

Unit B: Understanding Animal Body Systems

Lesson 5: Protein Digestion by Enzyme Action

Student Learning Objectives: Instruction in this lesson should result in students achieving the following objectives:

1. Describe the environment of the stomach and its relation to protein digestion.
2. Observe the action of an enzyme on the breakdown of protein.
3. Explain the necessity for breaking down protein for utilization by animals.

Recommended Teaching Time: 3 hours

List of Resources: The following resources may be useful in teaching this lesson:

- Biondo, Ronald J., Michael G. White, and Eric B. Reutter. *Biological Science and Agriculture*. Danville, IL: Professional Educators Publications, Inc. (PEP), 2006.
- Blakely, James, Bade, David H., *The Science of Animal Husbandry: Fourth Edition*. Reston, Virginia: Reston Publishing Company, Inc., 1985.
- <http://www.userworld.com/users/life/enzymes.htm>
- http://www.alternativemedicine.com/books/enzyme_cure/chap1.shTM:l
- <http://www.idrc.ca/books/focus/821/chp2.hTM:l>

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student lab sheet
- Copies of technical supplement
- Materials for Lab (see lab sheet)
- Paper
- Animal Stomach (if available)

Terms: The following terms are presented in this lesson: **PowerPoint Slide 2**

- > Antibodies
- > Catalysts
- > Digestion
- > Epithelium
- > Gastric pits
- > Hemoglobin
- > Insulin
- > Pepsin

Interest Approach: Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Ask students to remind you of some of the essential nutrients animals need to survive. When they name protein, ask students where animals get their protein. Why is protein important for survival? What happens if the body can not break down protein? Lead this into objective 1.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Describe the environment of the stomach and its relation to protein digestion.

Anticipated Problem: What is the environment of the stomach and how does this environment relate to protein digestion?

***Ask students to write down words that describe what they think an animal's stomach looks like. Then, have students share these words with their partner. Then, have all students share at least one word describing the stomach.**

- I. The **epithelium**, or stomach lining, is the source of "digestive juices."
 - A. The upper epithelial surface of the stomach is dotted with deep depressions called **gastric pits**. These pits contain glands with two types of excreting cells which excrete both hydrochloric acid and pepsinogen. The hydrochloric acid transforms pepsinogen into the enzyme pepsin in the stomach.
 - B. Due to the large amounts of HCl secreted by the stomach, the pH level of the stomach is very acidic (1.5 to 2.5).

Use a variety of techniques to introduce this concept to students. Along with a lecture/discussion format to explain content, a demonstration showing the actual stomach lining may allow students to visualize the interior of the stomach. Use TM: 5-1 to reinforce the concepts in this objective. Begin LS: 5-1 Student Laboratory Worksheet to allow students to experiment with the concepts of digestion and enzyme action on protein sources. Also use PowerPoint Slides 3 and 4 to help with note taking.

Objective 2 : Observe the action of an enzyme on the breakdown of protein.

Anticipated Problem: How does an enzyme breakdown protein in the stomach?

***Ask students what happens when food is broken down in the stomach. Has anyone ever seen this happen? After taking notes they will experience it first hand.**

- II. The majority of **digestion**, or break down of food, occurs in the stomach.
 - A. The stomach contains high concentrations of hydrochloric acid and the protein digestion enzyme called **pepsin**. Pepsin will only become active at low pH levels (around 2.0). Pepsin breaks down long globular proteins into shorter polypeptide chains. **PowerPoint Slide 5.**
 - B. After the stomach, the proteins are further digested in the small intestine by enzymes secreted by the pancreas. The pancreas releases the enzyme Trypsin that continues to break down proteins into amino acids, which are absorbed into the blood stream.
 - C. Enzymes are **catalysts**, substances that speed up chemical reactions. **Ask students, “What are catalysts?”** Water itself can break down proteins, but at such a slow rate that the body would not be able to absorb enough energy to carry out basic functions. Enzymes break long chains of proteins into smaller chains, which are in turn broken down into individual amino acids. These amino acids can then be rearranged into proteins that are found and used in our bodies. **PowerPoint Slides 7 and 8.**

Have students create a flow chart on a sheet of paper showing how an enzyme breaks down protein in the stomach. A flow chart starts with one topic and an arrow is drawn to the next step. This will help students visualize the sequence of events involved. Also, use TM: 5-2 to show students how an enzyme helps to break down long proteins into smaller units.

Objective 3: Explain the necessity for breaking down protein for utilization by animals.

Anticipated Problem: Why is it necessary for animals to break down proteins to be utilized by the body?

***Ask students to recall where animals get protein. What type of feedstuffs contain protein? Also, why is protein important? Have students share answers out loud.**

- III. Proteins make up more that 50% of the dry weight of animals.
 - A. Proteins perform many important functions in living organisms. **Have students create a “protein pamphlet” by folding 2 pieces of paper in half. Use this to take notes about the function of proteins in animals.**
 - 1. Hair and fingernails are composed of fibrous structural proteins.
 - 2. Animal body fluids contain soluble proteins, known as **antibodies**, that help combat disease. **PowerPoint Slide 9.**
 - 3. **Hemoglobin**, is an oxygen carrying protein found in red blood cells.
 - 4. Some proteins, actin and myosin, help muscles contract.
 - 5. **Insulin**, which helps the body absorb sugar, is a number of protein hormones.
 - 6. Proteins are found in biological membranes that regulate the passage of substances through these membranes.
 - 7. The most numerous class of proteins is the enzymes. **PowerPoint Slide 10.**

***Ask students how animals and humans are different and similar in protein functions.**

- B. Proteins are complex organic compounds made up of amino acids.
1. Amino acids contain carbon, hydrogen, and oxygen. In plants, proteins are largely concentrated in the growing portions, especially leaves and seeds.
 2. Essential amino acids cannot be produced fast enough by animals, and therefore must be supplied in the livestock feed. Maize and cotton seed cakes together as feed, usually provide a good source of the essential amino acids. **PowerPoint Slides 11 and 12.**

Have students form small groups. Assign each group one type of animal feed or plant native to Afghanistan that is a good source of protein. Then, have student groups research their topic and find information such as where it originated, where and how it is grown and what animals use this feed. Also use TM: 5-3 to reinforce the concepts of this objective.

Review/Summary: The review and summary should be based on the three student objectives listed earlier in this lesson. Discuss the environment inside the stomach and how the stomach produces enzymes to aid in the digestion of proteins. Ask students to describe an enzyme and explain why enzymes are important to food digestion and protein absorption in the blood stream. Finally, have students list several of the important functions of proteins in the body and explain how livestock animals receive proteins from their food sources.

Application: Application can occur as students consider food sources and digestion in animals produced in their area or later in their careers. If possible, have animals where students can apply information on animal health and digestion. Use the PowerPoint Slides, lab sheet, and technical supplement to apply the information.

Evaluation: Evaluation should be based on mastery of the objectives by the students. This can occur during instruction, review, or later as students apply the information. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1. h
2. c
3. f
4. d

5. a
6. g
7. e
8. b

Part Two: Completion

1. Leaves, seeds
2. amino acids
3. enzymes

Part Three: Multiple Choice

1. b
2. a
3. c
4. a
5. c

Part Four: Short Answer

1.
 - a. Hair and fingernails are composed of fibrous structural proteins.
 - b. Animal body fluids contain soluble proteins, known as antibodies, which help combat disease.
 - c. Hemoglobin, is an oxygen carrying protein found in red blood cells.
 - d. Some proteins, actin and myosin, help muscles contract. Insulin, which helps the body absorb sugar, is a number of protein hormones.
2. Enzymes are catalysts, substances that speed up chemical reactions.
 - a. Enzymes break long chains of proteins into smaller chains, which are in turn broken down into individual amino acids. These amino acids can then be rearranged into proteins that are found and used in our bodies.

Test: 5-1

Name _____

PROTEIN DIGESTION BY ENZYME ACTION

Part One: Matching

Instructions: Match the term with the correct response.

- | | | |
|-----------------|---------------|---------------|
| a. pepsin | d. catalysts | g. hemoglobin |
| b. antibodies | e. epithelium | h. insulin |
| c. gastric pits | f. digestion | |

- _____ 1. A protein hormone that helps the body absorb sugar.
- _____ 2. Depressions in the lining of the stomach that secrete enzymes.
- _____ 3. The breakdown of food in the stomach.
- _____ 4. Substances that speed up a chemical reaction.
- _____ 5. The primary digestion enzyme in the body.
- _____ 6. Oxygen carrying protein found in red blood cells.
- _____ 7. The lining of the stomach.
- _____ 8. Soluble proteins that combat disease.

Part Two: Completion

Instructions: Provide the word or words to complete the following statements.

1. In plants, proteins are largely concentrated in the growing areas, especially _____ and _____.
2. Corn and soybeans are excellent sources of essential _____.
3. The most numerous class of proteins is _____.

Part Three: Multiple Choice

Instructions: Circle the letter of the correct answer.

- _____ 1. What is the enzyme that breaks down protein into amino acids?
- a. lactase
 - b. pepsin
 - c. sucrase
 - d. amylase
- _____ 2. What are buffers used for?
- a. resist the change in pH of a solution
 - b. change the pH of a solution
 - c. make a solution acidic
 - d. make a solution basic
- _____ 3. What acid is secreted in the stomach and aids in the digestion of food?
- a. sulfuric acid
 - b. carbonic acid
 - c. hydrochloric acid
 - d. carboxylic acid
- _____ 4. Pepsin works best at what pH?
- a. 2.0
 - b. 5.0
 - c. 6.0
 - d. 8.0
- _____ 5. A catalyst is a substance that does what to a chemical reaction?
- a. slow it down
 - b. neutralize it
 - c. speed it up
 - d. stop it

Part Four: Short Answer

Instructions: Provide information to answer the following statements.

1. List four important functions of proteins in animals.

2. Explain how proteins are broken down and used in the body.

THE STOMACH ENVIRONMENT

Epithelium—stomach lining; the source of "digestive juices."

Upper epithelial surface of the stomach is dotted with deep depressions called gastric pits.

These pits contain glands with two types of excreting cells which excrete both hydrochloric acid and pepsinogen.

The hydrochloric acid transforms pepsinogen into the enzyme pepsin in the stomach.

Due to the large amounts of HCl secreted by the stomach, the pH level of the stomach is very acidic (1.5 to 2.5).

PROTEIN DIGESTION BY ENZYMES

The majority of digestion occurs in the stomach.

The stomach contains high concentrations of hydrochloric acid and the protein digestion enzyme called pepsin.

Pepsin will only become active at low pH levels (around 2.0).

Pepsin breaks down long globular proteins into shorter polypeptide chains.

After the stomach, the proteins are further digested in the small intestine by enzymes secreted by the pancreas.

The pancreas releases the enzyme Trypsin that continues to break down proteins into amino acids, which are absorbed into the blood stream.

Enzymes are catalysts, substances that speed up chemical reactions.

Enzymes break long chains of proteins into smaller chains, which are in turn broken down into individual amino acids.

These amino acids can then be rearranged into proteins that are found and used in our bodies.

BENEFITS OF PROTEINS

- **Hair and Fingernail Composition**
- **Antibodies to Help Fight Disease**
- **Hemoglobin to Carry Oxygen to Cells**
- **Muscle Contraction**
- **Insulin to Help Body Absorb Sugar**
- **Regulation of Substance Passage Through Membranes**

PROTEIN DIGESTION BY ENZYME ACTION

Agricultural Applications and Practices

The proper feeding of livestock depends upon supplying animals with the correct amount of chemical elements and compounds known as nutrients. Determining the amount of proper nutrients is done through formulating a balanced ration. A balanced ration is the correct amount of feed that furnishes adequate nutrients for an animal for a 24 hour period and is based on standards or guidelines for the minimum nutrients needed by livestock. Producers use these standards to select the proper mix and quantity of food sources which provide a balanced ration.

A common method of balancing rations is by the use of Pearson's Square. This method is based on the digestible protein requirements of an animal. Protein provides structural material for body building and maintenance, energy for growth, and amino acids for regulating body processes. It is one of the most important components of a balanced ration. Protein from plant products is found in complex forms which must be broken down by the animal during digestion. The breaking down of protein is aided by an enzyme secreted into the stomach known as pepsin.

Science Connections—Questions for Investigation

1. What is the function of protein in the growth and development of animals?
2. What forms of protein are commonly provided by plants?
3. How are proteins chemically changed in digestion?
4. What is the role of enzymes in the digestion of proteins?
5. What conditions exist in the stomach which promote protein digestion?

Purpose of Laboratory and Student Performance Objectives

The purpose of this experiment is to investigate the activity of a stomach enzyme in the digestion of protein. Through this laboratory exercise and related discussion students will be able to:

1. Describe the environment of the stomach and its relation to protein digestion.
2. Observe the action of an enzyme on the breakdown of protein.
3. Explain the necessity for breaking down protein for utilization by animals.

Equipment and/or Materials

- hard boiled egg white
- test tubes and rack
- water
- pepsin tablets
- dilute hydrochloric acid
- knife or razor blade
- sodium bicarbonate
- pH paper or test kit
- wax pencil

Procedure

Give each student or group of students a copy of the worksheet to perform the activity.

Anticipated Findings

Egg white contains protein which begins to digest in the stomach.

The enzyme pepsin is secreted by cells in the lining of the stomach which aids in protein digestion. These cells also secrete HCl which makes the stomach fluid acidic.

The greatest breakdown of the egg white will occur in the test tube which contains 5 ml of pepsin and 5 ml of buffer A because this solution most closely resembles the fluid in the stomach.

Digestion of the egg white may vary depending upon temperature. In general the tubes will appear as follows.

Test Tube	Contents of Tube	Amount of Digestion
1	Egg white & 10 ml of distilled water	none
2	Egg white & 10 ml of buffer A	none
3	Egg white & 10 ml of buffer B	none
4	Egg white & 10 ml of pepsin solution	some
5	Egg white & 5 ml of pepsin & 5 ml of buffer A	much
6	Egg white & 5 ml of pepsin & 5 ml of buffer B	none

Student laboratory reports should include answers to the following questions:

1. Egg white contains what nutrient?
2. In which tube did the most digestion take place? How is this explained?

Ideas for Other Experiments

Use the same procedures but vary the environments where the test tubes are placed overnight. Put one set of test tubes in a warm place, another at room temperature and a third set in the refrigerator. Relate body temperature to the results of the experiment.

PROTEIN DIGESTION BY ENZYME ACTION

Procedure

1. Label six test tubes 1, 2, 3, 4, 5, and 6 and place in a test tube rack.
2. Chop the white of a hard boiled egg into small pieces and evenly divide the egg into test tubes.
3. Prepare buffer solution A, by filling a dropper bottle with .01 M HCl. Measure and record the pH of the solution.
4. Prepare buffer solution B, by dissolving 25 grams of sodium bicarbonate in 250 ml of distilled water. Measure and record the pH of the solution.
5. Prepare an enzyme solution by dissolving a tablet of pepsin (or 5 grams) in 250 ml of distilled water.
6. Fill each test tube containing egg white with the following solutions. The egg white should be completely covered by the solution.
 - a. Tube 1—10 ml of distilled water
 - b. Tube 2—10 ml of buffer A
 - c. Tube 3—10 ml of buffer B
 - d. Tube 4—10 ml of pepsin solution
 - e. Tube 5—5 ml of pepsin and 5 ml of buffer A
 - f. Tube 6—5 ml of pepsin and 5 ml of buffer B
7. Place the test tubes in a warm area for one day.
8. Observe the condition of the egg white in each tube and record your results.

Data Summary and Analysis

Test Tube	Contents of Tube	Amount of Digestion
1	Egg white & 10 ml of distilled water	
2	Egg white & 10 ml of buffer A	
3	Egg white & 10 ml of buffer B	
4	Egg white & 10 ml of pepsin solution	
5	Egg white & 5 ml of pepsin & 5 ml of buffer A	
6	Egg white & 5 ml of pepsin & 5 ml of buffer B	

Laboratory reports should include answers to the following questions:

1. Egg white contains what nutrient?
2. In which tube did the most digestion take place? How is this explained?

Ideas for Other Experiments

Use the same procedures but vary the environments where the test tubes are placed overnight. Put one set of test tubes in a warm place, another at room temperature and a third set in the refrigerator. Relate body temperature to the results of the experiment.

Technical Supplement

PROTEIN DIGESTION BY ENZYME ACTION

1. What is the function of protein in the growth and development of animals?

Proteins make up more than 50 percent of dry weight of animals. Proteins perform many important functions in living organisms. Hair and fingernails are composed of fibrous structural proteins. The body fluids of animals contain soluble proteins that help combat disease and are known as antibodies. Hemoglobin is an oxygen carrying protein found inside red blood cells. Some proteins, actin and myosin, help muscles contract. Insulin, which helps the body absorb sugar, is a number of protein hormones. Proteins are also found in nearly all biological membranes which regulate the passage of many substances through membranes. The most numerous class of proteins is the enzymes, which speed up chemical reactions.

2. What form of proteins are commonly provided by plants?

Proteins are complex organic compounds made up of amino acids. The amino acids contain carbon, hydrogen, oxygen, and nitrogen. In plants, proteins are largely concentrated in the growing portions, especially the leaves and seeds. Legumes have the ability to synthesize protein from carbon dioxide, water, nitrates, and sulfates.

Essential amino acids cannot be produced fast enough by animals and therefore must be supplied in the feed. Maize and cotton seed cakes together as feed, usually provide a good source of the essential amino acids.

3. How are proteins chemically changed in digestion?

The first act of digestion of proteins occurs in the stomach. The stomach contains high concentrations of HCL and a protein digestion enzyme called pepsin. Pepsin will only work at a very low pH, about 2.0. Pepsin breaks long globular proteins into shorter polypeptide chains.

After the proteins or polypeptide chains advance out of the stomach and into the small intestine, they are further digested by enzymes secreted by the pancreas. The pancreas secretes proteolytic enzymes or enzymes that are inactive until they reach the small intestine. This keeps the pancreas from becoming digested itself. The pancreas releases the protein digesting enzyme called trypsinogen. Trypsinogen is cleaved or changed by another protein called enteropeptidase. This change produces the active form of the enzyme called trypsin. Trypsin continues to break down the chains of amino acids, which are now absorbed into the blood system.

4. What is the role of enzymes in the digestion of proteins?

Enzymes act as a catalyst. A catalyst is a substance that speeds up a chemical reaction. Without the help of a catalyst, food digestion would take a great deal of time and our body would not be able to efficiently obtain enough energy to grow or carry on many basic life functions. Water itself will digest or break down proteins but at a much slower rate. Enzymes are needed in small quantities to help this reaction. Enzymes break long chains (100 to 300 or more) of amino acids into small chains and other enzymes break these small chains into individual amino acids. Our body can now rearrange these amino acids into proteins that are found in our body.

5. What conditions exist in the stomach which promote protein digestion?

The epithelium of the stomach is the source of the "digestive juices," a combination of HCL and digestive enzymes that when mixed with food, form a semi-solid material called chyme. The upper epithelial surface of the stomach is dotted with deep depressions called gastric pits. In them the epithelial membrane is invaginated, forming exocrine glands with the underlying layer called the mucosa. These glands contain two kinds of secreting cells, parietal cells which secrete HCL and chief cells which secrete pepsinogen. Within the stomach, HCL cleaves a terminal fragment from the pepsinogen, converting pepsinogen into the active digesting enzyme called pepsin. The stomach secretes large amounts of HCL causing it to have a very low pH (1.5-2.5).