SECTION 4

Digestion and pH

DISCOVER ACTIVITY

Where Does Digestion Begin?

1. Obtain a bite-sized piece of crusty bread.
2. Chew the bread for about one minute. Do not swallow until after you notice a change in taste as you chew.

Think It Over

Inferring How did the bread taste before and after you chewed it? How can you explain the change in taste?

GUIDE FOR READING

- Why is it necessary for your body to digest food?
- How does pH affect digestion?

Reading Tip Before you read, preview Figure 27. List the organs of the digestive system in the order in which food passes through them.

You've probably seen the following commercial: A man has a stomachache after eating spicy food. A voice announces that the problem is excess stomach acid. The remedy is an antacid tablet.

Ads like this one highlight the role of chemistry in digestion. You need to have acid in your stomach. But too much acid is a problem. Other parts of your digestive system need to be basic. What roles do acids and bases play in the digestion of food?

What Is Digestion?

Foods are made mostly of three groups of compounds: carbohydrates, proteins, and fats. But your body can't use foods in the forms you eat. **Foods must be broken down into simpler substances that your body can use for raw materials and energy.** The process of **digestion** breaks down the complex molecules of foods into smaller molecules.

Digestion involves two processes—mechanical and chemical digestion. **Mechanical digestion** tears, grinds, and mashes large food particles into smaller ones. The result is similar to hitting a sugar cube with a hammer. The size of the food is reduced, but the foods aren't changed into other compounds. **Chemical digestion** breaks large molecules into smaller molecules. Some molecules provide your body with energy. Others serve as building blocks for the compounds in muscle, bone, blood, skin, and other organs.

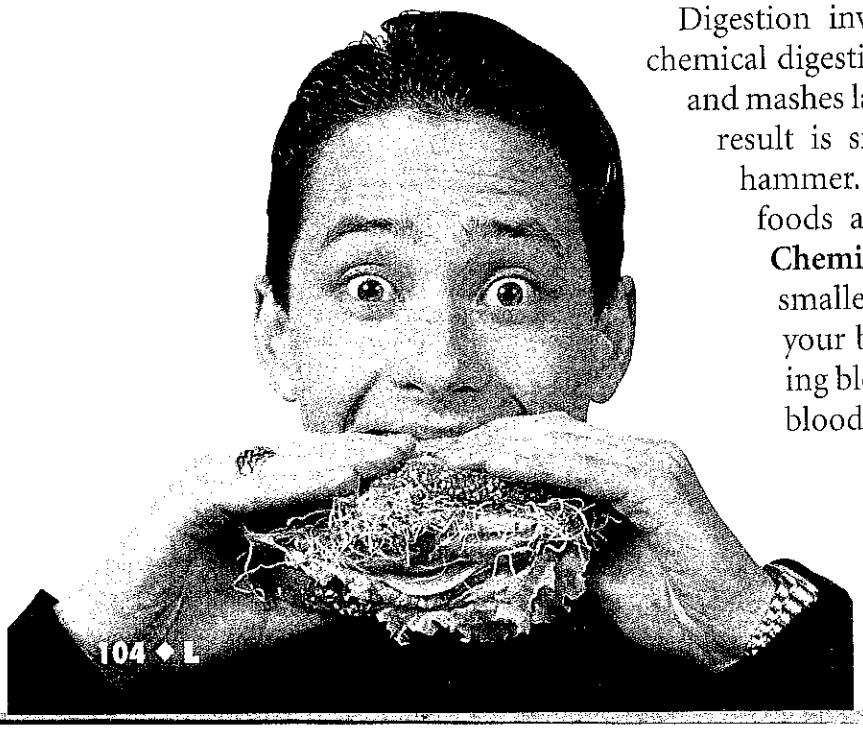


Figure 25 Each food molecule in this bite of a sandwich is about to begin a journey that includes changing pH.

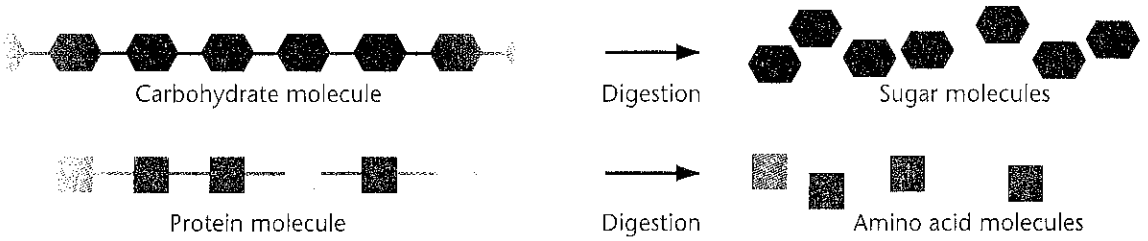


Figure 26 Carbohydrates and proteins are large molecules that must be broken down by digestion. *Interpreting Diagrams What smaller molecules result in each case?*

Chemical digestion takes place with the help of enzymes. Enzymes are catalysts that speed up reactions in living things. Enzymes require just the right conditions to work, including temperature and pH. **For some digestive enzymes, the pH must be low. For others, the pH must be high or neutral.**

Checkpoint What happens to foods in your body?

pH in the Digestive System

A bite of sandwich is about to take a journey through your digestive system. What pH changes will affect the food molecules along the way? Figure 27 shows the main parts of the human digestive system. As you read, trace the food's pathway through the body.

Your Mouth The first stop in the journey is your mouth. Immediately, your teeth chew and mash the food. The food also gets wet with a fluid called saliva. Have you ever felt your mouth water at the smell of something delicious? The odor of food triggers extra production of saliva.

What would you expect the ususal pH inside your mouth to be? Remember that saliva tastes neither sour nor bitter. So you're correct if you think your mouth has a pH near 7, the neutral point.

Saliva contains amylase (AM uh lays), an enzyme that helps break down the carbohydrate starch into smaller sugar molecules. Amylase works best when the pH is near 7. You can sense the action of this enzyme if you chew a piece of bread. After about two minutes in your mouth, the carbohydrate is broken into sugars. This makes the bread taste sweet.

Your Stomach Next, the food is swallowed and arrives in your stomach. This muscular organ starts digestion of foods that contain protein, such as meat, fish, and beans. Cells in the lining of your stomach release solutions that include hydrochloric acid. Rather than the near-neutral pH of your mouth, the pH drops to a very acidic level of about 2. This pH is even more acidic than the juice of a lemon.

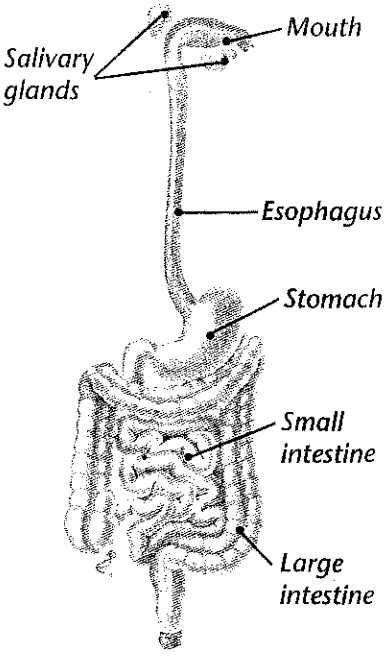


Figure 27 Foods undergo changes in pH as they move through the digestive system.

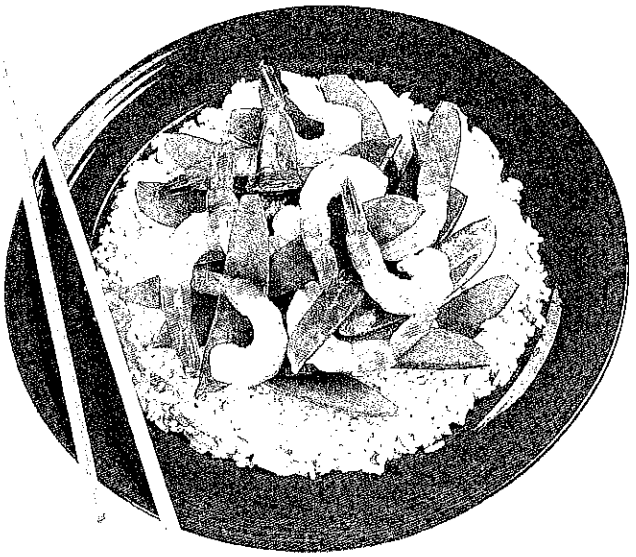


Figure 28 Shrimp contains protein. Rice and pea pods contain carbohydrates.

Why does your stomach have such a low pH? The main enzyme that works in your stomach is pepsin. It helps break down proteins into small molecules called amino acids. Most enzymes work best in a solution that is nearly neutral. But pepsin is different. It works most effectively in acids.

Your Small Intestine Your stomach empties its contents into the small intestine. Here, other digestive fluids surround the food. One fluid contains the bicarbonate ion (HCO_3^-). This ion creates a slightly basic solution, so the pH in the small intestine rises to about 8. A large variety of enzymes complete the breakdown of carbohydrates, fats, and proteins. All of these enzymes work best in a slightly basic solution. Most chemical digestion ends in the small intestine.

The food molecules from the bite of sandwich have been split up into smaller ones by now. These smaller molecules are absorbed into your bloodstream and carried to the cells that will use them.

Figure 29 The pH varies greatly through the digestive system. ***Relating Cause and Effect*** *Why do certain digestive enzymes work only in certain parts of the digestive system?*

pH Changes During Digestion

Organ	pH
Mouth	7
Stomach	2
Small intestine	8

Section 4 Review

1. How are foods changed by your digestive system?
2. How does pH differ in your mouth, your stomach, and your small intestine? Why are the differences important?
3. What two processes of digestion begin in the mouth? How do they differ?
4. **Thinking Critically Predicting** How would the digestion of food be affected if your stomach did not produce hydrochloric acid?

CHAPTER PROJECT 3

Check Your Progress

Use indicator paper for testing pH to find the pH of each substance you tested earlier. Add to your data table the pH value you measure for each substance. Compare the results using your indicators with the pH values you measure.

SECTION 1 Working With Solutions

Key Ideas

- A solution is a well-mixed mixture. Particles dissolved in a liquid solution cannot be seen or separated by settling or filtration.
- In a solution, solute particles separate from each other and become surrounded by particles of the solvent.
- Every solute has a specific solubility in a particular solvent. Solubility changes with temperature, pressure, and type of solvent.
- Solutes affect the freezing points and boiling points of solvents.

Key Terms

suspension
solution
solvent
solute
dilute solution
concentrated solution
solubility
saturated solution
unsaturated solution

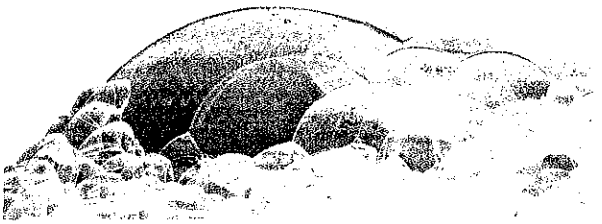
SECTION 2 Describing Acids and Bases

Key Ideas

- An acid tastes sour, reacts with metals and carbonates, and turns litmus red.
- A base tastes bitter, feels slippery, and turns litmus blue.
- An indicator is a substance that turns different colors in an acid or a base.

Key Terms

acid
corrosive
indicator
base



SECTION 3 Acids and Bases in Solution

Key Ideas

- An acid forms hydrogen ions (H^+) when it dissolves in water.
- A base forms hydroxide ions (OH^-) when it dissolves in water.
- The pH measures the acidity of a solution. A pH value below 7 indicates an acid. A value above 7 is a base. A neutral solution has a pH of 7.
- When a base reacts with an acid, water and a salt form.

Key Terms

hydrogen ion (H^+)
hydroxide ion (OH^-)
pH scale
acid rain
neutralization
salt

SECTION 4 Digestion and pH

INTEGRATING LIFE SCIENCE

Key Ideas

- Digestion breaks down complex foods into simpler materials that can be used for energy and raw materials by the body.
- Enzymes in the digestive system do not all work best at the same pH. The pH values vary from the mouth, to the stomach, to the small intestine.

Key Terms

digestion
mechanical digestion
chemical digestion

ACTIVITY

USING THE INTERNET

www.science-explorer.phschool.com

CHAPTER 3 REVIEW

Reviewing Content

For more review of key concepts, see the Interactive Student Tutorial CD-ROM.

Multiple Choice

Choose the letter of the best answer.

1. Sugar water is an example of a
   a. suspension. **b.** solution.
   c. solute. **d.** solvent.
2. A solution in which as much solute as possible is dissolved in a solvent is a
   a. dilute solution.
   b. filtered solution.
   c. saturated solution.
   d. unsaturated solution.
3. Washing soda (Na_2CO_3) will make bubbles if you add
   a. tap water. **b.** salt water.
   c. ammonia cleaner. **d.** lemon juice.
4. Litmus and cabbage juice are examples of
   a. indicators.
   b. strong acids.
   c. strong bases.
   d. concentrated solutions.
5. If a base separates completely into ions when dissolved in water, it is a
   a. weak acid.
   b. weak base.
   c. strong acid.
   d. strong base.

True or False

If the statement is true, write true. If it is false, change the underlined word or words to make the statement true.

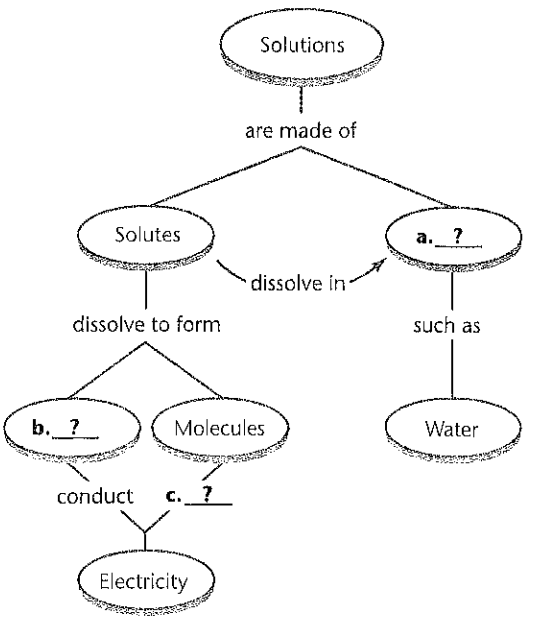
6. The solubility of a gas in water goes up if you <u>increase</u> the temperature.
7. The slightly sour taste of lemonade tells you that it is a <u>base</u>.
8. The gas produced when an acid reacts with a carbonate is <u>oxygen</u>.
9. Dilute hydrochloric acid is an example of a <u>strong</u> acid.
10. Amylase, the enzyme in saliva that helps to break down carbohydrates into simple sugars, works best in a <u>neutral</u> solution.

Checking Concepts

11. Describe at least two differences between a dilute solution and a concentrated solution of sugar water.
12. You have three different unknown compounds that are all white powders. How can you use solubility to identify each compound?
13. Tomatoes are acidic. Predict two properties of tomato juice that you would be able to observe.
14. Explain how an indicator helps you distinguish between an acid and a base.
15. What combination of acid and base can be used to make the salt potassium chloride, KCl?
16. **Writing to Learn** Some of the limestone on the outside of buildings in an area looks as if it is being gradually eaten away. As an investigator for the local air pollution agency, write a brief memo explaining what may be causing the problem.

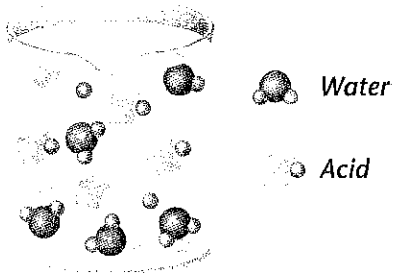
Thinking Visually

17. **Concept Map** Copy the concept map about solutions onto a separate sheet of paper. Then complete it and add a title. (For more on concept maps, see the Skills Handbook.)



Applying Skills

The diagram below shows the particles of an unknown acid in a water solution. Use the diagram to answer Questions 18–20.



18. **Interpreting Data** How can you tell from the diagram that the acid is weak?
19. **Making Models** Suppose another unknown acid is a strong acid. Make a diagram to show the particles of this acid dissolved in water.
20. **Drawing Conclusions** Explain how the pH of a strong acid compares with the pH of a weak acid of the same concentration.

Thinking Critically

21. **Developing Hypotheses** Some power plants release hot wastewater into nearby rivers or streams. Fish living in these waters sometimes die from lack of oxygen. Write a hypothesis to explain what has happened to the oxygen in the water.
22. **Comparing and Contrasting** Compare the types of particles formed in a water solution of an acid with those formed in a water solution of a base.
23. **Applying Concepts** When calcium oxide (CaO) dissolves in water, it reacts as shown below. Is calcium oxide an acid or a base? Explain.

$$CaO + H_2O \rightarrow Ca^{2+} + 2OH^-$$

24. **Predicting** Predict what type of food might not be digested well if someone took greater than the recommended dose of antacid tablets. Explain.

Performance Assessment

CHAPTER PROJECT 3

Wrap Up

Present Your Project Demonstrate the indicators you tested. Make a list of the substances you tested in order from most acidic to least acidic.

Reflect and Record In your journal, discuss whether or not you would use the same materials as indicators if you did this project again. Explain why. Describe how acid-base indicators could be useful for farmers and gardeners. Would you recommend that they use any of the indicators you made?

Getting Involved

In Your Community Find out the acidity of rainfall in your area. Collect a small sample of rainwater, if possible, and test its pH. How does it compare to the pH of normal rainwater? If you tested rain at different times of the year, do you think the pH would differ? Design an experiment to demonstrate how you would test the pH in your community at different times.