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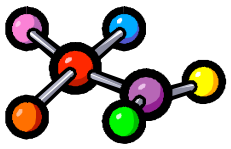
# Molecular Modeling

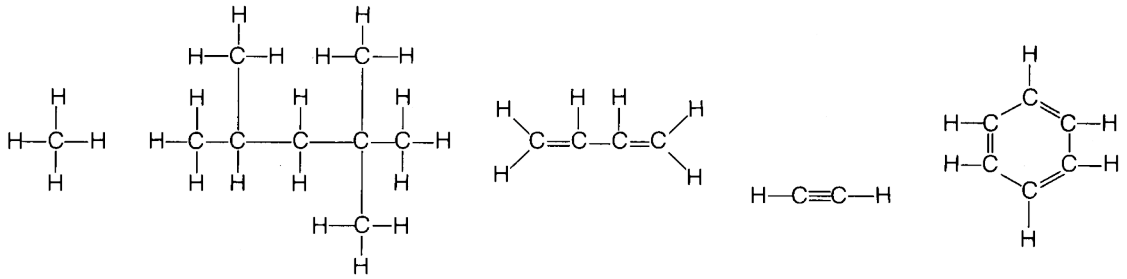


## Background:

In biology, the four most important elements found in living things are:

**H** – hydrogen (1 valence electron)
**O** – oxygen (2 valence electrons)
**N** – nitrogen (3 valence electrons)
**C** – carbon (4 valence electrons)

***Carbon*** is the most important elements found in living things because…



**Methane** **Iso-Octane** **Butadiene** **Acetylene** **Benzene**

- ❑ Carbon can bond to with up to 4 other elements.
- ❑ Carbon can bond to other carbons to make chains, branches, and rings!
- ❑ Carbon can have single, double, or triple bonds!

Carbon is found in a diverse array of molecules with many different shapes. In biology, it is the overall shape of the biological molecules that is important. Cells tell different molecules apart by comparing their shape. An interesting part of ***organic chemistry***, the study of molecules containing carbon and hydrogen, is how these complex molecules are built. Often, huge ***macromolecules*** are actually conglomerations of many smaller atom groups-- called ***functional groups*** — stuck together much like an item built of Legos®.

You will be using a molecular modeling kit to build organic molecules. This particular kit is ideally suited for biochemistry, because the model atoms when bonded together clearly show the overall shape of the finished molecule. Each atom in the molecule is represented by a specific piece with a unique color (see table below). Plastic bonds hold the atoms together.

## Lab Objectives:

The goal of this lab is twofold:

1. To help you become familiar with the basic structure of common molecules important to biology.
2. To help recognize common functional groups.

Pay attention to functional groups, which are the building blocks of complex organic molecules.

### Pre-Lab Questions:

1. What are the four most important elements in biology?

_____

2. Why is carbon such an important atom in biology?

_____

3. Why does the shape of the molecules found in your body matter so much?

_____

4. What is a functional group?

_____

**Procedure:**

***Part I: Chemistry Review***

1. Complete the following table before starting.

| **Element** | **Hydrogen** | **Oxygen** | **Nitrogen** | Carbon |
|---|---|---|---|---|
| **Conventional Color** | **White** | **Red** | **Blue** | Black |
| **Chemical Symbol** | | | | |
| Number of bonds element can make | | | 3 *(Model has four prongs and can be used in place of carbon if needed.)* | |

2. Draw a Structural or Lewis Diagram for the following Molecules:
   a. Methane- $CH_4$
   b. Carbon Dioxide- $CO_2$

   c. Water- $H_2O$
   d. Ammonia- $NH_3$

3. Using your molecule model kit, build each of these molecules. For double bonds, use the long, thin, flexible connectors found in the model kit. After building all the basic molecules, have your teacher initial your lab sheet. **Initials:**_____

***Part II: Functional Groups***

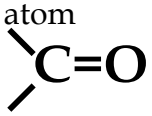
In organic chemistry, ***functional groups*** are specific groups of atoms within molecules that determine their characteristics and chemical reactivity. Functional groups are attached to the carbon backbone of organic molecules. There are at least 30 function groups. Don't worry, we are going to identify and build only five.

1. Using your molecule model kit, build each of the functional groups listed below. For double bonds, use the long, thin, flexible connectors found in the model kit. After building all the basic molecules, have your teacher initial your lab sheet. **Initials:**_____

   **a.** ***Hydroxyl group -*** Functional group consisting of an oxygen atom and a hydrogen atom connected by a covalent bond.

   **–OH**

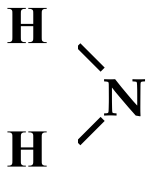
   b. ***Carbonyl Group-*** Functional Group composed of a carbon atom double-bonded to an oxygen atom

   c. ***Carboxyl Group –*** Functional Group composed of one carbon atom attached to an oxygen atom by double bond and to a hydroxyl group by a single bond.

   **–COOH** ***(It doesn't look like this. Read the description for clues)***

d. ***Amino Group-*** Functional Group composed of one atom of nitrogen attached by covalent bonds two atoms of hydrogen, leaving a lone valence electron on the nitrogen which is available for bonding to another atom.

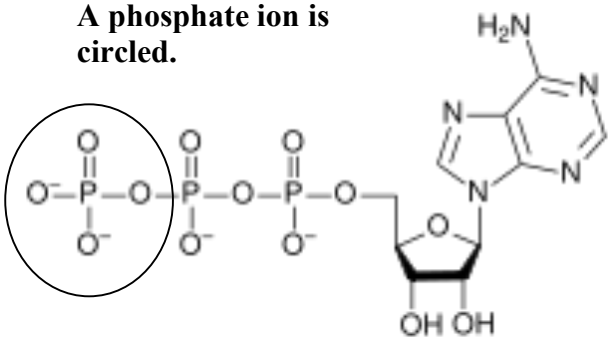



***e. Phosphate Group-*** Functional Group composed of one central phosphorus atom surrounded by four identical oxygen atoms. This functional group is actually a polyatomic ion, called phosphate ion. Phosphates are most commonly found in the form of adenosine phosphates (the energy all living things use) and in DNA and RNA. ***Since we do not have a phosphorus atom in the kit, we will skip building this one.***

What is the **phosphate ions charge?**

_____

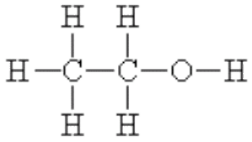
**A phosphate ion is circled.**




*Part III: Organic Molecules*

1. Using your molecule model kit, build each of the simple organic molecules listed below. For double bonds, use the long, thin, flexible connectors found in the model kit. After building all the basic molecules, have your teacher initial your lab sheet. **Initials:**_____

a. ***Ethanol, $C_2H_6O$, (ethyl alcohol)*** Yeasts carry out ethanol fermentation, breaking down sugars in the absence of oxygen. Ethanol fermentation is responsible for the rising of bread dough, the production of ethanol in alcoholic beverages, and for much of the production of ethanol for use as fuel.



***Question → What type(s) of function group(s) are in this molecule?***

_____

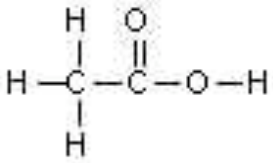
***Question → What organism carries out ethanol fermentation?***

_____

***Question → What is the product produced in ethanol fermentation?***

_____

b. ***Acetic acid:*** The sourness of vinegar is due to acetic acid. Notice that one of the carbons is only linked to three other atoms. This is because oxygen forms a double bond with this carbon.



***Question → What type(s) of function group(s) are in this molecule?***

_____

***Question → What is another name for acetic acid?***

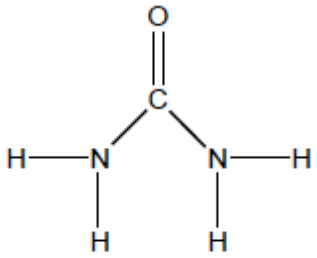
_____

c. **Urea,** $CH_4N_2O$. When proteins are digested and burned for energy, the very toxic compound ammonia ($NH_3$) is made. Ammonia is converted into urea by the liver. The slightly less poisonous urea is transported into the blood for eventual removal from the body. Urea is composed of a central carbon double bound to an oxygen, with two amino groups attached. Construct it.

***Question → What type(s) of function group(s) are in this molecule?***

_____

***Question → What does your body do to ammonia? Why?***



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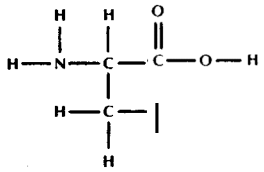
_____

_____

**2.** Using your molecule model kit, build each of the complex organic molecules listed below. For double bonds, use the long, thin, flexible connectors found in the model kit. After building all the basic molecules, have your teacher initial your lab sheet. **Initials:**_____

***a. Amino Acids*** – the building blocks of proteins. There are twenty that commonly occur in nature. Build the following amino acids:

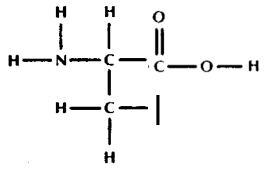
***i. Alanine***



***Question → What type(s) of function group(s) are in this molecule?***

_____

ii. Serine



***Question → What type(s) of function group(s) are in this molecule?***

_____

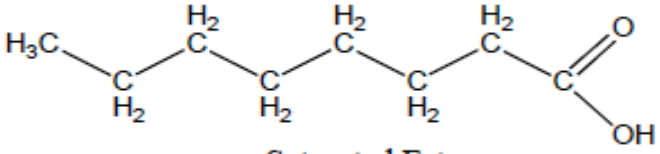
***Question → What are two things all amino acids have in common?***

_____

b. ***Lipids***- Lipids or fats are easy to make because they all long chains of carbon and hydrogen. They come in two varieties: saturated and unsaturated. Construct the following two pieces of a fat molecule.

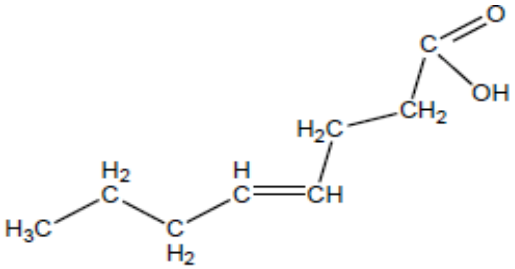
***Note*** *-$CH_3$ is an abbreviation for a carbon with individual hydrogens attached.*

i. Saturated Fat



**Saturated Fat**

ii. Unsaturated Fat



**Unsaturated Fat**

***Question → What type(s) of function group(s) are in these molecules?***

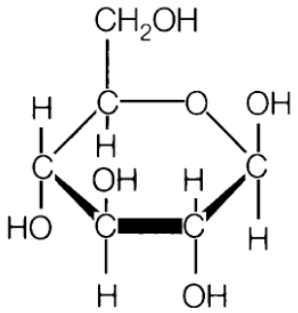
_____

***Question → How do saturated and unsaturated fats differ?***

_____

c. ***Carbohydrates*** – Saccharides are organic compounds that comprise sugars, starches, and cellulose. They are important sources of energy in living things, supporting tissue in plants and probably the precursors of the fats and proteins. Most carbohydrates are built of units containing 6 carbons, although five-carbon sugars exist.

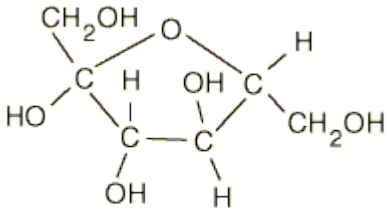
i. ***Glucose ($C_6H_{12}O_6$)*** The most important simple sugar (monosaccharide) used in cells. Notice the main part of this molecule is a hexagon.




***Question → What type(s) of function group(s) are in this molecule?***

_____

ii. ***Fructose ($C_6H_{12}O_6$)*** Fructose is a monosaccharide found in fruits.



Fructose

***Questions → What type(s) of function group(s) are in this molecule?***

_____

***<u>Compare</u> and <u>contrast</u> glucose and fructose.***

iii. ***Sucrose ($C_{12}H_{22}O_{11}$)*** Sucrose is made up of a Glucose and Fructose molecule bonded together. Because it is made up of two monosaccharides, it is called a disaccharide.

1. Construct a sucrose molecule from your glucose and fructose models. This is a synthesis reaction that will form a basic molecule as another product.
2. ***Describe what you did to make your sucrose molecule.***