COC Biotechnology Program Module 6

Organic Macro-Molecules (OMMs), the foods you eat: VERSION B

- ✓ Food is big money. We pay billions to market and consume it. Billions to loose the excess weight. Billions to make food more nutritious. Despite these efforts, every year Americans become more overweight and spend more on diet plans. From genetically engineered foods to understanding the nutritional label on over priced, over salty, fatty snack food, OMMs are central.
- ✓ You will learn to diagram and model the crucial parts of OMMs called functional groups. These functional groups will help you to grasp a number of basic properties about OMMs. For instance, why does sugar dissolve in water and fats do not? How can fat from the fryer help to power a diesel engine in a car?
- ✓ Once you understand these functional groups you will conduct a series of tests to identify the foods that have large amounts of OMMs (fats, carbohydrates and proteins).
- ✓ Using these simple tests, you will assess an unknown food items for its OMM composition. Using deductive and inductive reasoning you will identify you unknown food by examining its nutritional composition.
- ✓ These tests are used by the Food and Drug Administration (FDA) when determining the composition of foods. This information is then listed on the nutritional label located on the container the item came in.
- ✓ Strive to understand the process of inductive and deductive reasoning implied in the analysis of the unknown food item. This skill of using tests to suggest or deny a particular food item may seem simplistic, but is at the heart of the scientific process. Simply put, this skill will help earn you an income!

Did you know that rigorous science training would make you more competitive for ANY type of job? Employers know that students who can tackle hard science will do well with almost ANY challenges presented them. For information on biotechnology and other robust science courses, contact: Jim Wolf, College of the Canyons Biotechnology Director at (661)362-3092 or email: jim.wolf@canyons.edu
GOT SCIENCE? GET AHEAD!

OBJECTIVES: When you have completed this topic, you should be able to:
1. Define and diagram various functional groups and indicate the functional group or groups common in: fats, carbohydrates, sugars and proteins.
2. Distinguish organic from inorganic matter and link this idea with caloric value.
3. Describe how to carry out a simple laboratory test for a sugars, polysaccharides, proteins, and fats.
4. Using these tests, identify an unknown food item by deductive and inductive reasoning.
5. Assess nutritional labels to determine various information relating to food and caloric composition.

INTRODUCTION: As you might imagine, this lab can cover a wide range of topics. In order to get the most information out of this lab, read the following information and them complete the homework at the END of this lab. Then bring the completed homework with you to class and be prepared for a possible quiz on the below introductory material as well as the homework.

ELEMENTS:
An element is a particular type of atom that is different from the atoms of all the other elements. It is the simplest form a matter and can not be broken down by chemical or biological means. The only way you can change an element is to have it undergo a nuclear reaction! The elements most abundant in living organisms are:

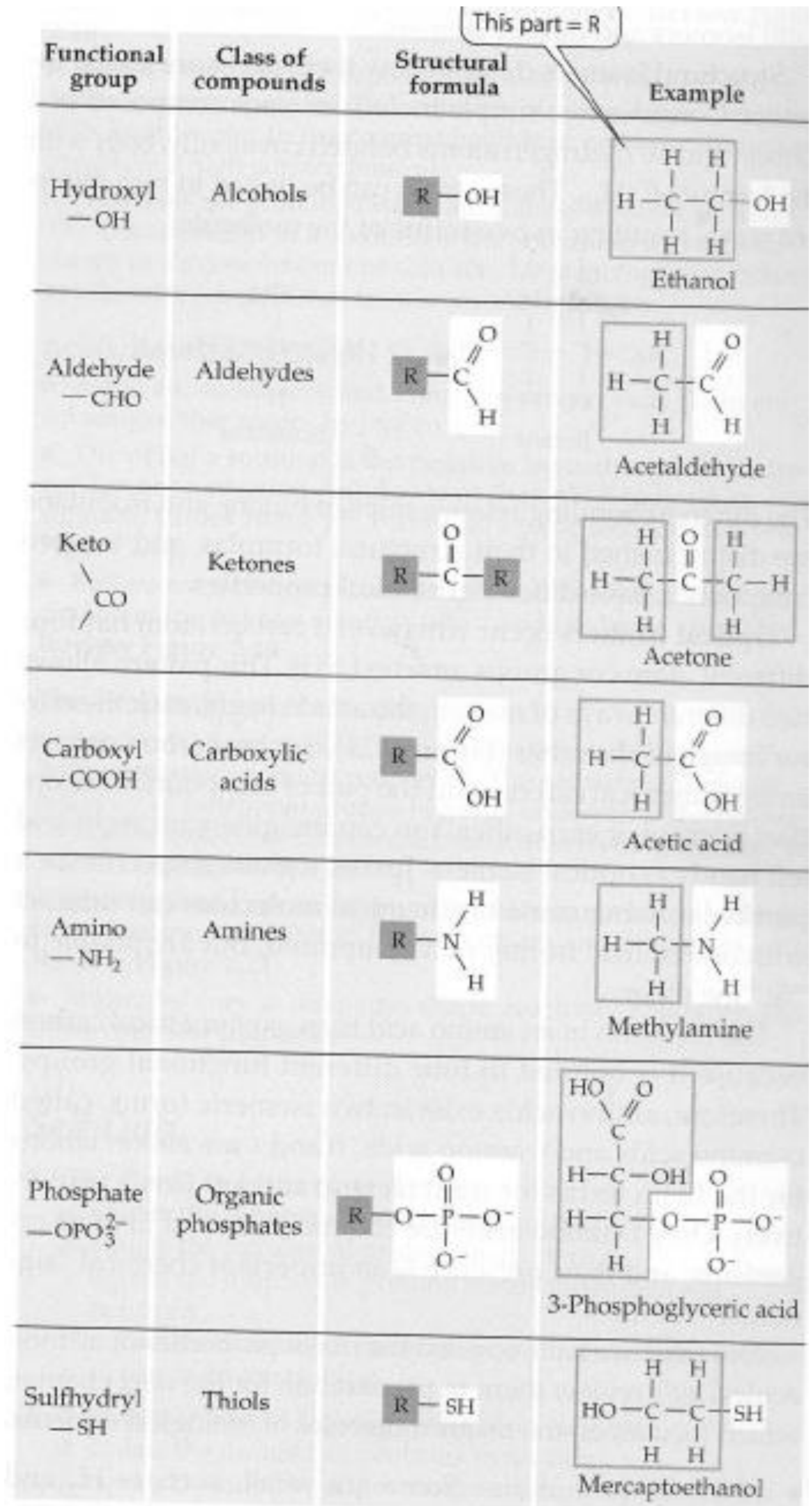
Carbon= C	Nitrogen= N	Calcium = Ca	Potassium = K
Hydrogen= H	Sulfur = S	Iron= Fe	Chlorine = Cl
Oxygen= O	Phosphorus= P	Sodium = Na	Magnesium = Mg

96% of the body is made from C,H,O,N. When elements are put together into a specific structure, with a characteristic role or function they are called functional groups.

FUNCTIONAL GROUPS:
Functional groups are small groups of atoms that combine some of the above listed elements in very common ways. In the realm of biology, there about 2 dozen functional groups. If you understand these functional groups, you are will on your way to understanding the molecular basis for a variety of biological phenomena. One way is to think of functional groups are like wood and hardware. Most of a biological molecule is made of carbon and is analogous to a piece of wood. One piece not much different than the other. Once you start to add hardware to the wood, it begins to take on a certain appearance and from this appearance you can deduce a lot regarding its possible role. For instance, if you take a piece of wood and attach some screws and nails, it will begin got look like part of larger item perhaps suggesting some structure like a box or door frame. If you add some hinges, it could look like a door. A handle or lock could suggest what type of door it is. The nails, screws, hinges, locks and knobs are all like functional groups, each one giving the carbon skeleton (wood) a specific functional role. When this thinking is applied to molecules it helps biologist predict the properties of many molecules simply by looking at the distribution and abundance of functional groups.

Below are some example functional groups in both name, chemical shorthand and chemical drawing. Please note that
a chemical diagram more accurately shows the structure versus the easy to type/write chemical shorthand. Also note that R means any other carbon compound. It can mean a single carbon or along chain. When you compare an aldehyde versus a ketone the carbon with the oxygen is at the end of a carbon chain in the aldehyde and in the middle of the chain in the case of the ketone.

Some common functional groups seen in organic macromolecules (OMMs):



Confused? Well the exercises at the end of the lab will help clarify things. Using 4 different colored gumdrops for the 4 common elements in OMMS consider the following list of chemicals and the accompanying shorthand. You should then draw a two dimensional representation and ultimately create a 3-D model of the molecule using the gumdrops and toothpicks. NOTE: This assignment is on the last pages of this lab to help you remove them and turn them in and or work with them as directed by your teacher.
For example Consider water. It formula is the familiar H20. It 2-D looks like this : H--O--H. The 3-D structure looks like a Mickey Mouse head with the large oxygen and the two smaller hydrogen atoms making up the ears.

Table 1: Foods, functional groups and the tests for functional groups.

Food:	Food/Functional Group(s)	Tests	Comments;
Meat	Proteins/Amino acids	Biurets	Many meats also have fats.
Sugars	Sweets/alcohols/ketones/aldehyde	Benedicts	Only tests for certain sugar types.
Starches	Complex carbs. (bread, pasta, etc.)	Iodine	Checks for all carbohydrates
Fats	Oils, lard, margarine (C---H)	Sudan 4	Unfortunately . ..fats make it into many other foods (snacks, soup, etc)
Foods .	Anything with calories	Char Test	Food with calories will char (turn black) and others (salt, baking soda . . etc.) will not char and has no calories.

Diagnostic Tests for OMM's: Demonstrations:

Your instructor will demonstrate 2 test commonly conducted tests on food items. After viewing these tests and recording their results/significant you will then conduct three additional tests on example foods. Once you are familiar with these three new tests you will be given an unknown food and asked to determine what is it based on test results on the food.

5 common food (functional groups) diagnostic tests.

1. Organic and Inorganic Compounds: The Char Test (Background)

Chemical compounds are either organic or inorganic. Before the days of modern chemistry, an organic compound would have been defined as one produced only by living organisms. As organic chemistry developed, however, it became possible to synthesize many organic compounds from inorganic substances. For instance, certain "look alike" substances such as Olestra and Nutra Sweet have been produced in the lab as a molecular calorie free equivalents of sugars (Nutra Sweet) and fats (Olestra). Organic chemists have been able to synthesize a range of diverse organic compounds such as hormones, enzymes, and nucleic acids. How then can we define organic compound today? For one thing, all organic compounds contain carbon, but some inorganic compounds also contain carbon. In organic compounds, however, the carbon atoms in the molecule are in the form of rings or chains and the molecule is quite large, as a rule. Some organic molecules contain thousands of atoms. Inorganic compounds with carbon, on the other hand, have molecules in which the number of carbon atoms is usually small and the size of the molecule is not large. Another way of identifying organic versus inorganic molecules is that organic molecules usually have calories and most in-organics do not have calories. The charring reaction is one way to demonstrate the presence of organic carbon in some organic molecules. **<u>This reaction is all too familiar to cooks who allow food to get too hot on the stove or in the oven</u>**. Some liquid organic compounds will not leave a char, but will vaporize and the carbon is given off as carbon dioxide. None of these will be included in the substances to be demonstrated, however testing the gas given off for the presence of carbon dioxide can recognize these compounds. Some inorganic compounds, such as water, also will vaporize when heated, but the vapor will not contain carbon dioxide. Some inorganic substances may react to the heat and leave a residue, but it will not be black carbon. A final note: if upon heating no residue or a clear/white residue usually indicates an inorganic compound (no calories) and black indicates an organic (calories). Yes it is a bit confusing, but there are clear patterns and with a little research you will be well versed in the material.

<u>1. CHAR TEST PROCEDURE: NOTE. Your instructor will demonstrate this test. Ask instructor for details!</u>

1. The following items will be placed on a metal spatula, so remember to note what items is placed where:
egg white, table sugar, table salt, sodium bicarbonate (baking soda), gelatin.
2. Place a small amount (even a drop is too much, just touch the tip of the dropper onto the slide) of the substances on a metal spatula. You can test two or three substances on one metal spatula if you can remember what each one is. Remember, a <u>small</u> drop will help avoid having the samples smearing into each other while being heated. For the first example test the following five compounds: egg white, table sugar, table salt, sodium bicarbonate, gelatin and record their results in table A at the end of the lab exercise.
3. Have your instructor use the ignition source to ignite the candle. Hold the spatula well above the flame at first so as to heat the spatula gradually and rapid boiling and possible splashing. Keep the spatula moving and as it heats up, you can bring the spatula closer to the Bunsen burner. Heat until everything is dry. Remember, <u>clear does not mean dry</u>. There should be either no residue, white or brown, or black residue and be persistent when heating samples that do not change into the previously noted colors.
<u>4. DO NOT TOUCH SPATULA</u>. Place spatula onto lab top to cool and not the resulting color.
5. Record the results on Table A towards the end of this handout (page 10).
6. Use the pumace stone to clean off the residue off of the spatula. Use care the spatula may be hot!

<u>Identification of Biological Molecules: Tests 2-5</u>

Molecules of a certain class have similar chemical properties because they have the same functional groups.. A chemical test that is sensitive to these groups can be used to identify molecules that are in that class (sugars verse proteins, etc). Practice the following tests by using them to see what organic macromolecules (OMMs) various foods contain. (also what functional groups). You will use foods that should or should not have the functional groups based on their chemistry. At the end of this lab is a table of common foods and the molecules they contain. You could also get this information looking at a nutritional label. So a piece of beef jerky should test positive for a Biuret's test for proteins. A Sudan 4 test for milk will be positive for regular or whole mile and negative for fat free milk. As a result, you will get a positive and a negative

Sudan 4 reaction respectively. You will first check for the presence or absence of food groups (functional groups) in the following 3-5 tests. NOTE: This following Benedicts test may be demonstrated by your instructor you may be assigned for you to test!.

2. Reducing and Non-reducing Sugars: The Benedicts Test (Background)

Carbohydrates are polymer of sugars monomers. To put this another way, a carbohydrate (i.e. starch) is made of many small subunits (i.e. sugars). All sugars end in the letters "-ose" to aid in easy identification (i.e. fructose, glucose, sucrose, etc.)
Below are three common functional groups seen some carbohydrates and sugars. Label them, correctly

```
               O                                              R
 R-------C                  R-------O ------H                       C------O
               H                                              R

       _______________      _______________      _________________
```

Certain mono- and disaccharides (commonly known as sugars) can be detected because of if they have an aldehyde groups. Carbohydrates are for the most part also water soluble due to their many hydroxyl groups. The Benedicts test checks for the presence of a reducing sugar which are those sugars that have a free aldehyde group.

2. Benedicts test for reducing sugars: Theory

```
                                           O                                        O

BENEDICT'S REAGENT  +    R ---- C       -----> BENEDICT'S REAGENT  +    R----

       (oxidized form)                     H            (reduced form)              O---H
```

This is a typical oxidation-reduction reaction in which oxidation of the sugar occurs simultaneously with reduction of the Benedicts reagent. Remember that:

REDUCTION means removal of oxygen or addition of hydrogen.
OXIDATION means addition of oxygen or removal of hydrogen.

In this case the sugar gained an oxygen during the reaction, and therefore the sugar underwent oxidation.   Since the sugar underwent oxidation we know that something else must have been reduced. That something is the Benedicts reagent. The Benedicts reaction is more sophisticated than shown, but in the end a copper ion Cu^{+2} gains an electron (recall that reduction means to gain an electron) and turns into a Cu^{+3}.   When copper goes from +2 to +3 it changes color from blue to orange. This is the chemical basis of the color change.
Some disaccharides (e.g. sucrose) and all polysaccharides (e.g. starch and cellulose) are not reducing sugars because they do not have free aldehyde groups.
Your instructor will demonstrate the Benedicts test outlined below.
The procedure is provided to help you to understand the procedure of positive and negative controls. Remember, shortly you will be conducting your own tests and then applying these tests to the investigation of an unknown food, so make sure you understand the procedure.

<u>Benedict's Test Procedure:</u>
<u>The Benedict's test to compare glucose, sucrose and lactose.</u>

- Add 10 drops of glucose to the first tube
- Add 10 drops of sucrose to the second tube
- Add 10 drops of water to the third tube, the control
- Add 10 drops of Benedict's reagent to all 3 tubes and mix
- Heat the tubes for 2 minutes in a boiling water bath
- Remove the tubes and record the colors
- Dispose of solutions in the "Benedict's Waste" bottle

Record your results below (color/sugar type). Not that not all sugars are reducing sugars
Glucose_____ Sucrose______ Water _______

Results:

<u>Record and analyze your results in the *table A at the end of these tests*.</u>

A change from clear blue to red-orange indicates an abundance of reducing sugars. A change to green indicates the presence of a smaller amount of reducing sugar. What was the purpose of tube #3? ______________?

3. Three diagnostic tests that your group will conduct:

Your group will now conduct three additional tests in small groups. In each test, you will be including a substance that does not react in the test to serve as a <u>negative</u> <u>control</u>. A substance known to give a reaction in the test is be also used and is called a <u>positive</u> <u>control</u>. By comparing these two types of tests to an unknown, you can determine if a food item does or does not have a particular group of OMMs (functional groups). It is important that you conduct positive and negative controls as merely conducting the procedure on known compounds does not give you enough information to make an informed decision. Please note, a single test may help you to identify a particular food item, but remember you want to conduct all 3 tests to help eliminate other possible foods. For example, what if you test a blue colored food and it gives you a blue reaction (positive for starch). What would you do? Is the blue from the color from the food or due to a positive reaction for starch? The other tests will help you to narrow the scope of possible answers.

<u>Final Point: Please follow the directions carefully, so that your test results are clear. Record and analyze your results in the *table A at the end of these 3 tests*. These tests will form the basis for further analysis of an unknown to be given to you later in lab, so take good/detailed notes.</u>

<u>Test 3-5: Community Equipment and Personal Equipment.</u>

<u>To quickly complete these labs, you will need to get some items of equipment to work with at your lab station. You will also need to go to one of three stations where the test reagents and other supplies are located:</u>

<u>Get the following items and return to your lab station.</u>

One blue ½ test tube rack
15 test tubes (12 x 100)
One large filter paper circle
4 plastic pipets

China marking pencil
1 metric ruler

<u>Traffic Control Hint!!</u>

- Go to any one of the three below listed stations and complete the tests as directed. Order is not important. Again note: you will need to go to the station to complete the exercise and use equipment both at the individual station and the items collected by you from your lab station.

<u>Test 3: Carbohydrates: </u>Iodine Test for Starch: Background

Some polysaccharides (aka carbohydrates) can be detected because of their specific three-dimensional structure.
Another test, the iodine test, can be used to distinguish starch from mono-, di-, and other polysaccharides. Starch is a polymer of glucose in which the chains are coiled up in a particular way so that they can interact with the iodine molecules to give a distinctive blue-black color. Other polymers, even other polymers of glucose, lack the precise coiled structure of starch and do not give the dark blue color.
<u>The reaction looks something like this:</u>

Iodine in Solution (brown) + starch ----→ starch/iodine complex (dark blue, almost black)

<u>Test 3: Carbohydrates </u>Iodine Test for Starch: Procedure

<u>Iodine Test Procedure:</u>
<u>Items at Iodine Test Station:</u>
Iodine stain
1% starch solution in wash bottle
1% sucrose solution in wash bottle
Water in wash bottle
1 liter waste container

<u>Procedure:</u>

Add 10 drops of starch solution to a tube labeled starch
10 drops of sucrose to a second tube labeled sucrose
10 drops of water to a third tube labeled water
Add 2 drops of iodine solution to each tube and mix

<u>Record and analyze your results in the *table A on page 10 and below*.</u>

A positive test will give a blue-black color. A yellow or brown result is negative.
Dispose of solutions in the "Iodine Waste" bottle.
______ starch ______sucrose ______water

4. Lipids: Sudan Test for Fats and Oils: Background

A fat is a hydrophobic molecule consisting of a glycerol molecule joined to three fatty acids. The important functional groups involved in a fat are the following (name them):

________________ ____________ ____________

COOH H-----C-------H O------H

The hydroxyl groups of the glycerol (label the HYDROXYL functional group above) react with the carboxyl groups of the fatty acids (label the carboxyl group) in a condensation reaction, so these functional groups are not available in the fat itself for a test reaction. Instead, the Sudan 4 Test depends on the detection of the hydrocarbon groups remaining. The colored dye, Sudan, and the hydrocarbon groups are non-polar and stick tightly together in their polar surroundings. This is called hydrophobic expulsion and is the basis for this test. The dye is forced into the non-polar fat as it does not dissolve well in the relatively polar alcohol or water.

Since fats are not soluble in water, extracts of four foods have been made using 95% isopropanol. A fifth sample contains only water and isopropanol is used for the control.

Sudan 4 Test for Fats: Procedure:

Equipment at Lab Stations: Supplies:

Ethanol extracts of margarine, cream, , water, flour, coconut oil.
Large culture dish with water
Small culture dish with Sudan 4.
Small filter papers in small culture dish
Large filter papers cut in ¼ (used for unknowns)
Forceps

Procedure:

- Using a lead pencil, mark a filter paper disc with a "W" (water), "F" (flour), "K" (cream), "C" (coconut), "M" (margarine) so that the letters are fairly equally spaced on the filter paper. Draw a small circle next to each letter. Add your initials. Tear or cut the filter paper into five equal sections.
- Using the appropriate pipette, add a small drop from each sample to the designated circle on the filter paper
- Allow the paper to dry completely (about 5 minutes)
- Soak the paper for three minutes in the Sudan 4 solution
- Rinse the filter paper in the water bath for one minute
- Examine the intensity of orange staining of the five spots

Rate the four foods and water (negative control) as 0 = no color over the filter paper background, + = faint orange color, and the ++ = definite orange color. Record the results below:
_____water _____ flour ____ cream ____coconut ____margarine

What was the purpose of the water spot? Which food had the highest fat content

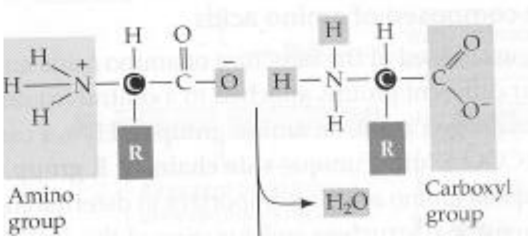
Record and analyze your results in the *table A on page 11.*

5. Biuret Test for Protein: Background

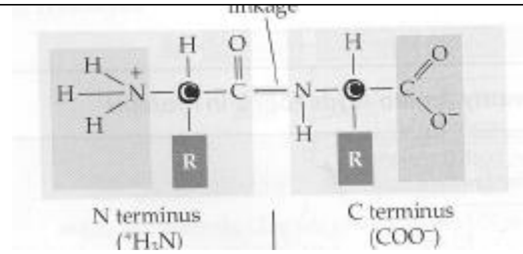
COOH or COO^-	NH_2 or $NH3^+$
Carboxyl group	Amino group

Proteins are polymers of amino acids in which the carboxyl group of one amino acid residue joins head-to-tail with the amino group of another amino acid to form a peptide bond (see below). In this reaction a molecule of water is also formed. Compare the functional groups above with the peptide bond shown below and circle the atoms lost to form the water molecule. In a peptide bond, the bound amino group is nevertheless sufficiently reactive to change the

Biuret reagent from blue to violet. Thus the basis of the test is a subtle interaction between the copper ions specific for the amino group found in the peptide bonds of proteins:



Individual amimo acids join to form…



a dipeptide (start of a protein).

5. Biurets Test for Protein: Procedure:

Equipment at Lab Station:

Chicken soup in wash bottle
Egg white solution
1% Copper sulfate in dropper bottle
0.5 M Sodium hydroxide
Wash bottle with water
Safety goggles
All purpose gloves 2-3 sets per station.
4 liter container to collect waste

You will observe how the blue Biuret reagent reacts in the presence of protein by comparing the amount of protein in egg white with the amount in chicken soup. The solutions contain a serving of egg white or of chicken broth in equivalent volumes.

Procedure:

- Add 10 drops of egg white solution to the first tube
- 10 drops of chicken soup to the second tube
- 10 drops of water to the third tube
- Add 0.5 M sodium hydroxide (NaOH) to the 2 cm mark of each tube and mix. Be careful not to get NaOH on yourself
- Add 2 drops of 1% copper sulfate, the Biuret reagent, to each tube and mix
- Hold the tubes against a white background, note the color of each below and on table A, and page 10.
- Dispose of solutions in the "Biuret Waste" bottle

A color change from blue to violet occurs when copper ions react with the amide bonds, and such a change indicates the presence of proteins. Which food contains more protein? Record your results in table A:

STOP POINT. ONCE YOU HAVE COMPLETED THE 5 TESTS ON THE EXAMPLE SET OF CHEMICALS, YOU CAN STOP FOR THE DAY OR CONTINUE ON AS DIRECTERDS BY YOUR INSTRUCTOR.

TABLE A: Results from 5 chemical tests on foods for functional groups:

These tests will give mostly clear results. If these results are not clear, make note of this. Some results may be presence or absence (i.e. char test) others may be degree (i.e. fats, sugars). Be sure to record any data that seems to be unclear and consult with your colleagues and instructor for help if not sure.

CHAR TEST: Black residue is positive

Code	Substance	Color of Residue?	Carbon present?
P	egg white		
S	table sugar		
T	table salt		
B	sodium bicarbonate		
G	gelatin		

BENEDICT'S TEST: Green to red is positive with varying degrees depending on color intensity.

Tube	Substance	Color?	Reducing Sugar Present?
1	glucose		
2	sucrose		
3	water		

IODINE TEST: Blue to black is positive

Tube	Substance	Color?	Starch Present?
1	starch		
2	sucrose		
3	water		

SUDAN TEST: Orange spot is positive

Code	Substance	Color of Spot?	Fat Present?
W	water		
F	flour		
K	cream		
C	coconut		
M	margarine		

BIURET TEST: Violet is positive

Tube	Substance	Color?	Protein present?
1	egg white		
2	chicken soup		
3	water		

TABLE B: Composition of Foods

Amounts in parentheses are not detected in these tests as the concentration is too low or the substance otherwise interferes with getting a positive result. A "trace" result means that the results will be very faint (if visible at all). The carbohydrate column has information for both the starch test and sugars. Please note that not all sugars are reducing sugars (i.e. sucrose) so consult your text or ask the instructor if not sure.

SUBSTANCE	CALORIES	% PROTEIN	% FATS	%CARBOHYDRATE
corn starch	362	(0.3)	trace	87.6 (starch)
egg white	51	10.9	trace	(0.8)
egg yolk	348	16	30.6	(0.6)
enriched flour	364	(10.5)	(1)	76.1 (starch)
gelatin	335	85.6	(0.1)	0
glucose	335	0	0	91 (glucose)
ground coffee	301	(12.5)	15.4	28.5 (starch)
honey	304	(0.3)	0	82.3 (glucose and fructose)
instant coffee	129	0	0	35 (starch)
maple flavored syrup	299	0	0	77 (glucose and fructose)
potato starch	351	(8)	(0.8)	79.9 (starch)
powdered skim milk	352	35.8	(0.7)	51.6 (lactose)
baking powder	0	0	0	0
table salt	0	0	0	0
table sugar	385	0	0	99.5 (sucrose)
baking soda	0	0	0	0

UNKNOWNS: Your group will receive an unknown food labeled A, B, or C. Artificial colors and odors may have been added to prevent you from simply guessing which food you have. You will have one of the three foods listed under that letter. The composition of these foods are given in Table B. Low levels of components will probably not show up in these tests and are denoted by parenthesis ().

A	B	C
Table Salt	Corn Starch	Instant Coffee
Egg White	Baking Soda	Baking Powder
Enriched Flour	Egg White	Gelatin

1. Record the letter of the unknown.
2. Determine the results you would expect for each possible food in each of the tests you have used.
3. Using part of the unknown for each test, place a small sample in a clean test tube and then test it for reducing sugar, starch, fat, and protein or char. (DO NOT add reagents to the entire original unknown!)
4. Identify your unknown. Save your tests until you have confirmed a correct answer.

RESULTS OF UNKNOWNS

Name ______________________________________ Unknown Number ________________________

Group ______________________________________ Unknown was ___________________________

Possible Unknowns in My Unknown Group (substances listed in group A, B, or C)

Component			
carbohydrate			
fat			
protein			

Actual Results of tests (+/- or unsure)

Test:	Test results (+/- or unclear)	Foods ruled out
Iodine test for starches		
Sudan 4 test for fats		
Biuret's test for proteins		

Homework/lab-work for Organic Macromolecules (OMM) page 1.

Name____________________ Note: read all 3 pages prior to starting work!

Separate this sheet from the other sheets and turn in as directed by your instructor.

Complete the following background information. The text, lecture, lab and common knowledge could all help.

__________________ , __________________, __________________ and __________________ are four elements that combine in many ways to form many of the molecules in organisms. In some organisms, these _______ make up over ______% of the weight of the organism. Other elements are present in organisms, but occur in _______amounts.

Hydrocarbons constitute a large group of __________________ compounds. They contain the elements __________________ and __________________. Often, other atoms, other than carbon or hydrogen, or a group of atoms are substituted on the __________________ molecule. . This substitute group of atoms is called a __________________ group.

The _ group determines the chemical properties of an organic molecule. CH_4 is a gas called __________________. By removing one hydrogen and adding a hydroxyl group
(______), the substance becomes CH_3OH, methyl __________. Although methane was a gas, the new substance, methyl __________________, is a __________________.

As you continue your study of biology, your __________________ of how organisms make __________________ molecules will be extremely important! Your goal in this portion of the lab is that given the molecular _____________ of some compounds found in living things, you will be able to use the bonding potential/patterns of __________________, __________________, __________________, and __________________ to determine the two-dimensional _______________ formulas of the compounds and build three dimensional __________________ of the compounds.

Homework/lab work for Organic Macromolecules (OMM) page 2.

Name____________________ Note: read all 3 pages prior to starting work!

Using colored pencils or elements names draw the chemical and structural formula of the following compounds. Element Symbol Color

Element	Symbol	Color
Carbon	C	
Oxygen	O	
Hydrogen	H	
Nitrogen	N	

<u>Chemical and structural formula of the compounds: ethyl alcohol example:</u>

1. ethyl alcohol

```
      H     H
       I     I
H---C---C----O---H
       I     I
      H     H
```

$C2H5OH$

____

2. water

____

____

3. glucose

____

4. acetic acid

____

5. glycine

____

6. urea

7. pyruvic acid

8. acetaldeyde

____

9. butyric acid

Homework/lab work for Organic Macromolecules (OMM) page 3.

Name____________________ Note: read all 3 pages prior to starting work!

Lab Questions:

1. If you changed any of the functional groups of your models, could they resemble any of the other eight molecules?

2. Do your models resemble models of other class members? Give reasons for similarities and differences that might have existed between models from other students.

3. How are the nine models you constructed alike?

4. How are the nine molecules you constructed different?

Additional Lab Activities:

Gumdrop Organic Macromolecules (OMMs) Lab. Complete this lab as directed by your teacher.

Materials: Gumdrops of 4 different colors and a about 50 toothpicks.

Procedure:

1. How many bonds are possible with the below noted elements?

Carbon = ___? Hydrogen = ____? Nitrogen = ___? Oxygen = ____?

2. Using the above noted bonding capabilities, the below table of functional groups draw the 2-D structure of the following nine compounds using the included table on the preceding pages:

1. C_2H_5OH	ethyl alcohol
2. H_20	water
3. $C_6H_{12}O_6$	glucose
4. CH_3COOH	acetic acid
5. NH_2CH_2COOH	glycine (an amino acid)
6. $CO(NH_2)_2$	urea
7. $CH_3COCOOH$	pyruvic acid
8. CH_3CHO	acetaldehyde
9. $CH_3CH_2CH_2COOH$	butyric acid

3. Build three dimensional models of each compound using gumdrops and toothpicks. Have each model checks and initialed on your data sheet by your instructor as you build it.