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1361233 REV 001

Neo/SCI Student's Guide

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Food Digestion Lab Investigation

WARNING — This set contains chemicals that may be harmful if misused. Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

Objectives

- ***Learn*** **the parts of the digestive system**
- ***Demonstrate*** **how complex food molecules break down into smaller molecules with the aid of digestive enzymes**
- ***Study*** **the subunits that make up carbohydrates, proteins and fats**
- ***Understand*** **where digestion occurs for each nutrient**
- ***Learn*** **about the major nutrients and their function within the human body**

Background

The food that we consume must be digested, or broken down into nutrients that our bodies can use. Digestion in vertebrates is extracellular and takes place in the digestive tube where food is mechanically and chemically digested. During mechanical digestion, large pieces of food are ground and crushed into smaller pieces. This action increases the amount of surface area available for chemical digestion where digestive enzymes break down complex molecules such as carbohydrates into simple molecules such as glucose. Digestive enzymes are called catalysts because they catalyze or speed up the reaction.

Chemical digestion takes place in several organs of the digestive system. Each organ contains enzymes targeted to breaking down specific food types. For example, the mouth contains salivary amylases (ptyalin). They breakdown starches (polysaccharides) into disaccharides (maltose). Protein digestion begins in the stomach where pepsin breaks proteins into smaller polypeptide chains. Digestion is completed in the small intestine through the action of many specific enzymes. Pancreatic amylase continues to break starches down to disaccharides which, in turn, are converted to monosaccharides (simple sugars) through the action of maltase, lactase, or sucrase. Polypeptide chains are further digested to peptides by trypsin and chymotrypsin and then to amino acids by peptidase. Lipids are converted into fatty acids and glycerol (an alcohol) by lipase. The products of chemical digestion are absorbed in the small intestine through specialized structures called villi.

All foods contain at least one of six basic nutrients: carbohydrates, proteins, lipids, vitamins, minerals, or water. These nutrients are chemical substances found in foods that provide energy, serve as building materials, help repair and maintain cells, and support growth and development for our bodies. They include macronutrients that are required in large quantities such as fats, carbohydrates, and proteins, and micronutrients that are required in small quantities such as vitamins and minerals. Four of these nutrients (carbohydrates, proteins, lipids, and vitamins) are called organic compounds because they contain the elements carbon, hydrogen, and oxygen. The other two nutrients, minerals and water, are inorganic and are required for normal functioning of the body.

Few foods contain all six nutrients. Most foods contain a concentration of one or two of them. Therefore, it is important that the foods we eat contain a combination of all six nutrients. Fortifying foods with additional vitamins and minerals is one way to ensure a properly balanced diet and to prevent and, in some cases, eliminate nutritional deficiency diseases.

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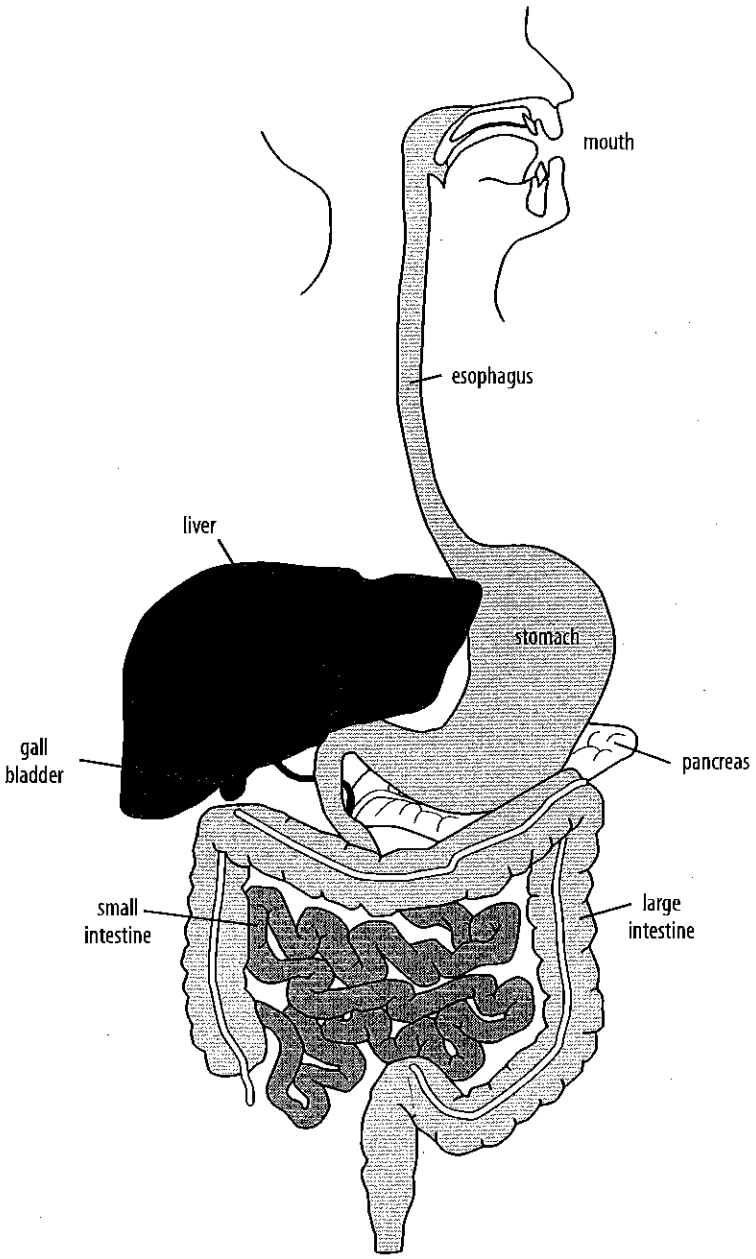
In this lab activity, you will investigate how digestive enzymes break down complex food molecules, and how they affect the rate of digestion.

PARTS OF THE DIGESTIVE SYSTEM



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Organ	Mechnical Digestion	Chemical Digestion
Mouth	• crushing • grinding • moistening	starch —(*salivary amylase*)→ maltose
Esophagus	• moistening	
Stomach	• crushing • churning • moistening • absorption of liquids • absorption of simple sugars	proteins —(*pepsin*)→ polypeptides
Small intestine	• fat emulsification • food absorption	starch —(*pancreatic amylase*)→ maltose disaccharide —(*maltase, lactase, sucrase*)→ monosaccharides protein —(*trypsin, chymotrypsin*)→ polypeptides polypeptide —(*peptidases*)→ amino acids fats —(*lipase*)→ fatty acids & glycerol
Large intestine	• water absorption	

Safety & Disposal

Be sure to follow proper lab safety protocol as directed by your teacher.

Always wear safety goggles, gloves, and a lab apron to protect your eyes and clothing when working with any chemicals. Be sure to keep your hands away from your face and mouth. Always wash your hands before leaving the laboratory.

Iodine solution is a poison. Avoid any skin contact. Be sure to wear proper safety equipment.

Hydrochloric acid is caustic. In case of contact, flush with copious amounts of water. Remove clothing, if possible.

Dispose of any waste materials at the end of the investigation as directed by your teacher.

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ACTIVITY 1

Digestion of Proteins

What you need

Per group

- 1 Spot plate
- 4 pH test strips
- 3mL Albumin, 2%
- 3mL Hydrochloric acid, 1%
- 3mL Pepsin, 3%
- 3mL Biuret solution
- 3 Plastic pipettes
- 5 Stirring sticks

What to do...

Step 1

Place 5 drops of albumin in wells 1-4 of the spot plate numbered 1-12.

Step 2

To well #2, add 5 drops of hydrochloric acid. To well #3 and #4, add 5 drops of pepsin solution. To well #4 add 5 drops of hydrochloric acid. To well #5, add 5 drops of hydrochloric acid.

Step 3

Stir the mixture in each well using a clean stirring stick. Allow the mixture in each well to remain undisturbed for 5-10 minutes.

Step 4

Determine the pH in each of the wells. Dip a separate pH strip in each well and compare the color change to the pH chart provided on the package. Record your results in Data Table 1.

Step 5

Test for the presence of protein by adding 2 drops of Biuret reagent to each well. A positive test for protein is indicated by a pinkish color.

Carefully observe any color changes in each of the wells. Record your results and observations in Data Table 1.

Data Table 1

Well #	Contents	pH	Protein Test	Observations
1	Albumin			
2	Albumin + HCl			
3	Albumin + Pepsin			
4	Albumin + Pepsin + Hydrochloric acid			
5	Hydrochloric acid			

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Questions

1. Explain what may have happened to the protein in well #2 after the addition of hydrochloric acid? After the addition of pepsin in well #3? After the addition of pepsin and hydrochloric acid in well #4?

2. What are the subunits that make up a protein?

3. How could you tell that protein digestion took place?

4. Which of the wells showed the greatest degree of protein digestion and why?

5. What is the purpose of well #1?

6. What is the role of pepsin in human digestion? In what parts of the digestive system does protein digestion take place?

7. Does the effectiveness of pepsin depend on pH? Explain your answer.

8. Explain the differences between mechanical and chemical digestion.

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ACTIVITY 2

Digestion of Carbohydrates

What you need

Per group

1 Spot plate
3 Plastic pipets
Starch solution, 1%
Amylase solution, 2%
2 Plastic pipettes
2 Stirring sticks

Per class

Potassium iodine solution (IKI)

What to do...

Step 1

Place 15 drops of starch solution in the wells of the spot plate numbered 1 and 2.

Step 2

To well #2, add 5 drops of amylase solution. Stir the mixture thoroughly using a stirring stick. Allow the mixture to remain undisturbed for 5-10 minutes.

Step 3

Test for the presence of starch (carbohydrate) in each of the wells. Using a clean pipette, add 1 drop of IKI solution in each of the two wells. In the presence of starch, the mixture will change color from yellow-brown to blue-black.

Caution: *Iodine solution is a poison. Avoid any skin contact. Be sure to wear proper safety equipment.*

Step 4

Carefully observe any color changes in each of the wells. Record your results and observations in Data Table 2.

Data Table 2

Well #	Contents	Starch Test	Observations
1	Starch		
2	Starch + Amylase		

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1. Explain what happened to the starch in well #2 after the addition of amylase?

2. What are the subunits that make up carbohydrates?

3. How could you tell that carbohydrate digestion has taken place?

4. What is the purpose of well #1?

5. What is the role of amylase in human digestion? Where is it produced?

6. Where does carbohydrate digestion take place?

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ACTIVITY 3

Digestion of Fat

What you need

Per group

- 1 Spot plate
- 4 Plastic pipettes
- Corn oil
- Lipase solution, 10%
- Liquid soap
- 3 Stirring sticks
- 3 pH test strips

What to do...

Step 1

Place 10 drops of water and 3 drops of corn oil in the wells of the spot plate numbered 1-3.

Step 2

Stir each well thoroughly using a stirring stick.

Step 3

Test the pH in each of the wells. Dip a pH strip in each well and compare the color change to the pH chart provided on the package. Record the pH of each well in Data Table 3.

Step 4

Add 5 drops of lipase solution to well #2. Add 5 drops of lipase solution and 2 drops of soap solution to well #3.

Step 5

Stir the mixture in each well thoroughly using a stirring stick. Allow the spot plate to remain undisturbed for about 20 minutes.

Step 6

After the incubation period, test the pH in each well and record your results and observations in Data Table #3.

DATA TABLE #3

Well #	Contents	pH	Observations
1	Oil and water		
2	Oil, water, and lipase		
3	Oil, water, lipase, and liquid soap		

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1. How does the pH of each solution show that fat digestion has occurred?

2. Which well showed the greatest degree of fat digestion? Explain your reasoning.

3. Where does fat digestion take place in the human digestive system?

Going Further

1. Study mechanical digestion.

2. Investigate the effects of temperature, pH, and other environmental factors on digestive enzymes.

3. Using the procedures and reagents you used in this investigation, test for the nutrient content of foods such as egg whites, butter, bread, bananas, and other foods of your choice.

4. Isolating iron from breakfast cereals:

   Use the following procedure to isolate and quantify the amount of iron added to common cereals, and compare the amount collected to the amount listed on the Nutrition Facts Food Label.

   1. Obtain a one serving quantity of 3 different cereals that are iron-fortified. Read the Nutrition Facts food label for the amount of iron per serving indicated in the Recommended Daily Allowance column, and record the amount for each cereal in your lab notebook.

   2. Use a wax pencil to label 3 beakers with the name of each cereal.

   3. Use a mortar and pestle to grind a serving quantity of each cereal into a fine powder. Place each powdered cereal into the appropriately labeled beaker.

   4. Weigh a bar magnet to the nearest milligram and record your results in your lab notebook.

   5. Tape a bar magnet to the end of a glass stirring rod, leaving most of the bar exposed.

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6. Pour 250mL of warm water into each beaker. Stir the powdered flakes with the bar magnet for 10-15 minutes continuously. The longer the cereal solution is stirred, more of the tiny iron particles will precipitate out of the flakes and attach to the magnet.

7. Remove the magnet and carefully drain excess liquid from it. Determine its final weight to the nearest milligram. Record your results in your lab notebook.

8. Place the bar magnet on a piece of paper towel and observe the tiny slivers of iron attracted to the bottom of the magnet. You may use a magnifing lens for a closer look at the iron slivers. Describe what they actually look like.

Learn and Read More About It

Barbara J. Patten. *The Basic Five Food Groups (Food for Good Health).* The Rourke Book Company, Inc., 1997.

Dennis D. Miller. *Food Chemistry : A Laboratory Manual.* John Wiley & Sons, 1998.

T. P. Coultate. *Food: The Chemistry of Its Components.* American Chemical Society, 1996.

Neat Websites

For information on food science and technology, visit:
http://www.ift.org/car/car_b00.html
http://www.ift.org/car/food_ind/intro.html

To see a collection of food and nutrition links, visit:
http://www.library.tufts.edu/hsl/hsl_nutr_resources.html

For a comprehensive site of information on food composition, nutrition, dietary guidelines and other related information, visit:
http://www.nal.usda.gov/fnic/