College of the Canyons

COC Biotechnology Program
Module 6

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

- ✓ 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 item for its OMM composition. Using deductive and inductive reasoning you will identify your 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 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 then 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 of matter and cannot 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.

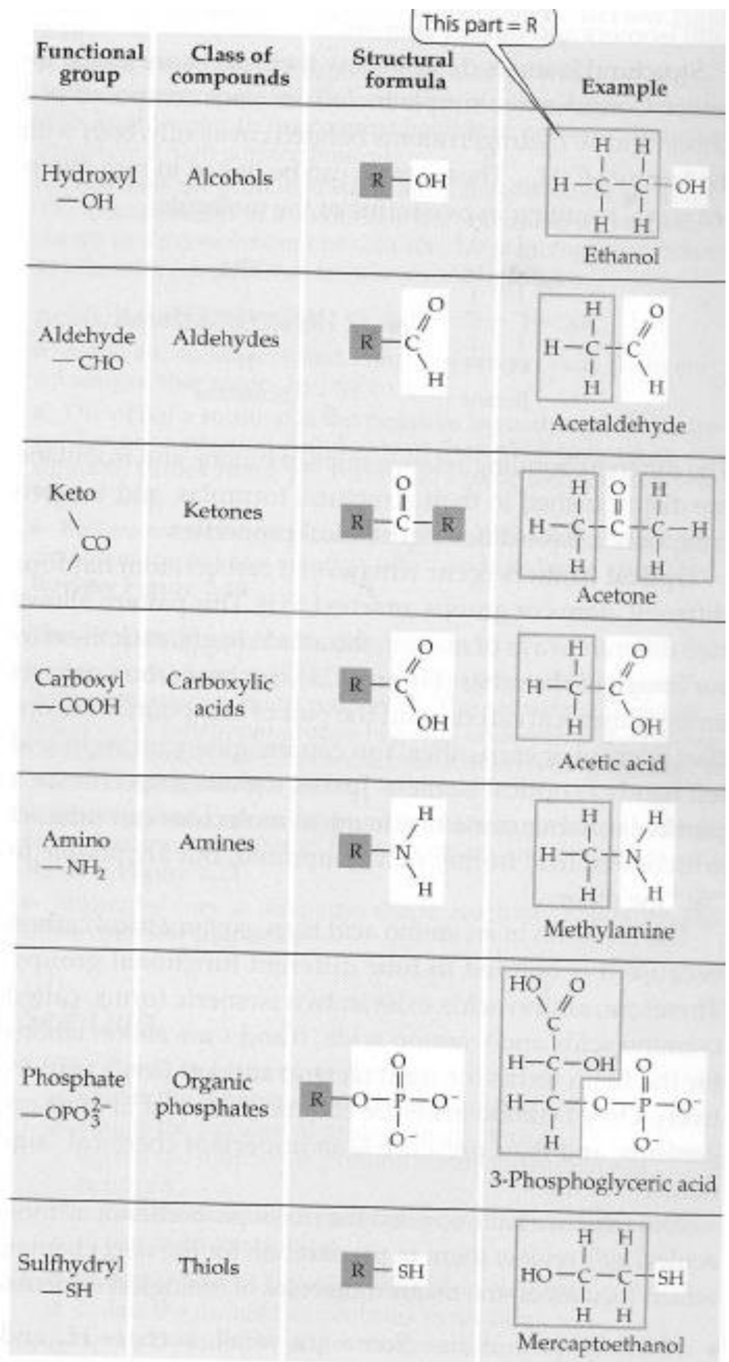
BONDS:
These elements can be combined in enormous variety to make up the chemical molecules on which life is based.
In most biological molecules, the atoms are held together by covalent bonds in which electrons are shared between adjacent atoms. Ionic bonds, hydrogen bonds, and disulfide bonds are also important. If you are not sure how each of these bonds are formed, return to your text or ask a colleague.
Fortunately for us, covalent bonds are not very easily broken down under ordinary conditions. Some small molecules are especially stable and are used as the building blocks or "monomers" of very large molecules called "polymers". A polymer often consists of many similar monomers strung together in a long chain. It is easier to break down a polymer into its monomers than to break apart the monomers themselves. This idea is similar to the fact that it is easier to break a string of beads than it is to break the beads themselves.

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 well 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 to look like part of larger item perhaps suggesting some structure like a box or doorframe. 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 applying this thinking 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 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.

<u>Functional Groups Common to Foods: Table 1: Example functional groups: First column shows short hand drawing. See below for more short hand drawings:</u>



Functional group chemical shorthand:

Name: CARBOXYL
Shorthand: COOH OR COO-

Name: HYDROXYL
Shorthand: R--OH

Name: AMINO
Shorthand: NH2 or NH3+

Name: ALDEHYDE
Shorthand: CH----O

Name: KETONE
Shorthand: R2----O

Name: SULFHYDRYL
Shorthand: R--S

Name: HYDROCARBON
Shorthand: CH2

Name: PHOSPHATE:
Shorthand: PO4--

Details on functional groups

For example, any molecule that has the carboxyl group is an acid. (Remember that one line represents one covalent bond and two lines represent a double bond.) The term fatty acid refers to the group of acids that have the carboxyl group and several hydrocarbon groups. An amino acid molecule has an amino group and a carboxyl group. A carbohydrate such as a monosaccharide or simple sugar has an aldehyde or ketone group and some hydroxyl groups. Aldehyde and ketone groups are specific examples of carbonyl compounds that can be seen in a variety of molecules including sugars, carbohydrates, proteins and even some fats. They are most abundant and reactive in sugars and therefore are utilized to test for the presence of sugars. Amino acid molecules may have additional functional groups (sulfhydryl, additional carboxyl groups, additional hydroxyl groups, and so on), but they all share the functional groups characteristic of an amino acid.

Functional groups can be divided into two broad groups, polar and non-polar, depending on whether they contain polar covalent bonds or ions or a simple non-polar covalent bond. Polar or charge-bearing groups tend to make the molecule hydrophilic (= water loving). Groups with non-polar covalent bonds such as C--C and C --H tend to make the molecule hydrophobic (= water fearing).

Polar Functional Groups:

Carboxyl group:
Acid basic
COOH or COO-

Aldehyde group

RC---O

Ketone group
R2C---O

Hydroxyl group
R----OH

Amino group
NH2

Amino acid anion (negative charge)
COO-

Cation (positive charge)
$NH3^{+}$

Non-polar (or low polarity) Functional Groups:

Hydrocarbon group	Sulfhydryl group
H-----C---H	S----H

Polar functional groups are hydrophilic because they interact with each other and with water, another polar substance; they do not interact significantly with nonpolar hydrophobic functional groups or with non-polar solvents.

Tests for food items and the organic macromolecules.

The functional groups you have just struggled to identify and become familiar with are now going to pay off. Many food stuffs can be identified by the functional groups they contain. Instead of having to worry about every atom in a large molecule, the identification of a few functional groups is often adequate enough to tell the scientist what type of molecules are in the food item. The following five tests will either be conducted by you or demonstrated in order to help you see what molecules are found in common food items. As you might imagine, many foods are made of many types of organic macromolecules. For the sake of this lab, most of the foods chosen are simpler foods consisting of only one to two types of molecules. It is important that you link the test with type of food with and its specific functional group(s). The below table will help simplify this idea. This table will be followed by 5 tests to identify food properties. Please note that this list is only a general outline and many foods are more complex and contain more food types and/or functional groups.

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/keytones/aldehyde	Benedicts	Only tests for certain certain types.
Starches	Complex carbs. (bread, pasta, etc.)	Iodine	Checks for all carbohydrates
Fats	Oils, lard, margarine	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 and have no color

5 common food (functional group) diagnostic tests.

1. Organic and Inorganic Compounds: The Char Test

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 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 an organic compound today? For one thing, all organic compounds contain carbon, but some inorganic compounds also contain carbon. 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 inorganics 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 without water</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. These compounds can be recognized by testing the gas given off for the presence of carbon dioxide. 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)

<u>1. CHAR TEST: NOTE.. this test may be demonstrated by your instructor or conducted by you. 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), and 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 ignite the candle with an ignition source. 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 candle. 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 note the resulting color.
5. Record the results on Table A towards the end of this handout (page 10).
6. Following the recording of results use the pumice stone to clean off the residue of your samples.

<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 versus 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 of absence of food groups (functional groups) in the following 4 tests. **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 would 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 reading procedure 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 5 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 4 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>Tests 2 and 3: Carbohydrates and Sugars</u>

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).

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 can be detected because they have an aldehyde group. 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.

<u>2. Benedicts test for reducing sugars:</u>

```
                                       O                                            O
BENEDICT'S REAGENT  +  R ---- C      -----> BENEDICT'S REAGENT  + R------C
     (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 Benedict's 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 Benedict's 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.
<u>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.</u>

<u>Benedict's Test Procedure: You will use 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
- Add10 drops of lactose to the third tube
- Add 10 drops of water to the fourth tube, the control
- Add 10 drops of Benedict's reagent to all 4 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___________ Lactose_____________

<u>Record and analyze your results in the *table A at the end of these 4 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 #4? ______________?

3. Iodine Test for Starch

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>Iodine Test Procedure</u>

Add 10 drops of starch solution to one tube
Add 10 drops of sucrose to a second tube
Add10 drops of water to a third tube
Add 2 drops of iodine solution to each tube and mix

<u>Record and analyze your results in the *table A at the end of these 4 tests*.</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:

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 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% ethanol. A fifth sample contains only water and ethanol to be used for the control.

Sudan 4 Test for Fats:
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. Then tear the filter paper equally into five pieces.
- 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
- Soak the paper for three minutes in the Sudan 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

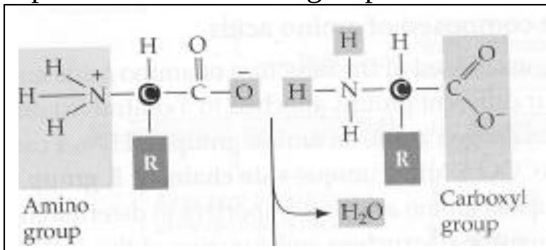
Record and analyze your results in the *table A at the end of these 4 tests*.

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

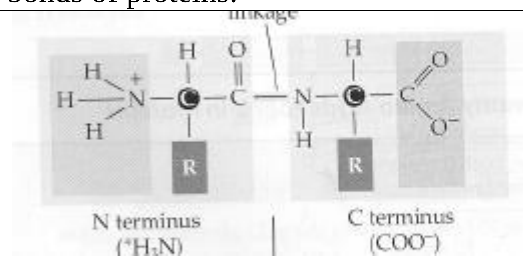
5. Biuret Test for Protein:

	H
COOH	N
	H
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 its neighbor in 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).

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

Procedure:

- Add 10 drops of egg white solution to the first tube
- Add 10 drops of chicken soup to the second tube
- Add 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, and record the results
- 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? _____ albumin solution _____ chicken soup

Record and analyze your results in the *table A at the end of these 4 tests*.

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?
A	albumin		
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	lactose		
4	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	albumin		
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)
soy flour (high fat)	380	41.2	12.1	33.3 (starch)
table salt	0	0	0	0
table sugar	385	0	0	99.5 (sucrose)
Vermont maple syrup	286	0	0	74 (glucose +fructose)

UNKNOWNS: Your group will receive an unknown food labeled A, B, or C. You will have one of the four 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.

A	B	C
Table Salt	Corn Starch	Glucose
Glucose	Honey	Table Salt
Powdered Milk	Table Sugar	Potato Starch
Enriched Flour	Albumin	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				
reducing sugar				
carbohydrate				
fat				
protein				
organic carbon				

Actual Results of tests (+/- or unsure)

Tests performed	Test results (+/- or unclear)	Foods ruled out
Benedict's test for reducing sugars		
Iodine test for starches		
Sudan 4 test for fats		
Biuret's test for proteins		
Char test for organics/calories		

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. CH4 is a gas called _________________. By removing one hydrogen and adding a hydroxyl group
(______), the substance becomes CH3OH, 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
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 none 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.