Name: ____________________
Date: ____________________

Poisoned Appreciation

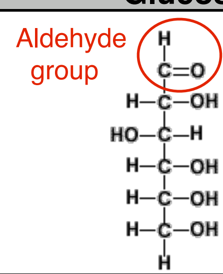
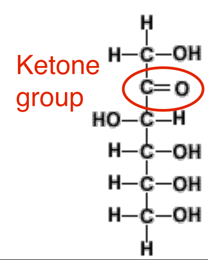
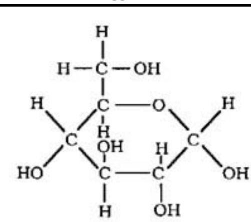
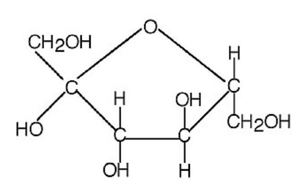
Time required: two or more 50-minute periods

The annual Teacher's Appreciation Luncheon has become a cautionary tale after one teacher died and four teachers came down with suspected food poisoning. Stomach contents from the teacher who died contained simple (reducing) sugars, protein, and fat. Those affected complained of diarrhea, nausea, and vomiting. You are a forensic scientist at the local health department. You have been assigned the task of interviewing the surviving teachers and analyzing samples of food from the luncheon to determine which organic molecules (reducing sugars, starch, protein, and/or fat) they contain. In this activity you will explore the chemical and structural formulas of these organic molecules and build a series of molecular models. You will analyze the results of chemical tests to determine the content of each of the luncheon food samples. It is your responsibility to determine which food at the luncheon was poisoned.

Part 1 - Reducing Sugars

A reducing sugar is a sugar that acts as a reducing agent by donating electrons to another molecule. A carbohydrate that contains a free aldehyde or ketone group can act as a reducing sugar. The simplest form of carbohydrate is a monosaccharide. All monosaccharides are reducing sugars and exist in solution as an equilibrium mixture of straight-chain and closed-ring (or cyclic) structures.

Table 1 - Monosaccharides

Monosaccharide	Glucose	Fructose
straight-chain structure		
closed-ring structure		

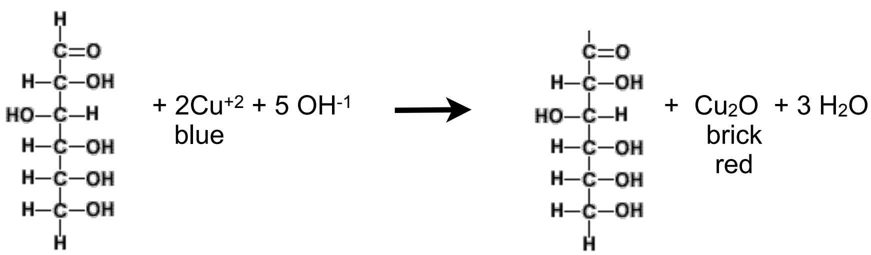
Monosaccharides consist of the elements carbon, hydrogen and oxygen. Carbon atom models are black; hydrogen atom models are white, and oxygen atom models are red.

The black links are used for C-C and C-O bonds. Use the short gray links to connect hydrogen atoms to the molecule. Use two long gray bonds to form a double bond. Build the straight-chain structures for glucose and fructose. Identify the aldehyde and ketone groups.

Instructor's approval ____

Benedict's solution is an indicator that can be used to test for a reducing sugar. In the presence of a reducing sugar, the blue copper(II) in the Benedict's solution is reduced to copper(I), a brick red solution. This is a positive test.

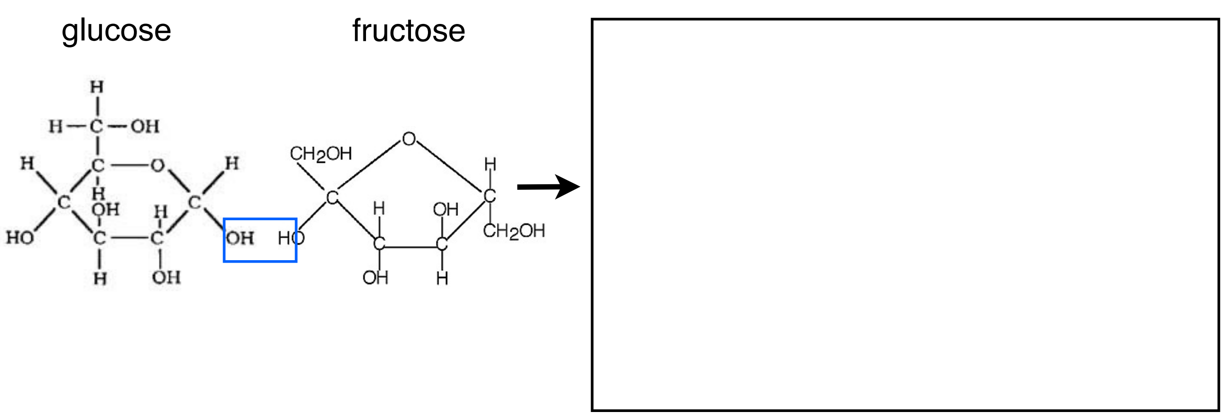
Figure 1 - Reaction of Reducing Sugar and Benedict's Solution



Convert the straight-chain structures of glucose and fructose to closed-ring structures.

Two monosaccharide sugar molecules can join together chemically, forming a larger carbohydrate molecule called a double sugar, or disaccharide. The prefix "di-" means two. By chemically joining a glucose molecule with a fructose molecule, a double sugar called sucrose and a water molecule are produced. This type of reaction is known as dehydration synthesis, which means to put together while losing water.

Figure 2 - Formation of a Disaccharide

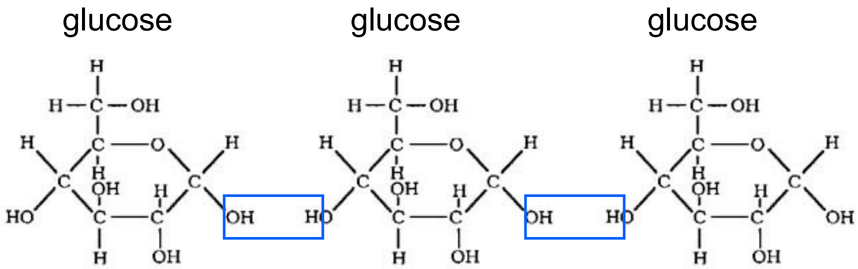


In order to join the molecules, remove an -OH end from one molecule and an -H end from another. Draw the structural formulas of the products, sucrose and water, in the box in Figure 2. Sucrose does not have a free aldehyde or ketone group and does not react with Benedict's solution. Other disaccharides, such as lactose and maltose, are reducing sugars and show a positive test with Benedict's solution.

Part 2 - Starch

Just as disaccharides are made from two monosaccharides using a dehydration synthesis reaction, polysaccharides and water are produced when many monosaccharides are chemically joined together. Build the 3 glucose molecules shown in Figure 3. Construct a portion of a starch molecule by joining the glucose molecules. This will represent only a small part of a starch molecule because starch consists of hundreds of glucose molecules that wrap to form a helical coil.

Figure 3 - Formation of Starch

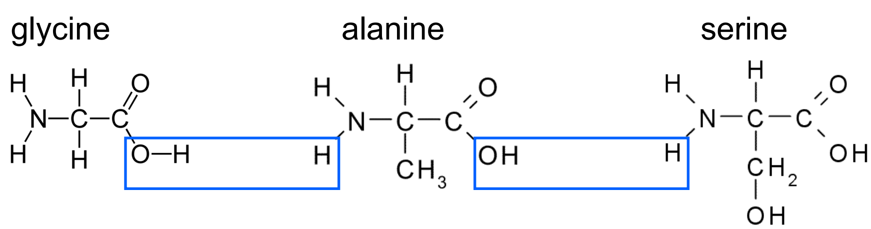


An iodine solution is used as an indicator for starch because it reacts, turning a dark-blue/black color. Iodine atoms fit into the helical coil of the starch molecule, creating a charge-transfer complex and producing the dark blue/black color.

Part 3 - Protein

Proteins are large biomolecules, or macromolecules, consisting of one or more long chains of amino acids. Amino acids contain carbon (C), hydrogen (H), oxygen (O), and nitrogen (N), and some contain sulfur (S). The nitrogen atom model is blue. Build the three amino acids shown in Figure 4.

Figure 4 - Formation of a Protein



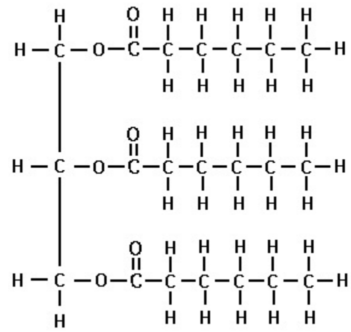
The amino acids are joined by strong, covalent peptide bonds that form by dehydration synthesis. Construct a small part of a protein molecule by joining the amino acids.

The Biuret test detects the presence of proteins. The blue Biuret solution is composed of potassium hydroxide and copper(II) sulfate. If proteins are detected, they must have at least three amino acids, which means that the protein must have at least two peptide bonds. The copper ions, with a charge of +2, are reduced to a charge of +1 in the presence of peptide bonds, causing the color to change from blue to violet. This is a positive test.

Part 4 - Fat

Lipids are a diverse group of chemical compounds that are related by their insolubility in water. One group of lipids, the triglycerides, contains the fats and oils. A fat is a saturated triglyceride, containing only single C-C bonds. Fats are solids at room temperature.

Build the saturated triglyceride (fat) shown in Figure 5.

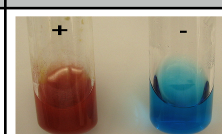
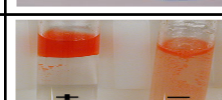


Triglyceride-Saturated

Figure 5

A simple test for fats and oils is based on their ability to produce translucent grease-marks on unglazed paper. Sudan IV can also be used to test for fats and oils. When Sudan IV (red) is added to a mixture of lipids and water, the dye will dissolve in the lipid layer, coloring it red. This is a positive test. When lipids are not present in the mixture, the Sudan IV molecules will form spherical aggregates and disperse throughout the solution.

You can determine whether specific organic compounds are present in a food sample by comparing the color change an indicator produces in the food sample with the change it produces in a sample of known composition. The color changes observed when samples of known composition were tested with the indicators are recorded in Table 2.

Organic Molecule	Indicator Used	Positive Result	Negative Result	Picture of Results
Reducing Sugar	Benedict's Solution	green, yellow, orange or brick red	blue	
Starch	Iodine Solution	black or dark blue	yellow, or orange	
Protein	Biuret Solution	violet	blue	
Fat	Sudan IV	red-orange ring	no ring	
	Brown Paper	translucent	opaque	

You have been assigned the task of analyzing the luncheon food samples to determine which organic molecules they contain. To determine which of the organic molecules are present in the food samples, use your analytical skills and Table 2. The food samples may contain one or a combination of organic molecules. Record the name of the organic molecules (reducing sugars, starch, protein, and/or fat) present in each food sample in the last column of Table 3.

Food Sample	Benedict's Test	Iodine (IKI) Test	Biuret Test	Sudan IV/ Paper Test	Organic Molecule(s)
pizza	orange	dark blue	violet	red-orange ring/ translucent	
bread/buns	orange	dark blue	blue	no ring/opaque	
tuna	blue	yellow	violet	red-orange ring/ translucent	
milk	green	blue	blue	no ring/opaque	
baked beans	orange	dark blue	violet	no ring/opaque	
apple juice	orange	yellow	blue	no ring/opaque	
peanut butter	green	blue	violet	red-orange ring/ translucent	
banana	yellow	dark blue	blue	no ring/opaque	
potato chip	green	dark blue	blue	red-orange ring/ translucent	
ground beef	blue	yellow	violet	red-orange ring/ translucent	
soda	blue	yellow	blue	no ring/opaque	

Answer each of the following questions.

1. Stomach contents from the teacher who died contained simple (reducing) sugars, protein, and fat. Name the type of organic molecule that was not present in the stomach contents.____

2. Which foods from Table 3 were probably not eaten by the teacher who died?

____

Notes From Teacher Interviews

Name of Teacher	Notes From Interview	Did this teacher experience food poisoning?

3. From the teacher interviews, which foods could be eliminated as the cause of the food poisonings?

____

____

4. Using your analytical skills as a forensic scientist, the results from the analysis of the luncheon food samples, and the teacher interviews, determine which food at the luncheon was poisoned. Explain the reasoning for your answer.

____

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5. Vegans don't use or consume any animals or animal products including milk, eggs, or honey. One of the teachers who did not have food poisoning ate only vegan foods, plant-derived foods. List the food samples in Table 3 that a vegan could eat as a source of protein? ____

Teacher's Key

The goal of this lesson is to engage students in the analysis of information, allowing them to arrive at conclusions. During the activity, students will apply their newly acquired knowledge of organic molecules to identify the food responsible for an mysterious food poisoning that lead to the death of a teacher.

It may be more interesting for the students if you adapt this activity to your own school. Have faculty members read their interview card and simulate an interview with your students.

Name of Teacher _______________
Since I am vegan, I eat only plant-derived foods. I ate a peanut butter sandwich, potato chips, a banana, and apple juice. I enjoyed the luncheon and did not get sick.

Name of Teacher _______________
I am on a high protein and low carbohydrate diet. I became ill about 3 hours after the luncheon. My symptoms included nausea, vomiting and diarrhea. It was hard to breath.

Name of Teacher _______________
I had a hamburger, potato chips, and milk. After the luncheon, I taught 2 more classes. When I heard about the poisonings, I went to the hospital to check on my friends.

Name of Teacher _______________
I am lactose intolerant. I ate a tuna sandwich, baked beans, potato chips, a banana, and soda. I suffered from nausea, hives, and itching. I was so sick that I could not drive home.

Name of Teacher _______________
I had stomach cramps and red skin on my face and body. I had to be taken to the hospital. I have diabetes. I tried to avoid sweets and starchy foods at the luncheon.

Name of Teacher _______________
Fortunately, I wasn't very hungry at the luncheon. I ate a piece of pizza and some soda. I didn't get sick.

Name of Teacher _______________
I sampled a little bit of everything. I had stomach cramps, nausea, wheezing and tightness in the chest. The doctor began an IV to help replenish lost fluids.

Answers for Table 3

Food Sample	Benedict's Test	Iodine (IKI) Test	Biuret Test	Sudan IV/ Paper Test	Organic Molecule(s)
pizza	orange	dark blue	violet	red-orange ring/ translucent	reducing sugars, starch, protein, and fat
bread/buns	orange	dark blue	blue	no ring/opaque	reducing sugars and starch
tuna	blue	yellow	violet	red-orange ring/ translucent	protein and fat
milk	green	yellow	violet	no ring/opaque	reducing sugars and protein
baked beans	orange	dark blue	violet	no ring/opaque	reducing sugars, starch, and protein
apple juice	orange	yellow	blue	no ring/opaque	reducing sugars
peanut butter	green	blue	violet	red-orange ring/ translucent	reducing sugars, protein, fat
banana	yellow	dark blue	blue	no ring/opaque	reducing sugars and starch
potato chip	green	dark blue	blue	red-orange ring/ translucent	reducing sugars, starch, and fat
ground beef	blue	yellow	violet	red-orange ring/ translucent	protein and fat
soda	blue	yellow	blue	no ring/opaque	none

Answers to questions.

1. Stomach contents from the teacher who died contained simple (reducing) sugars, protein, and fat. Name the type of organic molecule that was not present in the stomach contents. (starch)

2. Which foods from Table 3 were probably not eaten by the teacher who died? (pizza, bread, beans, peanut butter, banana, potato chips)

3. From the teacher interviews, which foods could be eliminated as the cause of the food poisonings? (pizza, bread, milk, apple juice, peanut butter, banana, potato chips, ground beef, and soda)

4. Using your analytical skills as a forensic scientist, the results from the analysis of the luncheon food samples, and the teacher interviews, determine which food at the luncheon was poisoned. (Nine of the foods were eliminated by the teacher interviews. Only the baked beans and tuna were possible sources of the food poisoning. The baked beans were not eaten by the teacher who died because her stomach contents did not contained starch. The tuna had to be the source of the food poisoning.)

5. Vegans don't use or consume any animals or animal products including milk, eggs, or honey. One of the teachers who did not have food poisoning ate only vegan foods, plant-derived foods. List the food samples in Table 3 that a vegan could eat as a source of protein? (baked beans and peanut butter)

For Your Information
Scombroid poisoning usually occurs from large, dark meat fish such as tuna. Because this poison develops after a fish is caught and dies, it does not matter where the fish is caught. The main factor is how long the fish sits out before being refrigerated or frozen. The harmful substances that cause Scombroid poisonings are heat stable, so no amount of cooking will prevent you from becoming poisoned if you eat contaminated fish. Scombroid poisoning symptoms usually occur immediately after eating the fish. They may include breathing problems, including wheezing and chest tightness, extremely red skin on the face and body, flushing, hives and itching, nausea, peppery or bitter taste, and vomiting.

A patient with Scombroid poisoning may receive: airway support, including oxygen, breathing tube through the mouth (intubation), breathing machine (ventilator), fluids by IV, medicines to stop vomiting, and medicines to treat severe allergic reactions. Scombroid poisoning symptoms usually only last for a few hours after medical treatment has begun. Only very rarely have serious outcomes or death occurred.

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