



YOUNG VOICES:

Life With Diabetes

Lesson 2: Digestion of fats, proteins, and carbohydrates

Inquiry Focus: How does the body get energy from food?

Student Learning Objectives: By the end of the lesson, students will be able to do the following:

- Explain why food must be broken down
- List the smaller units that fats, proteins, and carbohydrates are made up of
- Describe the mechanical forces that help digest food in the mouth and stomach
- Describe the action of enzymes that help break down food into more basic parts
- Tell where in the digestive tract most food is absorbed
- Describe the relative time needed until fats, proteins, and carbohydrates are available for use as energy

Time Frame: 2 class periods

Materials:

- For dissolving demonstration (this can be done by students using these materials for each group):
 - Beakers (2) or other clear containers for warm water
 - Hard candy pieces (mostly sugar with flavoring)
 - Paper towel
 - Mortar and pestle (students may use a heavy object like a textbook)
- Enzyme action on protein activity: for each group
 - Prepared 3cm³ Jell-O™ Brand gelatin cubes (4-5 cubes per group)
 - Shallow dish or pan (small Styrofoam cafeteria trays work well for this)
 - Fresh pineapple from which to extract the juice
 - Blender
 - Cheesecloth
 - Small containers or beakers to distribute the juice
 - Optional: small pieces of baked potato, lettuce, preserved meat, bread (for observing

how saliva acts on them in the mouth)

- Video from web site: “The Process of Digestion.”
- Digestion/Absorption Activity: for each group
 - Two paper towels
 - Petri dish or other shallow dish for water
 - Additional paper towels for table cleanup if needed

Teacher Background Information:

- Digestion is the process of breaking down food into simpler parts. Most of the food we eat must be digested into more basic parts so that it can be absorbed into the body and used within the body.
 - Fats are broken down and digested into fatty acids and glycerol
 - Proteins are digested into amino acids
 - Carbohydrates are digested into simple sugars
- Digestion involves mechanical and chemical processes. An enzyme is a protein that speeds up a chemical reaction; digestive enzymes speed up the breakdown of a food.
- To understand digestion, it is important to know the organs of the digestive system and what each organ does as food passes through.
 - Food is chewed in the mouth, which breaks the food into smaller pieces for swallowing and helps speed chemical digestion. To understand the idea of smaller pieces of food being more easily chemically digested, think of what happens when you chew a piece of hard candy rather than sucking on it- it dissolves in your mouth faster because your saliva can work on more surface area at the same time. Chemical digestion also starts in your mouth – saliva contains an enzyme called “amylase” that starts breaking down carbohydrates. This is why you might notice that a baked potato tastes a bit sweet after chewing it for a little while (remember: potatoes are rich in starch, but simple sugars taste sweet; breaking down starch from a potato makes simple sugars).
 - When you swallow, the food goes down into the muscular tube connecting your mouth to your stomach called the “esophagus.” The ball of food, called a “bolus,” is pushed down to the stomach with sequential squeezing of the esophagus called “peristaltic waves.” (Note: the action in the opposite direction, when food is brought up from the stomach, is technically called “reverse peristaltic waves” and is part of the vomiting mechanism.)
 - The stomach is a muscular sac that performs both mechanical and chemical digestion. The stomach squeezes and churns its contents, helping to make smaller particles and mix in the digestive enzymes. The stomach also makes a strong acid and a digestive enzyme called “pepsin” that starts breaking down protein. Once food has been digested

in the stomach, it passes on to the small intestine as a thick liquid called “chyme.”

- Gelatin is made from a protein called collagen which comes from the joints of animals. Gelatin may be dissolved in hot water. As the dissolved gelatin mixture cools, the collagen forms into a matrix that traps the water; as a result, the mixture turns into the jiggling semi-solid mass that is so recognizable as Jell-O™.
- Pineapple belongs to a group of plants called Bromeliads. Kiwi, papaya, and figs are other types of Bromeliads. The enzyme in pineapple juice that is responsible for the breakdown of collagen is bromelin. The process of canning pineapple denatures the bromelin, rendering it incapable of catalyzing the break down of gelatin.
- Several kinds of chemical digestion occur in the small intestine, beginning with other organs that empty digestive enzymes into the small intestine.
- The pancreas is an organ connecting to the small intestine with several functions, one of which is to make digestive enzymes including “lipase,” which helps digest fat by breaking the bonds between glycerol and the fatty acids, another amylase to break down starches into sugar, and two protein digesting enzymes called “trypsin” and “chymotripsin.”
- The liver makes “bile” which helps with the digestion and absorption of fats; while the liver connects to the small intestine, the liver also has a little sac that stores and concentrates bile so that it can be rapidly released into the intestine when it is needed.
- The small intestine itself has digestive enzymes on its surface that help break down proteins and carbohydrates.
- The small intestine does most of the absorbing of adequately digested food. Because absorption requires particles to come in contact with the surface of the intestine, the small intestine has fingerlike projections called “villi” that increase its surface area, and on the individual cells are even tinier projections called “microvilli.”
- What is not absorbed in the small intestine passes onto the large intestine, where water is reabsorbed. The remainder is stored in the rectum until a bowel movement.
- Simple sugars need little chemical digestion and are very rapidly absorbed into the blood stream. More complex carbohydrates require more digestion, so they are absorbed more steadily. Fats and proteins also generally require more time to digest than simple sugars.

Instructional Activities:

Introduce the lesson by reviewing the previous investigation into types of nutrients found in food. Ask students to discuss how that food gets to the cells in the body. Only blood takes nutrients to the body, and blood can only carry nutrients as individual molecules. Then all nutrients in food have to be broken down into a liquid.

Mechanical digestion:

Put one hard candy whole into a glass of warm water to represent a piece of unchewed food. Use the mortar and pestle or wrap the second piece of candy in a paper towel and crush it. Put the smashed hard candy pieces into the other to simulate mechanically digested food. At the end of class compare which has dissolved more. Alternative: bring in a bag of hard candy and take the average times it takes students to dissolve the candy in their mouths without chewing it.

Enzyme action:

Explain to students that simple sugars dissolve in water. In the body they require little digestion and are quickly absorbed into the bloodstream. Starches are also relatively simple and convert to sugars in the mouth. For example, take some baked potato and place it in the mouth. Without chewing, wait for the saliva to convert the starch and students will notice a slightly sweet taste after a while. This is the starch converting to sugar with the help of the enzymes in saliva.

While sugars and starches quickly can be prepared to go into the bloodstream, most foods are more complex. Ask students to respond to this question: if they placed a piece of food (lettuce, meat, bread) into their mouths without chewing, would it completely dissolve in their mouth so that the body could absorb the nutrients in it? (You may need to allow them to try this.) Starches, sugars, and carbohydrates are converted into glucose which is stored in the body. Proteins are broken down into amino acids and used to build and repair body tissues.

Explain that the digestive system produces many different chemicals called enzymes that help digest different nutrients. Introduce students to the concept of enzyme and substrate reactions. Students will use pineapple juice as an enzyme and Jell-O™ as a substrate to illustrate an enzyme/substrate complex.

Prepare Jell-O™ ahead of time (preferably the day before) in a flat, rectangular pan. Once set, cut the mold into small cubes (2 – 3 cm). Prepare the fresh pineapple juice either immediately before class or during class by pureeing the fresh pineapple in a blender. Use the cheesecloth to strain the juice. Distribute the juice, cubes, and flat trays to student groups.

You may wish to explain to students that gelatin is made from collagen and broken down by the enzyme in pineapple juice. Refer to the “Teacher Background” section above.

Students place the gel cubes in the tray, then slowly add the pineapple juice. Students should observe the set-up over 30 minutes and record their observations every five minutes.

Explain to students that this is just one type of enzyme reaction that occurs with foods as they are digested. From the Diabetes website, have students view the video: “The Process of Digestion” which explains how enzymes act on nutrients.

You may also wish to have students research the enzymes that digest carbohydrates, proteins, and lipids, and where those enzymes are produced in the body. An excellent web site with specific exercises on enzyme regulation is found at: the Maryland State Department of Education’s instructional web site:

http://mdk12.org/instruction/curriculum/hsa/biology/enzyme_activity/teachers_guide_engagement1.html

Nutrient absorption:

Explain to students that once the nutrients are broken down into molecules that can be used by the body, they are then absorbed into the bloodstream. In the human body, most of this absorption takes place in the intestines (although some is done earlier than that in the system, depending on the substance). Inside the digestive tract, the surface area is shaped to allow as much contact with the materials passing through as possible.

Have students add water to the petri dish. Take one paper towel and lay it flat over the water in the dish for just a second. Only a portion of the paper towel will absorb water. Take a second paper towel and challenge students to form it so that as much water will be absorbed as possible. Students may not tear the paper towel apart or cut it into pieces. It must be whole. Have them explore ways in which it can be crumpled or folded to absorb more water quickly or to absorb more water.

Explain that this same principle is at work in the body. In the small intestines, the surface is folded and shaped into villi which are like tiny fingers. Once food is broken down mechanically and chemically, it's ready to be absorbed into the bloodstream as glucose.

Lesson Assessment:

Have students choose one type of food for which they have a nutrition label. They will use the label to identify which types of nutrients are found in it and will explain what happens in the body to digest each nutrient within the food. Responses should go from the point where the food enters the mouth to its absorption into the bloodstream in the intestine.

Vocabulary:

- Digestion- the process by which food is broken down into substances that can be absorbed by the body
- Digestive enzyme- a protein the body makes to help break down food into substances that can be absorbed
- Fatty acid- a component of fats
- Glycerol- a component of fats
- Amino acid- the building blocks of proteins
- Sugar- the most simple part of a carbohydrate

NSES Standards Addressed:

Scientific Inquiry: Formulate and revise scientific explanations and models using logic and evidence.

Life Science: The Cell: Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts called enzymes.

Life Science: Matter, Energy, and organization in living systems: The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed.

Personal and Community Health: Personal choice concerning fitness and health involves multiple factors; selection of foods and eating patterns determine nutritional balance; many diseases can be prevented, controlled, or cured; some diseases . . . result from specific body dysfunctions and cannot be transmitted.

Historical perspectives: Usually, changes in science occur as small modifications in extant knowledge; scientific knowledge evolves by changing over time, almost always building on earlier knowledge.





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Bibliography

1. American Dietetic Association. www.eatright.org. 2008.
2. American Diabetes Association. www.diabetes.org. 2008.
3. Centers for Disease Control and Prevention. www.cdc.gov. 2008.
4. Dietary Guidelines for Americans. www.health.gov/dietaryguidelines. 2006.
5. Juvenile Diabetes Research Foundation International. www.jdrf.org. 2008.
6. Kids Health. www.kidshealth.org. 2008.
7. Maryland State Department of Education. <http://mdk12.org>. 2008.
8. Medline Plus. www.medlineplus.gov. 2008.
9. Miller, Kenneth. R. and Levine, Joseph. Prentice Hall Biology: Teachers Edition. Upper Saddle River. Pearson Education. 2002.
10. My Pyramid. www.mypyramid.gov. 2008.
11. National Diabetes Education Program. <http://ndep.nih.gov>. 2008.
12. National Digestive Diseases Information Clearinghouse. <http://digestive.niddk.nih.gov>. 2008.
13. The National Academies Press. www.nap.edu/html/nses. 1996.
14. Nutrition.gov. www.nutrition.gov. 2008.
15. USDA National Nutrient Database. www.nal.usda.gov/fnic/foodcomp/search. 2008.

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