Name: _____ Period: _____ Date: _____

Molecules of Life

Objective
Use models to visualize carbohydrates, lipids, and proteins. Join subunits to demonstrate dehydration synthesis, showing how each organic molecule is constructed.

Materials Needed
Black pieces (carbon atoms)
White pieces (hydrogen atoms)
Red pieces (oxygen atoms)
Blue pieces (nitrogen atoms)
Short tubes (single bonds)
Long tubes (double bonds)

Procedure

PART 1 – Structure of a Carbohydrate

1. Obtain five carbon atoms, one oxygen atom, and six single bonding tubes. Join the 5 carbons in a chain, with one bonding tube between each atom.
2. On the first carbon of your chain, place one of the unused bonding tubes. On the last carbon of your chain, place the remaining unused bonding tube.
3. Attach the ends of the first and last bonding tube to an oxygen atom. You should now have a six-pointed ring of atoms.
4. Place the ring on the table in front of you with the oxygen atom at the "twelve o-clock" position. Moving clockwise, place one hydrogen atom on each of the five carbons in the ring using short bonding tubes. Now each carbon should only have one bonding site open.
5. Moving clockwise, use the tubes to place one oxygen atom on each of the first four carbons in the ring. On each of the oxygen atoms, use a bonding tube to attach a hydrogen atom to the remaining bonding site.
6. At this point, the only bonding site not filled should be the one on the final carbon of the ring.
7. Bond another carbon atom to the final ring carbon.
8. Bond an oxygen atom to one of the bonding sites open on the new carbon.
9. Using three hydrogen atoms, fill all remaining bonding sites on the new carbon and oxygen atoms.
10. The molecule you have made is called GLUCOSE. It is a SIMPLE SUGAR and the building block for POLYSACCHARIDES or CARBOHYDRATES.
11. Check with your instructor to see if your model is constructed properly.

Question 1: How many carbon, hydrogen, and oxygen atoms are in your completed glucose?

C_____ H_____ O_____

Use these numbers to write the molecular formula for glucose.

12. Build a second glucose molecule in the same manner as the first.
13. Place the two models in front of you side by side so that both oxygens are at the "twelve o-clock" position.
14. On the left glucose molecule, locate the first carbon found clockwise from the oxygen in the ring. This carbon has a hydrogen and an oxygen-hydrogen section branching off of it. Now locate the oxygen-hydrogen section bonded off this carbon. Remove this oxygen-hydrogen combination (with the bonding tube) from this glucose. Save the piece you removed.
15. On the right glucose molecule, locate the first carbon found counter-clockwise from the oxygen in the ring. This carbon has another carbon branching off of it. Now locate the oxygen-hydrogen section bonded off this carbon. Remove ONLY the hydrogen (without the bonding tube) from this glucose. Save the piece you removed.
16. Join the two monosaccharides to create a disaccharide by placing a bonding tube between the two open carbons. The dissacharide you have made is called MALTOSE.

Question 2: If you joined the left-over pieces together, what molecule is formed as a byproduct of this chemical reaction? (hint – the reaction is called a DEHYDRATION SYNTHESIS)

$C_6H_{12}0_6$ + $C_6H_{12}0_6$ ---------- $C_{12}H_{22}0_{11}$ + _____
(glucose) (glucose) (maltose) (?)

Question 3: An empirical formula is a ratio of the elements in a molecule in their most reduced form. What is the empirical formula for glucose?

Question 4: Based on the information gathered during this activity, why are carbohydrates excellent sources of energy for organisms? (hint – we get energy from food by breaking apart the bonds in the food molecules)

PART 2 - Structure of a Triglyceride (Lipid)

1. GLYCEROL is one of two pieces in all lipids. FATS are an example of a lipid. To begin constructing a glycerol, obtain three carbon atoms and two short bonding tubes. Link the carbons together in a chain with the bonding tubes.
2. Now you will make the hydroxyl groups of glycerol. Connect one hydrogen and one oxygen atom together with a bonding tube. This –OH group is a HYDROXYL. Make two more hydroxyl groups.
3. Connect each of the three hydroxyl groups to each of the three carbons on the glycerol group.
4. Obtain five hydrogen atoms and five bonding tubes. Connect each of the hydrogen atoms to each of the remaining sites on the carbon atoms with the tubes. Your glycerol molecule is now complete.
5. The second part of making this lipid is to create a fatty acid. Start by making CARBOXYLIC ACID. Construct it by placing 2 long bonding tubes on the bonding sites of an oxygen atom.
6. Attach both tubes to two bonding sites on a single carbon atom (you will have to bend the tubes). You have made a DOUBLE BOND.
7. Attach a short bonding tube to the carbon atom, and link another oxygen to the carbon by connecting it to the short tube. Link a hydrogen atom to the remaining oxygen bond site with a short tube. This is a carboxylic acid molecule. Make two more just like the first
8. The last part of making the fatty acid is to build a hydrocarbon chain that you will eventually attach to the carboxylic acid you made in the steps above. Start this by connecting 2 carbons with a single bond, and then fill in their five bonding sites with hydrogen.
9. Make 2 more hydrocarbon chains as you did in step 8.
10. To complete a fatty acid, join a carboxylic acid from step 7 to a hydrocarbon chain from step 8. Do this by placing a single bond between the open carbon atoms of each group. Repeat the process so that you end up with three total fatty acids.
11. Now you are ready to finalize the triglyceride. Place the glycerol that you made in step 4 in front of you so that the hydroxyl groups are located on the right. Place the three fatty acids you made in step 10 to the right of your glycerol, oriented so the carboxylic acid ends of the fatty acids are near the hydroxyl ends of the glycerol.
12. Remove the hydrogen atom (without bonding tube) from each hydroxyl group on the glycerol. Remove the –OH group (with bonding tube) from each fatty acid. Save the left-over pieces.
13. Join each fatty acid to the glycerol to produce a TRIGLYCERIDE. Triglycerides are always made from one glycerol and three fatty acids.

Question 5: How many carbon, hydrogen, and oxygen atoms are in your completed lipid model?

C_____ H_____ O_____

Question 6: Energy available to an organism is stored within the carbon-hydrogen bonds of molecules. Oxygen atoms may intervene between carbon and hydrogen atoms, causing a decrease in the energy available. Therefore, The less oxygen present per hydrogen atoms, the more energy is stored within a molecule. Examine the ratio of carbon to hydrogen to oxygen in a carbohydrate (question 3) and in a lipid (question 5). According to your

observations, which substance stores more energy, carbohydrates or lipids, and what is your evidence to support this answer?

Question 7: Fill in the following general equation for producing a triglyceride:

_____ _____ + _____ = a triglyceride + _____

Question 8: How many molecules of the second product are formed in the equation above?

PART 3 – Structure of a Protein

1. A protein is made of hundreds of AMINO ACIDS. For this activity, you will be making one amino acid.
2. Connect one carbon atom to one hydrogen atom using a short bonding tube.
3. Make an AMMINE group to attach to the carbon. Do this by connecting a hydrogen atom to two sites on a nitrogen atom (you'll need 2 short tubes).
4. Using the third bonding site on the nitrogen, connect the ammine you just made to the carbon group you made in step 2.
5. The fourth bonding site on nitrogen represents an unshared pair of electrons and will not be used in this lab.
6. Finally, you will make a carboxylic group to bond to the ammine. Construct one carboxylic acid following the same procedure used for lipids in steps 5-7.
7. Use the fourth bonding site on the carboxylic acid carbon to connect it to the central carbon.
8. There are 20 different amino acids. Each amino acid has an AMINE group, which you just built. What makes the amino acids different from each other is that each of the 20 amino acids has a different "R" group. The "R" group attaches to the empty bonding site on the central carbon atom.
9. You will make two of the 20 amino acids, glycine and alanine. To make glycine, add a hydrogen to the remaining bonding site on the central carbon atom. Therefore, the "R" group for glycine is a single hydrogen atom.
10. Remove the hydrogen you just added. Now you will make alanine. Add a carbon with three hydrogens bonded to it to the central carbon (where you removed the hydrogen from step 9). This entire molecule is now alanine.

Question 9: What is the "R" group for alanine?

Question 10: What two functional groups are contained in all amino acids?

<u>General Questions</u>

11. Arrange the following terms in order of least to greatest for representative size: triglyceride, disaccharide, carbon atom, protein, carboxylic acid

12. State the similarities that exist between the three organic chemicals in these areas:

- Elements which make up the molecules.

- Type of reaction involved in forming the organic substance, and a secondary product given off in each instance.