ATP (adenosine triphosphate), which is manufactured inside your cells. When a substance arrives at the cell membrane, a protein molecule grabs

it, and ATP splits to release its stored energy. The energy changes the shape of the protein, which now acts as a gate in the cell membrane. When the gate (called a carrier) opens, the substance moves into (or out of) the cell. This uses up the energy the ATP has supplied to the carrier, and the gate closes.

Diffusion helps substances move through fluids and across cell membranes inside your body. When diffusion won't work, active transport may come to the rescue. These processes keep traffic moving smoothly to and from every cell in your body. □



THE LONG AND WINDING TUBE

Peppi and Bollo are gradually moving downward as the contractions of the stomach continue. Looking down, they see a round black hole. The hole suddenly grows larger.

Whoosh! Peppi and Bollo pass through the opening, which quickly closes.

“Another sphincter,” says Peppi. “Those muscles are powerful. That one was the pyloric sphincter. It’s the gateway to the next important part of the digestive system, the small intestine.”

“This is the duodenum,” says Peppi. “It’s a special name for the first 25 centimeters of the small intestine. It’s hard to see from this perspective, but the small intestine is about 7 meters long.”

“You’ve got to be kidding,” says Bollo. “How can it all fit into that small space? And why do they call it the ‘small’ intestine if it’s so long?”

“It fits because it’s folded and tucked away,” replies Peppi. “Even though it is long, it is probably called ‘small’ because of its diameter—only about 2.5 centimeters. Let’s go along for the ride and see what happens.”

A Change of Atmosphere

Peppi and Bollo are assaulted on all sides by spurts of liquid. One spurt comes from the direction of the pancreas.

“Pancreatic juice,” Peppi explains, “is packed with enzymes that help digest carbohydrates, proteins, and fats. Each day, the pancreas secretes about 1.5 liters of juice.

“As food enters the duodenum, the gall bladder swings into action, contracting and pumping out greenish-yellow liquid bile. It’s been stored there since it was manufactured in the liver. The liver, the largest organ in the body, performs many other functions as well.”

“The pancreatic juice is different from the juices in the stomach,” says Bollo. “It’s not acidic. What’s going on?”

“The juice from the pancreas is not acidic,” says Peppi. “In fact, it’s just the opposite: It is alkaline, or basic. It neutralizes the acid from the stomach and then starts off on some work of its own. Because digesting food is a big job, there’s still more specialization.

“Foods get customized treatment at this point.

“Proteins, which were partially digested in the stomach, are acted on by intestinal and pancreatic juices. Eventually, they break down into amino acids.

“Carbohydrates, already well on their way to being digested, complete the change to simple sugars as a result of interaction with intestinal and pancreatic juices.

“Fats get a big dose of bile, courtesy of the liver and gall bladder. Bile works like dishwashing detergent. It breaks large fat droplets into smaller ones so they can mix more easily with the juices from the small intestine and pancreas. Fat eventually gets broken down into fatty acids and glycerol.”

“More specialization!” says Bollo.



Peppi helps Bollo in a squeeze. It's the sphincter muscle that's causing his problem!

“Right!” says Peppi. “Both pancreatic and intestinal juices contain enzymes. Remember that enzymes are *specific*. What does that mean?”

“Each enzyme can digest only one type of nutrient,” says Bollo.

“Right you are!” says Peppi. “At some point during the pizza’s journey through the small intestine, digestion is complete. The pizza has been transformed into a soupy mixture of

sugars, amino acids, fatty acids, vitamins, and minerals. The particles are now simple enough to be absorbed through the lining of the small intestine.”

“How does this stuff actually get out into the body?” says Bollo.

“We’re going to find out,” says Peppi. “But first, let’s take a break. The pace of activity in the small intestine has worn me out.” □