Making "Poo"

Physiology and Chemistry of Nutrition

Grade Level
9-12

Lesson Length
2 periods x 55 Minutes

STEM Careers
- Nutritionist, Food Scientist, and Pathologist

Nebraska Science Standards
- SC12.3.1 (Structure and Function of Living Systems)

Next Generation Science Standards
- LS1.C (Energy Flow in Organisms)

Animal Biology
- Students will apply principles of animal nutrition to ensure the proper growth, development, reproduction and economic production of animals

These lessons aim to bring the science, skills of inquiry, critical thinking, and problem solving to life through an agricultural context

Learning Objectives

By the end of the unit, students should be able to:
- Describe the function of digestive organs
- Develop a simple digestive system that uses chemical, enzymatic, and mechanical digestion to process feed
- Design an experiment with their digestive system to predict how different enzymes impact digestion
- Evaluate how different food items are broken down for potential absorption by the body

Materials List (per student team)

- 100-125 ml each of prepared amylase, pepsin, pancreatin (lipase), and bile solutions
- Food for the "meal"
- 2 quart-sized resealable plastic bags
- Nylon sock
- Aluminum tray
- 4 syringes with needles
- Paper towels
- Goggles (one pair for each student)

Preparation

- Prepare enzymatic solutions
- Print Power Point slides for students
- Print lab reports and digestion guidelines for students
- Collect, organize, and prepare materials to be used for the creation of a digestive system and for the experiment.

Do

Introduction (Interest Approach)

In order to introduce students to the digestive system, prepare the following to simulate what partially digested food feels like. A day or two before class, put grass clipping in a small bucket then pour hot water on the grass clippings. Let the mixture sit for at least one night. Right before class starts, pour out some of the cold water and mix in some hot water. Have the students wear rubber gloves and then reach into the bucket. The grass clipping will simulate what partially digested food feels like.

Essential Questions

- *What is the purpose of digestion?*
- *How do the digestive organs work together as a system?*

Learning Activity 1:

Watch this YouTube video to provide a brief demonstration of what the students will be doing (https://www.youtube.com/watch?v=aemI64NAK08).

After watching the video, ask students to discuss and answer the following questions:

1) What types of digestion occurs in the mouth?
2) What is the function of incisors compared to molars? Do animals have incisors and molars? How do the teeth present in a carnivorous animal (dog) compare to the teeth present in a herbivorous animal (cow)?
3) What is the function of saliva in the mouth? Do animals produce saliva?
4) What types of digestion occur in the stomach?
5) Do all mammalian animals have a stomach or at least an organ that functions like the stomach?
6) What type of digestion occurs in the small intestine?
7) In addition to digestion, what is the second PRIMARY function of the small intestine? Clue – This is why she had to use nylon socks to represent the small intestine.

8) What type, if any, digestion occurs in the large intestine?

Learning Activity 2:

Students will design a “whole class” experiment to test the digestion of food under different conditions. When students design their experiment, they should consider the following factors: types of food, chemical digestion, enzymatic digestion, and mechanical digestion.

Prior to conducting the experiment to test digestion of food under different conditions. The instructor will conduct the “control”; normal digestion. Each of four student groups will then create a comparative experimental treatment. Each group must create a written plan of action that includes a research problem, hypothesis, materials list, procedure, and data tables. Students will select food and other materials that are provided by the instructor. Students may choose not to select all of the provided foods and materials for their experiment. The written plan of action must be approved by the instructor prior to students conducting the experiment.

Students will conduct their experiment. Each student in the group will use the provided lab report to document their findings.

Reflection

Using the prompts below to facilitate reflection, allow each student to respond in writing to the prompts and then facilitate a whole class discussion.

1. How well does this experimental demonstration mimic the digestion process in animals? What, if anything, is missing?
2. Based on your experiment, how does mechanical action, chemicals (acid), and enzymes impact digestion?

Apply

Use the prompts below to facilitate small group and whole class discussion.

1. How would animal nutritionist use their knowledge of digestive systems and nutrition to ensure healthy animals?
2. How can your knowledge of digestion and nutrition impact your life?

3. Based upon your knowledge gained in regards to digestion, how might you enhance digestion of otherwise poorly digested feeds?

References:

- Hill, D. Junkyard Digestion (APS Archive of Teaching Resources Item #384). [Online]. Bethesda, MD: American Physiological Society, 2002. http://www.apsarchive.org/resource.cfm?submissionID=384.

"Making Poo" Experiment Guidelines

Objective: Develop and simulate the monogastric digestive system.

Instructor Notes & Preparation:

1. Prior to usage, pepsin & amylase powders must be stored at 4°C (refrigerator)
2. Bile & pancreatin can be stored at room temperature.
3. Prior to conducting lab, instructor should make up enzyme solutions the day preceding. Mixed solutions may be stored at 4°C (refrigerator). When dissolving, use stir bars or gently mix (swirl) by hand. Avoid heating or allowing the solution to froth as this will denature the enzymes.
    - Dissolve one vial of amylase into 600 ml of distilled water.
    - Dissolve one vial of pancreatin into 600 ml of distilled water.
    - Dissolve one vial of bile into 600 ml of distilled water.
    - Dissolve one vial of pepsin into 600 ml of **VINEGAR**.
4. Prior to start of the actual lab, equally portion the dissolved enzyme solutions into 5 equal aliquots (assuming 5 total runs).
5. We recommend that the control be "normal" digestion of the meal (all enzyme included at recommended rate), and this could be conducted by the instructor simultaneously as he/she helps demonstrate will do.
6. It is recommended that each student group develop a comparative test treatment. Possible test treatments may include …
    - Differences in the substrate (meal).
    - Differences in the digestive process. Some possibilities might include …
        - Not slicing and grinding (not using mechanical digestion of teeth)
        - Not adding particular enzymes, or adding double the amount of enzyme
            - NOTE: You've got a set amount of enzyme for each year. Thus, the only way for one team to add more is if another team does not include that enzyme.
            - If you have a high protein meal (peanut butter, deli meats), what happens if the pepsin is not added?

Instructions

1. To calculate dry matter digestibility, given different substrates and/or different incorporation of enzymes, student groups will need to know how much DRY MATTER was consumed. This can be calculated given weights and dry matter values of food ingredients used.
    a. As-fed ingredient quantity * % DM = DM ingredient quantity
2. Simulation of the mouth –
    a. Each group should tear apart their meal, slice it (with scissors, if necessary) and grind it.
    b. Place into a quart-sized resealable plastic bag.
    c. Add 50 ml of amylase solution to bag. What does this represent?
    d. Further mash the contents by hand for 2-3 minutes.
        i. If possible, heat the bag at 98°F, which is the optimal temperature for the enzymatic reactions.

1. May use an incubator, water bath, or simply warm (NOT HOT) tap water.

ii. Allow amylase solution to act upon the bag contents for ~ 10 minutes total.

3. Simulation of the stomach –
    a. Add 50 ml of pepsin solution
    b. Mash for another 2-3 minutes
        i. If possible, heat the bag at 98^{o}F, which is the optimal temperature for the enzymatic reactions.
            1. May use an incubator, water bath, or simply warm (NOT HOT) tap water.
        ii. Allow pepsin solution to act upon the bag contents for ~ 10 minutes total.
4. Simulation of Small Intestine
    a. This step should be conducted in some type of pan or tray as there will be significant seepage.
    b. Transfer digesta to nylon sock.
        i. What does the seepage represent?
    c. Using syringes and needles, inject …
        i. 50 ml of amylase into several different locations on sock,
        ii. 50 ml of pepsin into several different locations on sock,
        iii. 50 ml of pancreatin (lipase) into several different locations on sock, and
        iv. 50 ml of bile into several different locations on sock.
    d. Massage the nylon sock and allow for seepage of nutrients. Continue digestion for ~ 10 minutes.
        i. Again, conduct in tray with warm (not hot) water to facilitate greater enzymatic digestion.
    e. After ~ 10 minutes of digestion, wring out as much liquid as possible.
        i. What exactly is being "wrung out"? How does this relate to primary function of small intestine?
5. Simulation of Large Intestine
    a. Transfer remaining contents from nylon sock onto paper towels and blot as dry as possible. This is "poo".
6. To calculate DM digestibility, "poo" must be dried.
    a. Ideally, "poo" is placed in dry matter oven set to ~ 105^{o}C overnight (likely not feasible for most schools).
    b. Other options to dry poo … spread onto plate as thin as possible and dry …
        i. place in oven, on warm, for 2-3 hours.
        ii. place in sun with fan blowing.
        iii. Theoretically, everything equilibrates to 90% DM if left in the air and wind with time.
        iv. DM Digestibility = (DM quantity of poo / DM quantity of food) * 100
7. Needles should be exposed of properly; i.e., into SHARPS container per teacher instructions.
8. Syringes may be washed and reused in future years.
9. Use lab report to report findings.

Name:

Lab Report

Please complete the following report during the design and implantation of your experiment.

Research Problem

- Describe what you are investigating and justify why you are investigating the problem.

Hypothesis

- Formulate one or more hypotheses for your experiment.

Procedures

- Create the steps you will follow for your experiment.

Data Collection

- Describe the data that you will collect during your experiment.
- Provide graphs, tables, charts, and raw data as necessary.

Results

- Explain you're your results.

Conclusion

- Based on your data:
  - What can you conclude?
  - Were your hypotheses supported?
  - Were their limitations to your experiment?
  - What are new research questions that derived from this study?