McMush Lab
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 significant 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.
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

<table>
<thead>
<tr>
<th>Test Performed</th>
<th>Substance Tested</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benedict’s solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lugol’s solution</td>
<td></td>
<td></td>
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<tr>
<td>Biuret reagent</td>
<td></td>
<td></td>
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<tr>
<td>Sudan III</td>
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<td></td>
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</tbody>
</table>

### Table 2: McMush Tests

<table>
<thead>
<tr>
<th>Test Performed</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benedict’s solution</td>
<td></td>
</tr>
<tr>
<td>Lugol’s solution</td>
<td></td>
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<tr>
<td>Biuret reagent</td>
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<tr>
<td>Sudan III</td>
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</tbody>
</table>
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 classified as carbohydrates.

<table>
<thead>
<tr>
<th>amino acids</th>
<th>triglycerides</th>
<th>glucose</th>
<th>enzymes</th>
</tr>
</thead>
<tbody>
<tr>
<td>fructose</td>
<td>hemoglobin</td>
<td>chitin</td>
<td>starch</td>
</tr>
</tbody>
</table>

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 find 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.
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>
<thead>
<tr>
<th>Food Substance</th>
<th>Predicted Biomolecule</th>
<th>Test to Be Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato juice</td>
<td></td>
<td></td>
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<tr>
<td>Cracker</td>
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<td></td>
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<tr>
<td>Egg white</td>
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<td></td>
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<tr>
<td>Honey</td>
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</tbody>
</table>

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