LAYING THE FOUNDATION
Building Academic Excellence

McMush Lab
Testing for the Presence of Biomolecules

About this Lesson

This lesson discusses the properties, examples, and functions of biomolecules along with introducing the terms monomer, polymer, dehydration synthesis, and hydrolysis. The activity provides an opportunity for the development of skills involved in chemically testing for the presence of carbohydrates, lipids, and proteins.

This lesson is included in the LTF Biology Module 2.

Objectives

Students will:

- Focus on the properties and functions of carbohydrates, lipids, and proteins
- Learn con rmation tests for the presence of glucose, starch, lipids, and proteins in food samples and, once familiar with these tests, will use those skills to determine which organic compounds are present in a given slurry

Level

Biology

Common Core State Standards for Science Content

LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, *A Framework for K–12 Science Education*, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

Code	Standard	Level of Thinking	Depth of Knowledge
(LITERACY) RST.9-10.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions de ned in the text.	Apply	II
(LITERACY) W.3	Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.	Apply	II

Connections to AP*

This lesson addresses concepts contained in Big Ideas 2 and 4 in the revised AP Biology curriculum under the following sections: 2.A.2.b and 4.A.1.a.

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Materials and Resources

Each lab group will need the following:

aprons
beaker, 250 mL
2 clamps, test tube
goggles
graduated cylinder, 50 mL
paper towels
test tube brush
test tube rack, jumbo
glove, disposable
marker, Sharpie®
glucose solution
iodine-potassium iodide solution in dropper bottle
McMush slurry
Sudan III in dropper bottle
Benedict's solution in dropper bottle
Biuret's reagent in dropper bottle
gelatin, solution
starch solution
2 test tubes, jumbo
oil, vegetable

Additional teacher materials:

beaker, 600 mL
blender
hot plate
marker, Sharpie®
pipette, thin stem
scissors
Benedict's solution
Biuret reagent
bottles, dropper
dextrose
gelatin, box
iodine-potassium iodide solution
starch, spray can
Sudan III
children's hamburger meal
water, distilled

Assessments

The following type of formative assessment is embedded in this lesson:

- Visual assessment of con rmation tests used within the lesson

The following assessments are located on the LTF website:

- Short Lesson Assessment: McMush
- Chemistry of Life Assessment

Teaching Suggestions

It is possible to divide this activity over several class periods. You could present pre-lab information about the structure and function of a particular group of biomolecules and then move to the laboratory to perform the test for that group. The following day you could address a second biomolecule group, and so on. If this activity will extend over a series of days, you will need to refrigerate the McMush slurry.

Benedict's solution, Biuret reagent, Lugol's solution, and Sudan III can be purchased from science suppliers and should be placed into dropper bottles for each group.

Students will need access to a hot water bath, either at their stations or in a central location.

Gelatin Solution

Dissolve 4 g gelatin in 396 mL distilled water.

Glucose Solution

Dissolve 20 g glucose (or dextrose) in 380 mL distilled water.

Starch Solution

Add 4 g cornstarch to 396 mL distilled water and heat until the starch dissolves. Alternatively, you can use aerosol fabric spray starch. Spray the starch directly into the water, holding for a count of ve.

McMush Slurry

Unwrap and place the entire edible contents of a children's hamburger meal into the blender, including the drink. Ask for a regular drink rather than a diet drink when purchasing your children's meal. In fact, a clear drink is recommended because it will not interfere with the color-dependent indicating tests. Blend the contents thoroughly, and add 250 mL distilled water to make the solution thin enough to be poured into the test tubes.

Acknowledgements

Sharpie® is a registered trademark of Sanford L.P., A Newell Rubbermaid Company.

Answer Key

Data and Observations

Table 1: Positive Tests Performed on Known Substances		
Test Performed	**Substance Tested**	**Results**
Benedict's solution	Glucose solution	Orange to brick-red color
Lugol's solution	Starch solution	Blue-black color
Biuret reagent	Gelatin solution	Purplish color
Sudan III	Oil	Diffused orange/pink

Table 2: McMush Tests	
Test Performed	**Results**
Benedict's solution	Positive if you used a regular (non-diet) drink
Lugol's solution	Positive
Biuret reagent	Positive
Sudan III	Positive

Answer Key (continued)

Conclusion Questions

1. Monomers are the smaller building blocks of the larger polymers.
2. a. Monosaccharides
   b. Glycerol and fatty acids
   c. Amino acids
3. Correct selections are shown in the table below:

~~amino acids~~	~~triglycerides~~	glucose	~~enzymes~~
fructose	~~hemoglobin~~	chitin	starch

4. a. Sudan III
   b. Biuret's reagent
   c. Benedict's solution
   d. Lugol's solution
5. Carbohydrates, lipids, and proteins.
6. a. Oil from the French fries
   b. Beef from the hamburger patty
   c. Drink (if not a diet drink)
   d. Hamburger bun
7. Inaccurate measurement, improper heating, or contamination.
8. See Table 3.

Table 3: Testing Food Substances

Food Substance	Predicted Biomolecule	Test to Be Used
Potato juice	Starch	Lugol's solution
Cracker	Starch	Lugol's solution
Egg white	Protein	Biuret reagent
Honey	Glucose	Benedict's solution

9. Press for good experimental design in the answers to this question. No control was included in the original protocol, so you may need to discuss this point with your students as they write their experimental design.

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Testing for the Presence of Biomolecules

Carbohydrates, lipids, proteins, and nucleic acids are organic molecules found in every living organism. These biomolecules are large carbon-based structures. Joining several smaller units (called **monomers**) together and then removing a molecule of water assembles the biomolecules. This reaction is called **dehydration synthesis**. Reversing the process and adding a molecule of water can disassemble the resulting polymer. The reverse process is called **hydrolysis**.

Carbohydrates

Simple carbohydrates are made of carbon, hydrogen, and oxygen atoms in a 1:2:1 ratio. This ratio means that for every carbon atom present in the carbohydrate, there are two hydrogen atoms and one oxygen atom present. The monomers for carbohydrates are referred to as **monosaccharides**. When many monosaccharides are chained together, the resulting molecule is called a **polysaccharide**.

Carbohydrates are used by living organisms as an important source of energy. Common examples of monosaccharides include glucose, fructose, galactose, ribose, and deoxyribose. Sucrose, or table sugar, and lactose, the sugar found in milk, are double sugars made from two monosaccharides. Important polysaccharides include cellulose, starch, and chitin.

Lipids

Lipids are also made of carbon, hydrogen, and oxygen but the ratio of carbon, hydrogen, and oxygen atoms is not 1:2:1. Instead, lipids have a much greater number of carbon and hydrogen atoms with few oxygen atoms present.

Lipids are biological-organic compounds that do not dissolve in water. The nonpolar bonds that form between the carbon and hydrogen atoms of a lipid cause them to be **hydrophobic** or "water-repellent" molecules, as opposed to **hydrophilic** or "water-loving" molecules. This attribute explains why water and oil do not mix.

The large number of carbon to hydrogen bonds also serves to make lipids energy-rich storage molecules. One gram of a lipid stores twice as much energy as one gram of a carbohydrate. Lipids from animals are referred to as *fats* and are solids at room temperature whereas those found in plants are referred to as *oils*, which are liquids at room temperature. Fats and oils are **triglycerides**, biomolecules that are composed of a glycerol and three fatty acid molecules.

One important relative of triglycerides are the phospholipids. **Phospholipids** differ in structure from regular triglycerides in that phospholipids are made of a glycerol and two fatty acids. A charged phosphate group replaces the third fatty acid. This arrangement causes phospholipid molecules to have both hydrophilic and hydrophobic regions. This feature also makes phospholipids an ideal structural component of the plasma membrane of cells.

Steroids are another signi cant group of lipids. These differ in structure because the carbon atoms are arranged in four rings. Examples of steroids include cholesterol, estrogen, testosterone, and morphine.

Proteins

Proteins are made of monomers called **amino acids**, which are composed of atoms of carbon, hydrogen, oxygen, and nitrogen. Proteins are large complex molecules that combine to form various components of living organisms such as muscle fibers, enzymes, and hemoglobin. Proteins are made from specific sequences of amino acids. A string of amino acid monomers joined together by peptide bonds is called a **polypeptide**.

Purpose

This activity provides an opportunity for the development of skills involved in chemically testing for the presence of carbohydrates, lipids, and proteins found in food samples.

You will learn how to test for the presence of proteins using Biuret reagent, to test for the presence of monosaccharides using Benedict's solution, to test for the presence of starches using Lugol's solution, and to test for the presence of lipids using Sudan III.

Once familiar with the detection techniques, you will apply these techniques to a slurry ("McMush") that has been made by blending the edible portions of a complete children's hamburger meal. Using the skills that you have developed, you should be able to determine which organic compounds are present in the slurry.

Materials

Each lab group will need the following:

- aprons
- beaker, 250 mL
- 2 clamps, test tube
- goggles
- graduated cylinder, 50 mL
- paper towels
- test tube brush
- test tube rack, jumbo
- glove, disposable
- marker, Sharpie®
- glucose solution
- iodine-potassium iodide solution in dropper bottle
- McMush slurry
- Sudan III in dropper bottle
- Benedict's solution in dropper bottle
- Biuret's reagent in dropper bottle
- gelatin, solution
- starch solution
- 2 test tubes, jumbo
- oil, vegetable

SAFETY ALERT!

- » Goggles and aprons should be worn at all times during this investigation.
- » Point test tubes away from individuals when heating samples.
- » Always handle hot test tubes with test tube holders.

Procedure

Part I: Testing for Monosaccharides

Benedict's solution can be used to detect the presence of monosaccharides. In the presence of a monosaccharide like glucose, Benedict's solution will change color from blue to orange when heated.

1. Place 5 mL of the glucose solution into a clean test tube.
2. Add 3 mL of Benedict's solution.
3. Using a test tube holder, place the tube in a beaker of boiling water and boil for 5 minutes or until a color change to orange occurs.
4. Record the color of the solution and your results for the glucose test in Table 1. Save your test tube for comparison.
5. Place 5 mL of the hamburger meal slurry into another clean test tube. Repeat Step 2 and Step 3, and record your results in Table 2.

Part II: Testing for Starches

Lugol's solution can be used to test for the presence of polysaccharides or starch. In the presence of starch, Lugol's solution will change color from amber to a dark blue.

1. Place 5 mL of the starch solution into a clean test tube.
2. Add 5 drops of Lugol's solution. Observe the change in color.
3. Record the color of the solution and your results for the starch test in Table 1. Save your test tube for comparison.
4. Place 5 mL of the hamburger meal slurry in another clean test tube. Repeat Step 2 and Step 3, and record your results in Table 2.

Part III: Testing for Proteins

Biuret's reagent can be used to test for the presence of protein. Biuret's reagent will change color from blue to blue-violet in the presence of protein.

1. Place 5 mL of the gelatin solution into a clean test tube.
2. Add 10 drops of Biuret's reagent. The gelatin is a protein-rich solution and should change color in the presence of protein.
3. Record the color of the solution and your results for the protein test in Table 1. Save your test tube for comparison.
4. Place 5 mL of the hamburger meal slurry in another clean test tube. Repeat Step 2 and Step 3, and record your results in Table 2.

Procedure (continued)

Part IV: Testing for Lipids

Sudan III can be used to detect the presence of lipids. In the presence of a lipid-rich solution and water, Sudan III will diffuse through the solution and produce an orange-pink color.

1. Place 5 mL of water and 5 mL of oil into a clean test tube.
2. Add 5 drops of Sudan III to the test tube. Observe the results.
3. Record the color of the solution and your results for the lipid test in Table 1. Save your test tube for comparison.
4. Place 5 mL of the hamburger meal slurry in another clean test tube. Repeat Step 2 and Step 3, and record your results in Table 2.

Data and Observations

Table 1: Positive Tests Performed on Known Substances		
Test Performed	**Substance Tested**	**Results**
Benedict's solution		
Lugol's solution		
Biuret reagent		
Sudan III		

Table 2: McMush Tests	
Test Performed	**Results**
Benedict's solution	
Lugol's solution	
Biuret reagent	
Sudan III	

Conclusion Questions

1. How are monomers and polymers different?

2. What are the monomers for each of these biomolecules?
   a. Carbohydrates

   b. Lipids

   c. Proteins

3. Circle any of the following compounds that would be classi ed as carbohydrates.

amino acids	triglycerides	glucose	enzymes
fructose	hemoglobin	chitin	starch

4. If you were given an unknown food sample and asked to identify its contents, which test would you use to determine the presence of each of these biomolecules?
   a. Lipids

   b. Proteins

   c. Glucose

   d. Starch

Conclusion Questions (continued)

5. Which biomolecule groups were found in the hamburger meal slurry?

6. What portion of the children's hamburger meal may have provided each of these biomolecules?
   a. Lipids
   b. Proteins
   c. Glucose
   d. Starch

7. Jonathan and Molly performed a similar experiment except that in their lab they tested a slurry made from crackers. Their results show that crackers contain both protein and fat. After checking the cracker package, the students were surprised to nd that protein and fat are not listed on the nutritional label. No other groups in their class have results that show protein and fat present in the sample. Describe three factors that could contribute to their erroneous results.

Conclusion Questions (continued)

8. Predict which biomolecules should be present in the food substances listed in Table 3, and indicate which test you would apply to detect the presence of that biomolecule. You may need to consult additional resources.

Table 3: Testing Food Substances

Food Substance	Predicted Biomolecule	Test to Be Used
Potato juice		
Cracker		
Egg white		
Honey		

9. Design and describe an experiment to test for the presence of carbohydrates, lipids, and proteins in a taco.