

McMush Lab

Testing for the Presence of Macromolecules

OBJECTIVE

Students will learn confirmation tests for the presence of glucose, starch, lipids and proteins. Students will then apply the test procedures to a slurry made from a McDonald's Happy Meal to determine the presence of these macromolecules in the sample.

LEVEL

Biology I

NATIONAL STANDARDS

UCP.1, A.1, A.2, B.2, B.3, E.1, E.2, F.1, G.2

TEKS

9(A)

CONNECTIONS TO AP

AP Biology:

I. Molecules and Cells A. Chemistry of Life 2. Organic molecules in organisms

TIME FRAME

90 minutes

MATERIALS

(For a class of 28 working in pairs)

McDonald's Happy Meal™ McMush slurry	64 test tubes (20mm x 150mm)
400 mL gelatin solution	14 50 mL graduated cylinders
400 mL glucose solution	28 test tube holders
400 mL starch solution	blender
56 beakers or plastic cups	hot water bath
14 dropper bottles of Benedict's solution	14 dropper bottles of Biuret Reagent
14 dropper bottles of Lugol's iodine	14 dropper bottles of Sudan III
400 mL vegetable oil	

TEACHER NOTES

Preparation of solutions

Gelatin solution – Dissolve 4 g gelatin in 396 mL distilled water. Refrigerate until needed.

Glucose solution – Mix 20 g glucose (or dextrose) with 380 mL of distilled water.

Starch solution – Add 4 g of cornstarch to 396 mL of 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 five.

McMush Slurry – Unwrap and place the entire contents of a Happy Meal into the blender, including the drink. Ask for a regular drink rather than a diet drink when purchasing your Happy Meal. In fact, a clear drink like Sprite is recommended since it will not interfere with the color indicating tests. Blend thoroughly. Add 250 mL of distilled water to make the solution thin enough to be poured into the test tubes.

Benedict’s Solution, Biuret reagent and Lugol’s solution can be purchased from science suppliers and should be placed into dropper bottles for each lab group.

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

It is possible to divide this lab over several class periods. You could present prelab information about the structure and function of a particular group of macromolecules and then move to the laboratory to perform the test for that group. The following day you could address a second macromolecule group, and so on. If this lab is going to be done over a series of days, you will need to refrigerate the gelatin solution and the McMush slurry.

POSSIBLE ANSWERS TO THE CONCLUSION QUESTION AND SAMPLE DATA

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

Data Table 2: McMush Tests	
Test Performed	Results
Benedict’s Test	Positive if you used a regular (not diet) drink
Lugol’s Test	Positive
Biuret Test	Positive
Sudan III	Positive

- How are monomers and polymers different?
 - Monomers are the smaller building blocks of the larger polymers.
- What are the monomers for each of these macromolecules?
 - Carbohydrates - monosaccharide
 - Lipids - glycerol & fatty acids
 - Proteins - amino acids

3. Circle any of the following compounds that would be classified as carbohydrates.
- a. amino acids
 - b. triglycerides
 - c. glucose
 - d. enzymes
 - e. fructose
 - f. hemoglobin
 - g. chitin
 - h. 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
- a. Lipids - Sudan III
 - b. Proteins - Biuret's reagent
 - c. Glucose - Benedict's test
 - d. Starch - Lugol's test
5. Which macromolecule groups were found in the McMush slurry?
- Carbohydrates, lipids, proteins
6. What portion of the Happy Meal may have provided each of these macromolecules?
- a. Lipids - oil from fries
 - b. Protein - hamburger patty
 - c. Glucose - drink, if not a diet drink
 - d. Starch - hamburger bun
7. Jonathan and Molly performed a similar lab except they tested a slurry made from crackers. Their results show that the crackers contain both protein and fat. After checking the packaging for the crackers, 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:
- Inaccurate measurement
 - Improper heating
 - Contamination
8. Predict which macromolecules should be present in the following food substances and indicate which test you would apply in order to detect the presence of that macromolecule. You may need to consult additional resources.

Food Substance	Predicted Macromolecule	Test to be used
a. Potato juice	Starch	Lugol's
b. Cracker	Starch	Lugol's
c. Egg white	Protein	Biuret's
d. Honey	Glucose	Benedict's

9. Design and describe an experiment to test for the presence of carbohydrates, lipids, and proteins in a taco.
- Press for good experimental design in the answers to question 9. 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.

REFERENCES

Bob Heun. “Re: Lab Tips at Teacher’s Corner AP Central”
3/15/01 <http://apcentral.collegeboard.com/members/article/1,3046,151-165-0-3895,00.html>

Biology Laboratory Manual. Prentice Hall. Englewood Cliffs. 1991

McMush Lab

Testing for the Presence of Macromolecules

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

Simple carbohydrates are made of carbon, hydrogen and oxygen atoms in a 1:2:1 ratio. This 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 are also made of carbon, hydrogen and oxygen but the ratio of carbon, hydrogen, and oxygen is not 1:2:1. Instead, lipids have a much higher number of carbons and hydrogens 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. This 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 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, while those found in plants are referred to as oils, which are liquids at room temperature. Fats and oils are triglycerides, which 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 makes phospholipid molecules have both hydrophilic and hydrophobic regions. This feature makes phospholipids an ideal structural component of the plasma membrane of cells. Steroids are another significant group of lipids. They differ in structure because the carbon atoms are arranged in four rings. Examples of steroids include cholesterol, estrogen, testosterone and morphine.

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

PURPOSE

This lab activity provides an opportunity for the development of skills involved in chemically testing for the presence of the carbohydrates, lipids and proteins found in food samples. You will learn how to test for the presence of proteins using the Biuret test, to test for the presence of monosaccharides using the

Benedict's test, to test for the presence of starches using Lugol's solution and to detect the presence of lipids using Sudan III. Once familiar with the detection techniques, you will apply those techniques to a slurry that has been made by blending a complete Happy Meal™. Using the skills that you have developed you should be able to determine which organic compounds are present in the slurry.

MATERIALS

McDonald's Happy Meal™ McMush slurry	6-8 test tubes
gelatin solution	50 mL graduated cylinder
glucose solution	2 test tube holders
starch solution	hot water bath
vegetable oil	Biuret Reagent in dropper bottle
2 beakers or plastic cups	Sudan III in dropper bottle
Benedict's solution in dropper bottle	

Safety Alert

1. Goggles and aprons should be worn at all times during this lab investigation.
2. Point test tubes away from all people when heating samples.
3. Handle hot test tubes with test tube clamps.

PROCEDURE

PART I: TESTING FOR MONOSACCHARIDES

1. 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. Place 5 mL of the glucose solution into your 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 five minutes or until a color change to orange occurs.
4. Record the color of the solution in Data Table 1.
5. Rinse out your test tube and record your results for the glucose test in Data Table 1.

PART II: TESTING FOR STARCHES

1. Lugol's solution can be used to test for the presence of the polysaccharide or starch. In the presence of starch, the Lugol's solution will change color from amber to a dark blue. Place 5 mL of the starch solution into your test tube.
2. Add 5 drops of Lugol's iodine solution. Observe the change in color.

5 *McMush Lab*

3. Rinse out your test tube and record your results for the starch test in Data Table 1.

PART III: TESTING FOR PROTEINS

1. Biuret's reagent can be used to test for the presence of protein. Place 5 mL of the gelatin solution into your test tube.
2. Add 10 drops of Biuret's reagent. The gelatin is a protein-rich solution and will test positive for the presence of protein. Biuret's reagent will change color from blue to blue-violet in the presence of protein.
3. Rinse out your test tube and record your results for the protein test in Data Table 1.

PART IV: TESTING FOR LIPIDS

1. 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 producing an orange-pink color. Add 5 mL of water and 5 mL of oil to a clean test tube.
2. Add 5 drops of Sudan III to the test tube. Observe the results.
3. Rinse out your test tube and record your results for the lipid test in Data Table 1.

PART V: TESTING THE M^CMUSH SLURRY OF UNKNOWNNS

1. Using the Benedict's solution test and the procedure described in Part I, determine whether or not the McMush slurry contains any monosaccharides and record your findings in Data Table 2.
2. Using the Lugol's solution and the procedure described in Part II, determine whether or not the McMush slurry contains starch. Record your findings in Data Table 2.
3. Using the Biuret's test for protein and the procedure described in Part III, test the McMush slurry to determine whether or not protein is present. Record your findings in Data Table 2.
4. Using the Sudan III test and the procedure described in Part IV, determine whether or not the McMush slurry contains lipids. Record your findings in Data Table 2.

Name _____

Period _____

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DATA AND OBSERVATIONS

Data Table 1: Positive Tests Performed on Knowns		
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Lugol's Test		
Biuret Test		
Sudan III		

Data Table 2: McMush Tests	
Test Performed	Results
Benedict's Test	
Lugol's Test	
Biuret Test	
Sudan III	

CONCLUSION QUESTIONS

- How are monomers and polymers different?
- What are the monomers for each of these macromolecules?
 - Carbohydrates- _____
 - Lipids- _____
 - Proteins- _____
- Circle any of the following compounds that would be classified as carbohydrates.

a. amino acids	e. fructose
b. triglycerides	f. hemoglobin
c. glucose	g. chitin
d. enzymes	h. starch

5 *McMush Lab*

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
- a. Lipids- _____
 - b. Proteins- _____
 - c. Glucose- _____
 - d. Starch- _____

5. Which macromolecule groups were found in the McMush slurry?

6. What portion of the Happy Meal may have provided each of these macromolecules?
- a. Lipids- _____
 - b. Proteins- _____
 - c. Glucose- _____
 - d. Starch- _____

7. Jonathan and Molly performed a similar lab 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:

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Food Substance	Predicted Macromolecule	Test to be used
a. Potato juice		
b. Cracker		
c. Egg white		
d. Honey		

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