Macromolecules

Strand Life at the Molecular and Cellular Level

Topic Investigating macromolecules

Primary SOL BIO.2 The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include
b) the structure and function of macromolecules.

Background Information

Students need to study molecular structures to be familiar with each monomer molecule. They need to understand that the presence of carbon is the basis for all the structures. They need to appreciate the intricate complexity of the polymeric molecules and understand why they are called "macromolecules." Based on the middle school Science SOL, Biology students should already have an understanding of the atomic models and bonding. Nevertheless, they may need refreshers on these topics as well as an introduction to Lewis models.

Materials

- Raisins
- Butter
- Applesauce
- Oatmeal
- Copies of the three attached handouts
- Scissors
- Test tubes
- Sugar
- Water
- Benedict's solution
- Pipettes
- Hot water baths
- Cornstarch
- Iodine
- Brown butcher paper or newspaper
- Vegetable oil
- Milk
- Biuret solution
- Ring stand and clamp (optional)
- Sugar cube (optional)
- Heat resistant watch glass or dish (optional)
- Lighter (optional)
- Centigrade thermometer (optional)

Vocabulary

amino acid, carbohydrate, lipid, macromolecule, negative control, positive control, protein

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)
Before undertaking this lesson, prepare a batch of "stomach contents" by adding raisins, butter, and applesauce to some cooked, runny oatmeal. Portion this mixture into specimen jars, if available, for added effect.

1. Introduce macromolecules by drawing an analogy to a sandwich. On the board, write the four different types of food ingredients found in a typical sandwich—i.e., bread, meat, vegetables, and condiments. Ask students to brainstorm what each of these foods does for the body. List their responses. Then, write the four macromolecules on the board, and ask students which ingredient would fit in each of the four categories.
2. Distribute scissors and copies of the attached Macromolecules Chart, and review it with students. Then, have students cut the chart apart, shuffle the resulting cards, and arrange them in the original order again under the five headings.
3. Group students, and provide each group with a container of unknown "stomach contents" and a copy of the Tests for Macromolecules handout. Direct groups to determine the macromolecules found in the mixture, based on doing the tests described on the handout and interpreting the results according to the Positive and Negative Control Results listed at the bottom.
4. Optional: Discuss the function of food in terms of energy. Remind students that carbohydrates are our number one source of energy. Have students observe the relative amount of energy in a carbohydrate via a demonstration. *(CAUTION: Put on safety goggles, wear a lab coat, and perform this experiment in an approved fume hood.)*
   - Place a test tube with 10 mL of room-temperature water in a clamp, and attach it to a ring stand.
   - Measure and record the temperature of the water.
   - Place a sugar cube (sucrose, a disaccharide) on a heat-resistant dish under the test tube.
   - Light the sugar cube with the lighter, and let it burn as completely as possible.
   - Measure and record the increase in temperature of the water.

   Discuss how the chemical potential energy in the sugar cube was changed to heat energy to heat the water.

Assessment

- **Questions**
  - What elements are present in the macromolecules in the table?
  - Which elements are present in all four types?
  - What makes the electron structure of carbon so flexible in making different biomolecules?
  - What is the difference between the Benedict's solution test and the iodine test?
  - Are the lipid/fat and carbohydrate tests qualitative or quantitative?
  - What are the monomer units of a protein called?
  - A meal of two scrambled eggs, two slices of toast, two slices of bacon, and coffee with cream and sugar can remain in the stomach for up to six hours. A meat loaf sandwich, mashed potatoes, and coffee without cream or sugar stay in the stomach for about four

hours. On the basis of these data, which macromolecule appears to influence the time it takes for the stomach to empty?

- **Journal/Writing Prompts**
  - Both steak and hamburger are proteins, but steak remains in the stomach longer than hamburger. Suggest a reason why this is true.
  - It is undesirable for an athlete to compete with a full stomach. During exercise, blood flow to the digestive system decreases, and if food is in the stomach, the decreased blood flow may cause cramps. Keeping in mind the roles that carbohydrates, fats, and proteins play for a person and the amount of time each remains in the stomach, choose a menu from the list that would be best for an athlete to eat three hours before engaging in strenuous exercise. Explain your choice.
    - Menu 1: Sausage, bacon, hash browns, low-fat milk
    - Menu 2: Country fried steak, potatoes, low-fat milk
    - Menu 3: Orange juice, cereal, low-fat milk, toast, potatoes

Extensions and Connections (for all students)

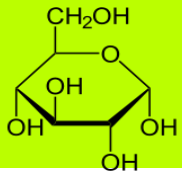
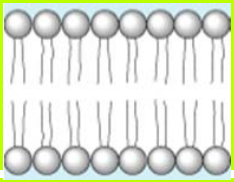
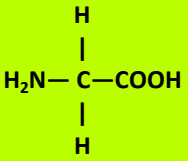
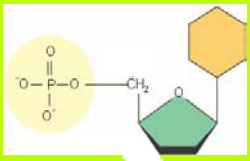
- Have students investigate how time of death is determined by using stomach contents.
- Create two mixtures of "stomach contents," using a blender. One should consist of a healthy meal and the other of an unhealthy meal (fast food). Have students decide which one is healthy and which is unhealthy, based on the macromolecules each contains.
- Distribute copies of the Insects as Human Food: Entomophagy handout, and have students complete it.
- Have students analyze the labels of several food items brought from home. Discuss the macromolecule content of each item and their relative healthiness.
- Have students create a healthy diet plan for one week, based on a budget of $75 or less. Discuss the difficulty of eating healthily on a tight budget and how this problem can be addressed.
- Show the video "Supersize Me," and discuss its relevance to the issues discussed in this lab.

Strategies for Differentiation

- Group students according to common readiness levels, shared interests, or diverse strengths.
- Have one student from each group complete one of the tests in the Tests for Macromolecules, and then have students regroup to discuss their findings.
- To reinforce the Macromolecules Chart, have students create a "Four Square Vocabulary" chart for each of the four macromolecules, as shown below.

Term	**Definition of the term in own words**
Illustration of the term	**Example of the term**

Macromolecules Chart

Macromolecule	Monomer	Structure	Function	Examples
Carbohydrate	Monosaccharide		Short-term energy source	Glucose, sucrose, starch
Lipid	Fatty acid		Cell membranes, insulation, long-term energy source	Oil, phospholipids, wax, cholesterol, fat
Protein	Amino acids		Structure, transport, speeds up reaction, immunity	Enzymes, proton pump, antibodies
Nucleic acid	Nucleotide		Holds genetic information	DNA and RNA

Tests for Macromolecules

A. Test for Monosaccharide (simple carbohydrate)

CAUTION: Benedict's solution is poisonous. Wear goggles, and point test tubes AWAY from you at all times.

1. Starting with three clean test tubes, place ½ inch of sugar solution in test tube 1, ½ inch of water in tube 2, and ½ inch of "stomach contents" in tube 3.
2. Add a dropper full of Benedict's solution to each test tube.
3. Heat the test tubes for 2 to 3 minutes in a hot water bath until a color change occurs.

	Known Monosaccharide	Water	Stomach Contents
Color change			

B. Test for Polysaccharide (complex carbohydrate)

1. Starting with three clean test tubes, place ½ inch of starch solution in test tube 1, ½ inch of water in tube 2, and ½ inch of "stomach contents" in tube 3.
2. Add two drops of iodine to each test tube.

	Known Polysaccharide	Water	Stomach Contents
Color change			

C. Test for Lipid

1. On a 4 x 4 inch square of brown butcher paper or newspaper, place a drop of vegetable oil in one place, a drop of water in a second place, and a small smear of "stomach contents" in a third place.
2. Let stand for 20 minutes.

	Known Lipid	Water	Stomach Contents
Spot appearance			

D. Test for Protein

CAUTION: Biuret reagent can stain your skin and fingernails.

1. Starting with three clean test tubes, place ½ inch of milk in test tube 1, ½ inch of water in tube 2, and ½ inch of "stomach contents" in tube 3.
2. Add about 2mL of Biuret reagent to each test tube.

	Known Protein	Water	Stomach Contents
Color change			

Positive and Negative Results

Test	Positive Result	Negative Result
Monosaccharide	Color changes from blue to green to yellow-orange-red.	Color remains blue.
Polysaccharide	Color changes from yellow-orange to blue-black.	Color remains yellow-orange.
Lipid	Spot will be translucent.	Spot will be opaque.
Protein	Color changes from blue to purple (complex protein) or pink (amino acid).	Color remains blue.

Insects as Human Food: Entomophagy

Crawly Cuisine

Would you believe that a serving of small grasshoppers packs nearly the same protein punch as ground beef? Would you believe that the UN's Food and Agriculture Organization is working on a policy to promote use of insects as food worldwide? As the global population grows, several organizations are looking at the possibility of farming insects for human consumption as a method of providing nutritious food. Insects can be farmed more cheaply and on much less land than animals or crops. At least a thousand species of insects are already part of the human diet. (*National Geographic* magazine, September 2010)

1. Research **entomophagy** (the practice of eating insects) and the nutritional content of several insects, such as giant water bugs, red ant eggs, small grasshoppers, and crickets.
2. Which insects would be best for a bear getting ready to hibernate? Defend your answer.
3. It is undesirable for an athlete to compete with a full stomach. During exercise, blood flow to the digestive system decreases, and if food is in the stomach, the decreased blood flow may cause cramps. Which insect would be best for an athlete to eat a few hours prior to a engaging in strenuous exercise? Defend your answer.
4. You've probably heard that chicken soup is great for someone who is ill, but if you were fresh out of chicken soup, which insect would be the best to eat if you were sick? Defend your answer.
5. You're creating a new "insect diet" to market. Which insect would be the main course in your diet plan? Defend your answer.

Postcard Honoring Entomophagy

1. Starting with an index card, create a postcard to honor entomophagy. On the lined side of the card, include a three-sentence message describing two pros of using insects as food and encouraging people to consider the possibility of entomophagy as a solution to world hunger.
2. On the blank side of the card, use at least five colors to draw a graphic that is inspired by the idea of entomophagy.