Unit B: Understanding Animal Body Systems

Lesson 4: Understanding Starch Digestion by Enzymes

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

1. Describe chemical processes of breaking down food in the body.
2. Explain the role of enzymes in helping to digest starches.
3. Describe the conditions necessary for the digestion of starches.

Recommended Teaching Time: 4 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.alternativemedicine.com/books/enzyme_cure/chap1.shtml
- http://www.idrc.ca/books/focus/821/chp2.html
- http://www.userworld.com/users/life/enzymes.html

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint projector
- PowerPoint Slides
- Copies of student lab sheet
- Copies of technical supplement
- Supplies for LS 4-1 (see lab sheet)

Terms: The following terms are presented in this lesson (shown in bold italics): **PowerPoint Slide 2**

Amylase
Carbohydrates
Carnivores
Enzyme
Herbivores
Hydrolyzed
Monosaccharides
Omnivores
Polysaccharides
Substrate

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.

Assign pairs of students to compile a list of common food for each of the following various animals such as sheep, dogs, cows, humans, foxes, rabbits, etc. (You made add additional animals to this list). Write student food lists on the writing surface and then ask "What do some of these animals have in common? What do foxes eat? What do dogs eat?" After students answer that they eat the same type of foods, begin grouping animals by food preferences. Students will discover that animals can be classified as carnivores, herbivores, and omnivores. Point out that basic nutrients are needed by all animals even though the source of nutrients may differ by classification. Refer to the previous lesson on nutrients. Carbohydrates found in starches are one important nutrient investigated in this lesson.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1 : Describe chemical processes of breaking down food in the body.

Anticipated Problem: What chemical processes are involved in the breakdown of food in the body?

***Ask students how we are able to use the food we eat? How do animals use their food? – They break it down.**

I. Most food for animals is in the form of complex molecules that must be broken down into smaller molecules before being used by the body.

A. One purpose of food is to supply energy to the body. ***Carnivores*** are animals that eat the flesh of other animals for a food source. ***Herbivores*** are animals that feed exclusively on plant life for energy. ***Omnivores*** are animals, such as humans, that each both meat and plants.

***Have students respond in unison to the 3 types of animals discussed. What type eats meat? "Carnivores" etc. PowerPoint Slides 3, and 4.**

B. Energy from food comes in two forms: fats and carbohydrates. ***Carbohydrates*** are the body's primary source of energy and are made up of carbon, hydrogen, and oxygen atoms. The energy source in carbohydrates, glucose, is stored in polysaccharides called starches. ***Polysaccharides*** are long chains of sugar units often referred to as complex carbohydrates. ***Monosaccharides*** are the simplest form of carbohydrates, a one-sugar unit such as glucose.

C. Because of their structure, starch units are quickly ***hydrolyzed***, or broken down, into simpler sugar subunits that are used for energy. Mechanical breakdown by chewing is not enough to transform starch into the usable form of glucose. The body uses other substances to help breakdown starches.

Use PowerPoint Slides 5 and 6 and TM 4-1 to show students the differences between polysacharrides, and monosacharrides. Ask students to share with their neighbor what they see as different. Then, have students sketch and label the picture.

Objective 2 : Explain the role of enzymes in helping to digest starches.
Anticipated Problem: What is the role of enzymes in helping to digest starches?
Ask students "How does the food animals eat get broken down?" "Will chewing the food break it down into small enough pieces?" "What helps the food break down even more?"

II. ***Enzymes*** are complex organic substances which act as catalysts that speed up a chemical reaction in the body without being changed themselves. A ***substrate*** is the molecule that undergoes a physical change as a result of enzyme interaction. **PowerPoint Slide 7.**

A. Enzymes involved in digestion include amylase, sucrase, maltase, and lactase. ***Amylase***, the enzyme that breaks down starches (polysaccharides) into glucose (monosaccharide) is active in two parts of the animal body, depending on digestive tract.

1. Non-ruminant animals have amylase present in both the saliva and the pancreas.
2. Ruminant animals only have amylase present in the pancreas.

Ask students "Which type of animal has amylase present in the salvia?" "Why do they need saliva there so early in the digestion process?" (There digestion is quicker and will not spend as much time in the digestive tract) Also, use PowerPoint Slide 8 to help with note taking.

B. Other enzymes and what they break down include:

1. Sucrase, breaking down sucrose into glucose.
2. Maltase, breaking down maltose into glucose.
3. Lactase, breaking down lactose into glucose.

Have students list the four enzymes mentioned out loud and research what food products would contain the different polysaccharides that must be broken down in digestion. Also, use PowerPoint Slide 9 and 10 and TM 4-2 to help with note taking.

Objective 3 : Describe the conditions necessary for the digestion of starches.
Anticipated Problem: What are the conditions necessary for the digestion of starches?
Ask students, "Do you think different feedstuffs are broken down differently?" "Do some ingredients break down slower than others? Faster?"

III. The digestion of starch must take place in conditions that are favorable for their activity. There are two general conditions that will affect the digestion of starches by enzymes. **PowerPoint Slide 11.**

A. pH. Amylase functions best in a pH range near 8.0 (slightly alkaline). Acidic pH conditions (less than 7.0) denature, or disrupt, the enzyme and its activity is halted.

B. Temperature. Enzyme activity is optimal at a temperature of approximately 40° C (104° F). Even a brief exposure to high temperature will destroy the enzyme and halt activity.

Ask students to describe the weather in Afghanistan. How would this effect digestion in animals? If an animal begins to overheat, or is at a constant high temperature will that effect the internal temperature of the animal? PowerPoint Slide 12 and TM 4-3. Also use LS 4-1 and the results to reinforce the concepts in this section.

Review/Summary. The review and summary of this lesson should be based upon the three student objectives listed earlier. Ask students to describe the difference between carnivores, herbivores, and omnivores and explain how food is taken in and used as an energy source. Have students compare polysaccharides and monosaccharides and explain why the body cannot use larger molecules as an energy source. List the four enzymes discussed in this lesson and the polysaccharides that they break down. Finally, discuss the conditions necessary for proper enzyme action and what happens to enzymes when these conditions are not held.

Application. Application can occur as students consider food sources and digestion in animals produced at local farms or later in their careers. If possible, have animals where students can apply information on animal health and digestion. Use the following powerpoint, 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. d
3. e
4. a
5. f
6. g
7. c
8. b

Part Two: Completion

1. Pancreas
2. 8.0
3. Halt (or stop)

Part Three: Multiple Choice

1. c
2. d
3. b
4. c
5. b
6. c
7. a

Part Four: Short Answer

1. Amylase—Amylose
   Maltase—Maltose
   Sucrase—Sucrose
   Lactase—Lactose
2. Ruminant and non-ruminants produce enzymes differently based on their digestive structure. Ruminant animals only produce amylase in the pancreas because they do not spend much time chewing, and most digestion is done in one of the four stomach compartments by microbial and other action. Non-ruminant animals however, do not keep food in their digestive systems as long, and therefore need to begin the break down of larger molecules into smaller ones as soon as possible. Therefore, non-ruminant animals produce amylase not only in the pancreas, but also in the saliva to begin the digestion process in the mouth.

Name _____

Starch Digestion by Enzyme Action

Instructions: **Match the term with the correct response.**

a. omnivore
b. hydrolyze
c. substrate
d. amylase
e. enzyme
f. polysaccharide
g. carbohydrate
h. monosaccharide

_____1 A simple molecule, such as glucose.

_____2 The enzyme that breaks down starches.

_____3 A substance that speeds up reactions, without being used up.

_____4 An animal that eats both plants and meat.

_____5 A complex molecule that must be broken down before being used.

_____6 The main source of energy found in animal food.

_____7 The molecule that is physically changed due to enzyme action.

_____8 The process of breaking down large, complex molecules

.

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

1. Non-ruminant animals produce amylase in the saliva and the _____.

2. Amylase enzyme functions best in a pH near _____.

3. Excessive temperatures will cause the enzyme activity to _____.

Instructions: **Circle the letter of the correct answer.**

_____1. What is the simplest form of a carbohydrate?

a. maltose
b. polysaccharide
c. monosaccharide
d. sucrose

_____2 What digestive enzyme is responsible for the initial breakdown of starch?

a. glucose
b. ribonase
c. thynase
d. amylase

_____3 The break down process of complex feed molecules into smaller molecules is called:

a. substration
b. digestion
c. conversion
d. carnivorous

_____4. Which is not a favorable condition for enzyme activity which breaks starch into sugars?

a. pH of 8.0
b. temperature of 40 degrees C
c. pH of 4.0
d. slightly alkaline solution

_____5 What enzyme involved in starch digestion is not present in the saliva of ruminants?

a. maltase
b. amylase
c. lactase
d. sucrase

_____6Animals that digest only cellulose and plant material are called:

a. carnivores
b. omnivores
c. herbivores
d. meat eaters

_____7 Which livestock feed ingredient would contain a high amount of starches?

a. corn
b. iron
c. soybean meal
d. fish meal

Short Answer

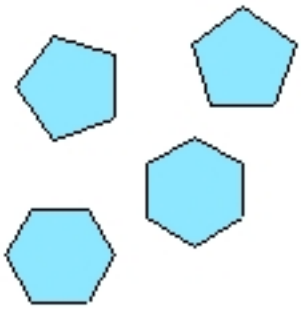
Instructions: **Provide information to answer the following statements.**

1. List the three of the four enzymes discussed in this lesson and give the name of the polysaccharide they help break down.

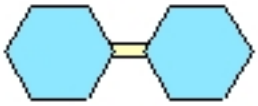
2. Discuss why ruminant and non-ruminant animals have difference in the production of enzymes and digestion activity.

TM 4-1

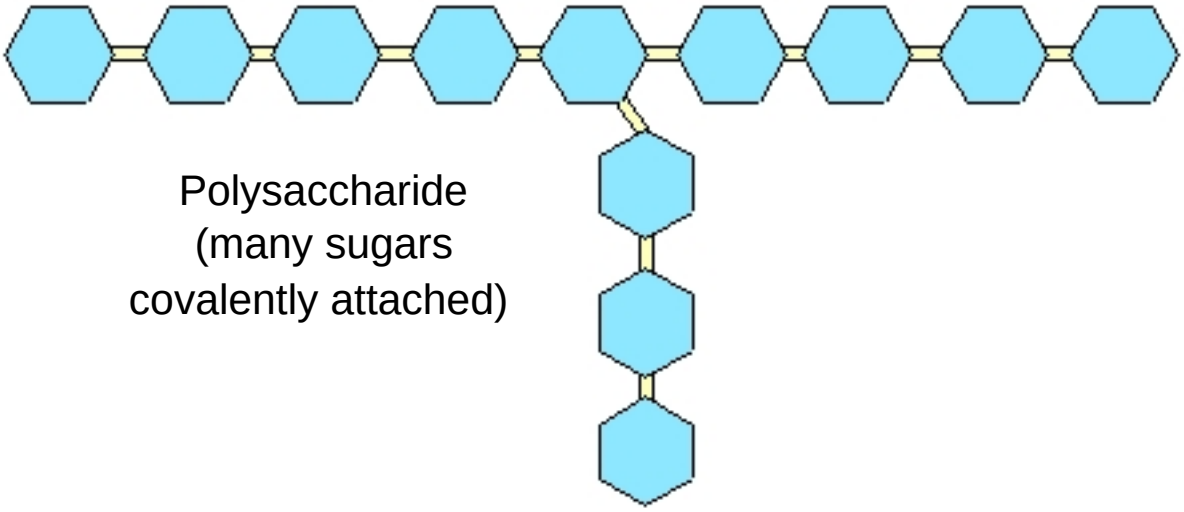
POLYSACCHARIDES AND MONOSACCHARIDES



Monosaccharides
(simple sugars)



Dinosaccharide
(two sugars
covalently attached)

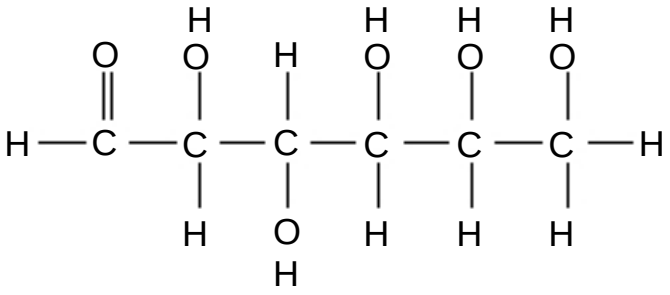


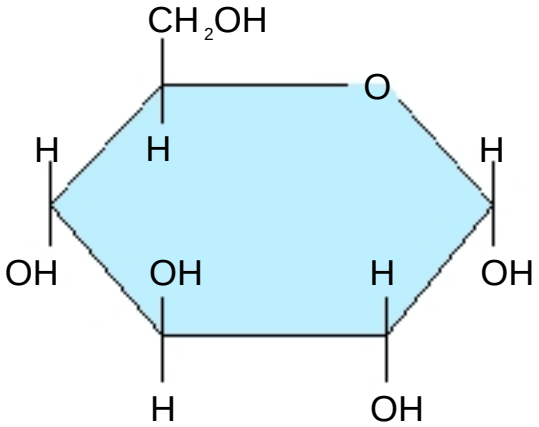
Polysaccharide
(many sugars
covalently attached)

ENZYME ACTION

Enzyme Action on Complex Molecules

Enzyme	Breaks Down
Amylase	**Amylose**
Maltase	**Maltose**
Sucrase	**Sucrose**
Lactase	**Lactose**





CONDITIONS NECESSARY FOR STARCH DIGESTION OF ENZYMES

- **pH:**
    - **Near 8.0**
    - **Slightly Alkaline**

- **Temperature:**
    - **Near 104°**
    - **Avoid Extremes**

STARCH DIGESTION BY ENZYME ACTION

Agricultural Applications and Practices

Animals, like humans, need a nutritionally balanced diet in order to grow and remain healthy. A balanced animal diet contains a proper mix of proteins, carbohydrates, lipids, vitamins, minerals and water. Livestock receive these nutrients in feed provided by producers. The preparation of livestock feed begins with determining a proper ration. Nutritionists have developed feeding standards for determining the nutritive requirements of animals. These requirements may vary depending upon the type of animal, its weight, age, size, and classification. Classification refers to the use or growth stage of the animal such as growing, fattening, producing, or reproducing.

Nutrients for animal growth are normally provided from plants. For example, poultry are fed corn while sheep and cattle eat both grain and forage. Although plants contain adequate nutrients for animal growth, they are present in a complex form that prevents easy utilization by animals. The purpose of the digestive system is to break down complex compounds into nutrients that can be use by animals. One important nutrient which provides energy for animal growth and development is carbohydrates. Carbohydrates are commonly found in starches, a major component of livestock rations.

Science Connections—Questions for Investigation

1. Why must starches be chemically changed in digestion?
2. What role do enzymes play in the digestion of starch?
3. How are starches chemically changed in digestion?
4. What conditions are necessary for digestion of starches?

Purpose of Laboratory and Student Performance Objectives

The purpose of this experiment is to investigate the role of a digestive enzyme responsible for the initial breakdown of starch (a complex carbohydrate). Through this laboratory exercise and related discussion students will be able to:

1. Describe chemical processes of breaking down food in the body.

2. Explain the role of enzymes in helping to digest starches.
3. Describe the conditions necessary for the digestion of starches.

Materials and/or Equipment

- hot plate
- beakers (2)
- water
- test tubes and rack
- iodine solution
- Benedict's solution
- cornstarch

Procedure

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

Helpful Hints

- This lab discusses and explains the process of starch digestion by enzyme action.
- Saliva from students is used in this lab because it contains the enzyme, amylase which will break down starch.
- Some schools have strict rules and regulations on the use of any bodily fluid of a student for lab experimentation. Please be sure to check with your school administrators or department head to become familiar with your school's policy regarding the use of saliva.
- For those that are not allowed the use of saliva (or choose not to use saliva), commercial amylase is available for purchase from nearly every biological supply company and is available at many locations online.

Data Summary and Analysis

Student laboratory reports should include answers to the following questions:

1. What is present in saliva that caused the breakdown of starch?
2. What is the function of starch in this experiment?
3. What is the function of saliva in this experiment?

Anticipated Findings

- Iodine turns from light brown or rust to dark blue or purple in the presence of starch.
- Benedict's solution changes from light blue to green, orange, yellow, or red in the presence of sugar (glucose).
- Saliva contains the enzyme salivary amylase which breaks down starch, a polysaccharide, to smaller units of glucose (a monosaccharide).

	Color— Iodine Solution	Color— Benedict's Solution	Type of Carbohydrate Present
Starch Solution	blue-black	light blue	starch
Saliva	no change	no change	none
Starch & Saliva Solution	no change	red, orange, green	glucose

Ideas for Other Experiments

- Students could use the same procedures but vary the temperature or pH of the solutions and record the results.

Name _____

STARCH DIGESTION BY ENZYME ACTION

Procedure

1. Prepare a starch solution by adding 1 gram of corn starch to 100 ml of hot water. The water must be heated to boiling to partially dissolve the starch to solution. Set aside to cool.
2. Prepare a hot water bath by filling a small beaker 1/2 full of water and bring to a boil.
3. Add 5 ml of starch solution to each of four test tubes and label them 1-4.
4. Add two drops of iodine solution to test tube 1 and record the color.
5. Add 5 ml of Benedict's solution to test tube #2 and place in hot water bath for 5 minutes. Record color.
6. Add about 2 ml of your saliva to test tubes #3 and #4. Mix and allow to stand for five minutes.
7. Put 2 drops of iodine in test tube #3 and observe color change.
8. Put 5 ml of Benedict's solution in test tube #4, place in hot water bath for five minutes and observe color change.

Data Summary and Analysis

	Color— Iodine Solution	Color— Benedict's Solution	Type of Carbohydrate Present
Starch Solution			
Saliva			
Starch & Saliva Solution			

Laboratory reports should include answers to the following questions:

1. What is present in saliva that caused the breakdown of starch?
2. What is the function of starch in this experiment?
3. What is the function of saliva in this experiment?

Ideas for Other Experiments

- Use the same procedures but vary the temperature or pH of the solutions and record the results.

Technical Supplement
For Teachers

STARCH DIGESTION BY ENZYME ACTION

1. Why must starches be chemically changed in digestion?

Plants are a food stuff for animals. One purpose of food is to supply energy. Energy comes in two forms: fats and carbohydrates. Although fats contain more gross energy, carbohydrates contain more energy that is usable by animals. The energy source in carbohydrates is glucose, which is stored in polysaccharides called starches. Because of its structure, starch is quickly hydrolyzed (broken down) into sugar sub-units, which are used in metabolism. Mechanical breakdown by teeth is not sufficient to transform starch into the usable sugar, glucose.

2. What role do enzymes play in the digestion of starches?

Enzymes are complex organic substances that act as catalysts that speed up a chemical reaction without themselves being changed in the process. Enzymes involved in starch digestion include: amylase, sucrase, maltase, and lactase.

Amylase is active in two parts of animals, depending on their digestive tract. In non-ruminants amylase is present in saliva and the pancreas. In ruminants saliva does not contain amylase.

Amylase breaks starch (polysaccharide) into smaller carbohydrates (disaccharide).

Sucrase is the enzyme that breaks down sucrose (dissach.) into glucose (mono.).

Maltase is the enzyme that breaks down maltose (dissach.) into glucose (mono.).

Lactase is the enzyme that breaks down lactose (dissach.) into glucose (mono.).

3. How are starches chemically changed in digestion?

The enzyme that matches the saccharide finds a receptor site that it is "programmed" to find. It attaches in that receptor and initiates the hydrolysis of the starch into the simple sugar.

4. What conditions are necessary for digestion of starches?

The digestion of starch must take place in conditions that are favorable for their activity. The following conditions are general rules for enzyme activity:

a. pH—amylase functions best in a mildly alkaline solution near 8.0. Acidic conditions denature the enzyme and its activity is halted.
b. temperature—enzyme activity is optimal at approximately 40° C. Brief exposure to high temperature will destroy enzymes.