Tasty Models

Name: Joe

Lab Partners: Sammy & Rachel

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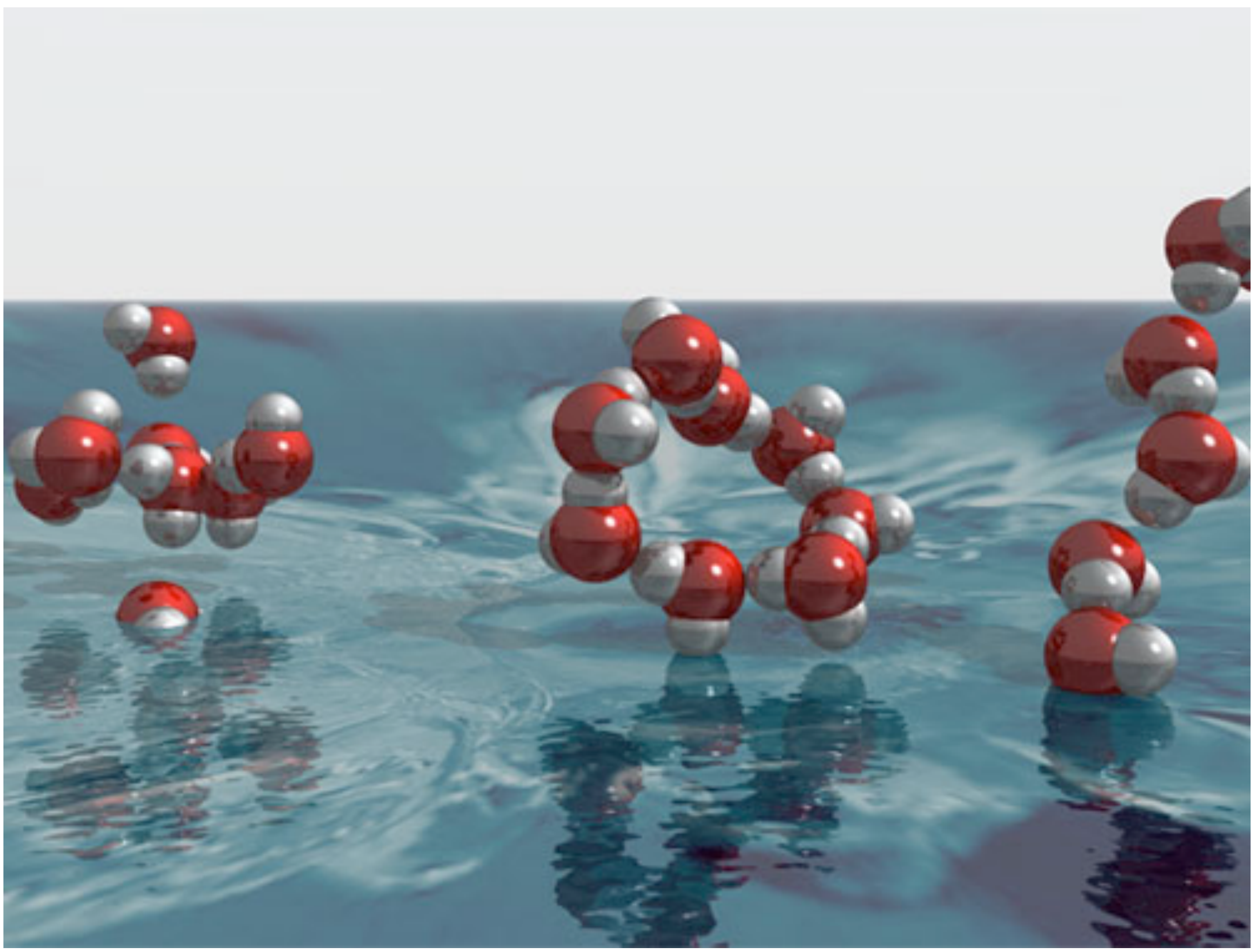


INTRODUCTION:

Understanding the arrangement of atoms within nutrient molecules often helps explain their chemical behavior, health attributes and role in weight balance. Although atomic representations do not accurately represent electron configurations, they can be used to show the arrangement of nuclei and bond type. In the following activities, you'll construct several different molecular models that represent substances that play an essential role in our nutritional needs.

PURPOSE:

- Insight into atomic arrangement of several nutrients
- A hands-on experience in constructing models
- A visualization of dehydration synthesis using molecular models
- A visualization of bond saturation in fat molecules
- An opportunity to apply critical thinking to atomic modeling

HYPOTHESIS:

What is atomic arrangement?

I hypothesize that each molecule has an atomic arrangement, which is how the atoms in the molecule are organized.

How might a hands-on experience help when constructing models?

I hypothesize that a hands on experience will help memorize and become familiar with such materials. It also may help with explaining something complex, which otherwise would be extremely hard to comprehend with words.

What is dehydration? How might that look on the molecular level?

I hypothesize that dehydration is loss of water molecules in any substance. I hypothesize that an object that was in the process of dehydration would contract, because of the loss of water molecules. Much like a cooked piece of pasta in the sun.

What is bond saturation?

I hypothesize that bond saturation is a limit in which nothing more can be extracted from a substance.

How might being familiar with atomic structures be important?

I hypothesize that knowing about the structures of molecules will be important because when a molecule is involved in a process, it would be easier to identify what that process accomplishes by the contents of the molecule.

MATERIALS & EQUIPMENT:

- ❒ Styrofoam Balls
- ❒ Toothpicks

PROCEDURE:

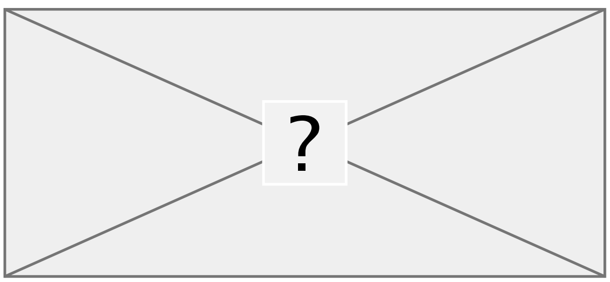
PART 1 – Carbohydrates

Carbohydrates are a group of nutrients that include sugars and starches. Perhaps, the most familiar carbohydrate building block is glucose. Glucose is a monosaccharide, which means that it contains one sugar unit. Monosaccharides can be joined together to produce larger chains of carbohydrates. Starch is an example of a long chain of sugar molecules that are linked together. In this set of activities, you'll construct a single sugar (glucose) and observe the effects of a dehydration synthesis reaction.

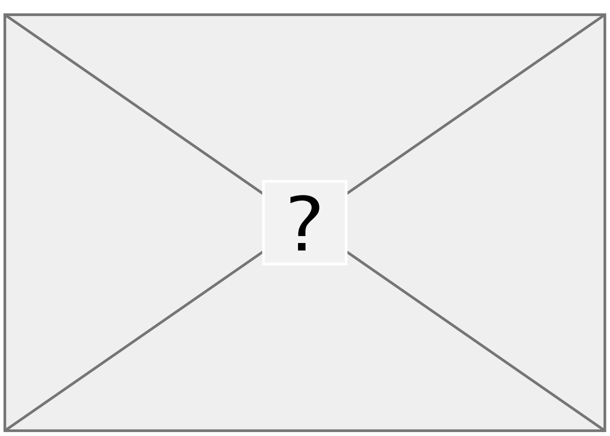
Glucose Model

1. Examine the study of Styrofoam that you will be using to assemble your molecular models. Now, consider the formula of glucose, C6H12O6. Based on this formula, how should you assign specific colors to the component atoms?
(The most common color should be assigned to hydrogen, since hydrogen atoms are the most numerous.)

2. To build the ring version of glucose, let's construct a closed ring formed by five carbon atoms and one oxygen atom.

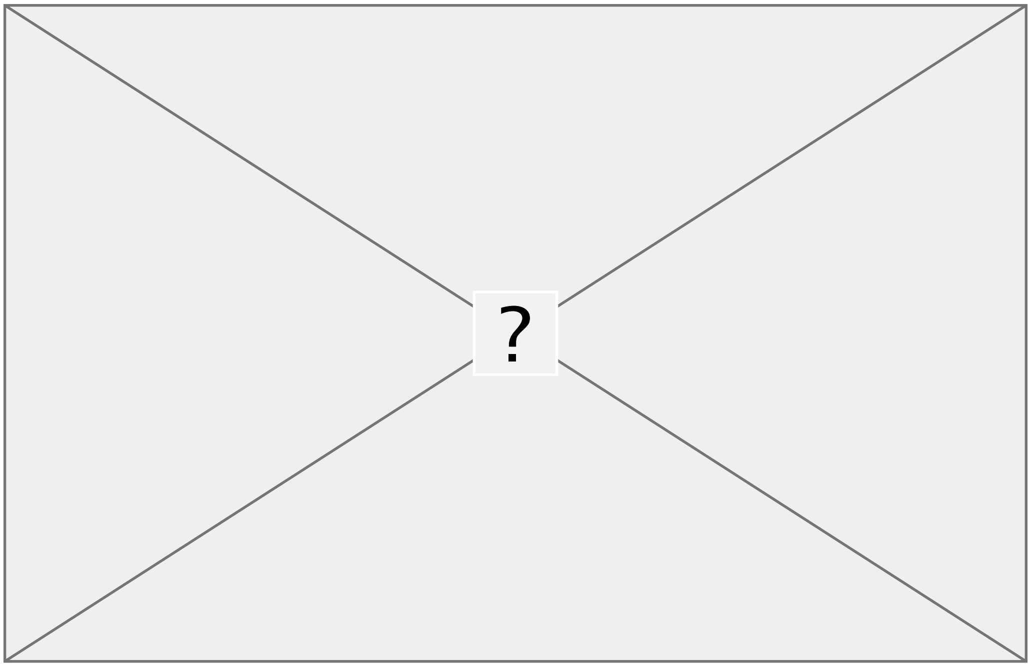


3. Now, let's add the sixth carbon atom. It is attached to the ring carbon that is immediately to the left of the oxygen atom.

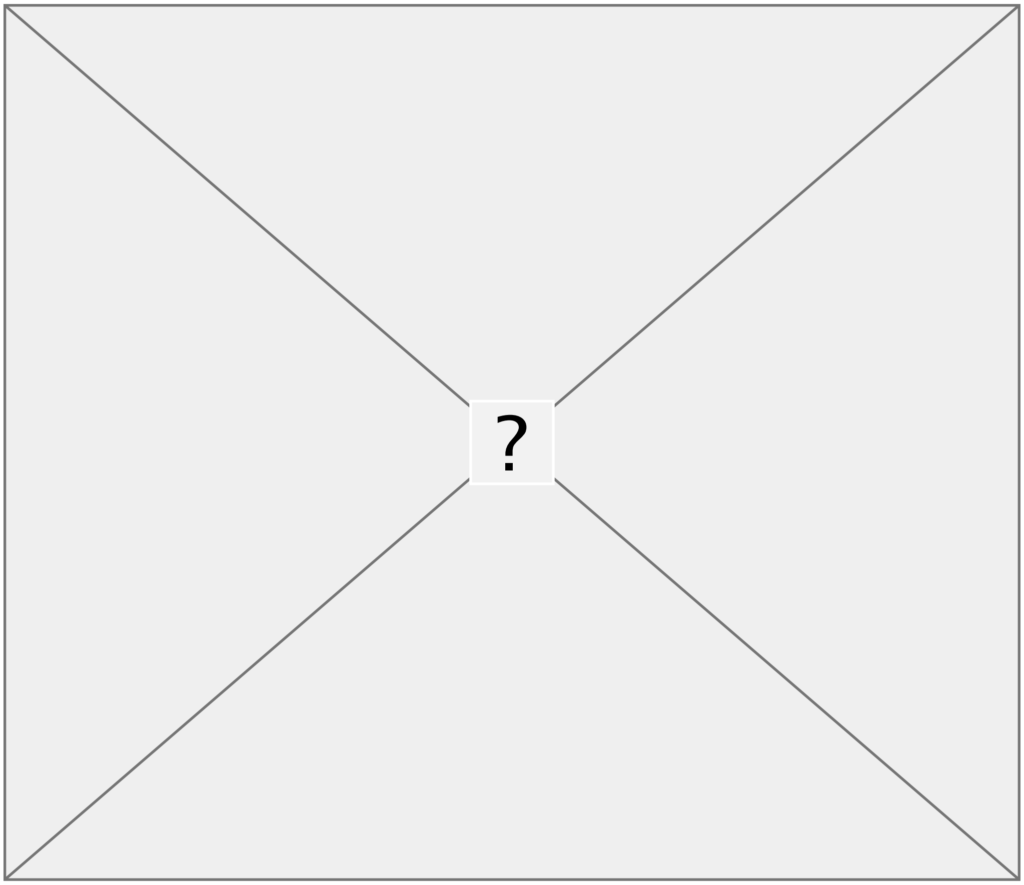


4. The remaining five oxygen atoms are part of hydroxyl (OH) groups. They are added as

shown here.



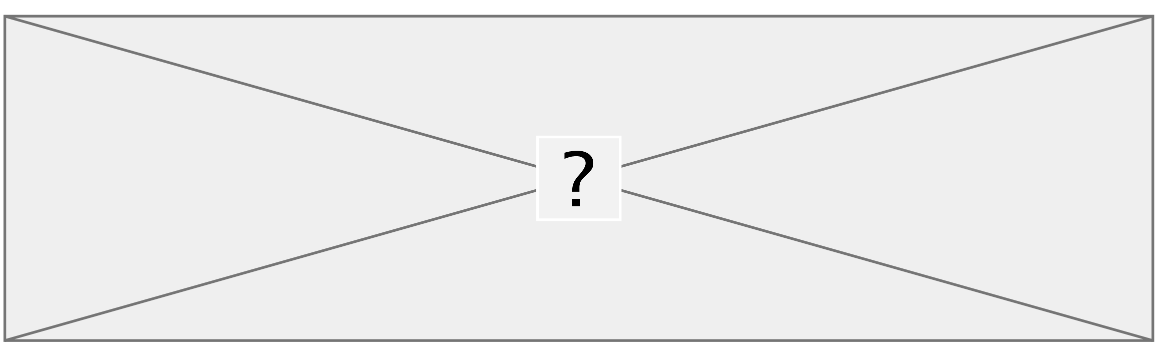
5. Finish the model by adding the remaining seven hydrogen atoms so that each carbon atom forms four bonds.



Modeling Dehydration Synthesis

To produce larger carbohydrate molecules, glucose is linked to other sugar molecules. During this bonding process, two atoms of hydrogen and one atom of oxygen are removed from the linking sugars. These atoms join together to produce a molecule of water. Hence, this type of sugar bonding is called dehydration synthesis.

1. Construct a second model of the glucose model.
2. Place both models side-by-side. Remove the two hydrogen atoms and one oxygen atom that are associated with dehydration synthesis (identified by the dashed line).



3. Join the free bond of the ring oxygen atom to the free bond of the carbon atom. Join the three removed atoms together to form a molecule of water.

PART 2 - Proteins

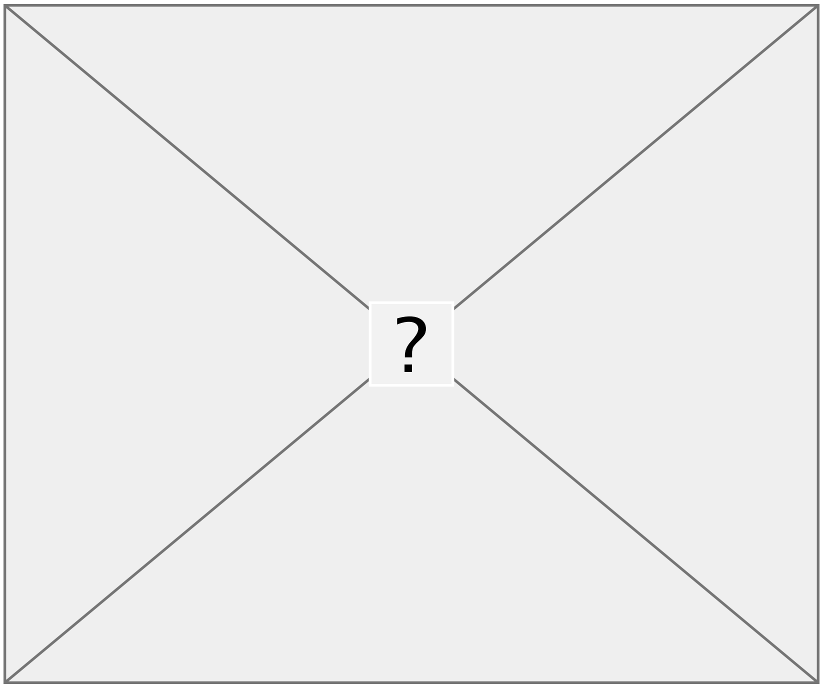
Proteins are macromolecules that are found in every living cell. Like carbohydrates, they form a critical part of our diet. They are also the profiled nutrient in the Atkins diet. The basic building block of a protein molecule is an amino acid. All amino acids share a common feature. They contain both an amine (NH2) group and a carboxyl (COOH) group.

Glycine Model

1. Glycine is the simplest structural amino acid. Like all amino acids, it has an amine (NH2) group. Use Styrofoam to construct this functional group.

2. Like all amino acids, glycine also has a carboxyl (COOH) group. Use Styrofoam to construct this functional group. Remember to retain consistency in your assignment of gumdrop colors.

3. The amine and acid group are both attached to a central carbon atom. The remaining two bonds of this backbone carbon are saturated with hydrogen.

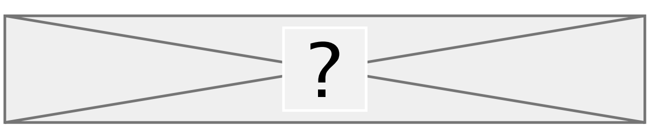


Your finished glycine model should resemble this image.

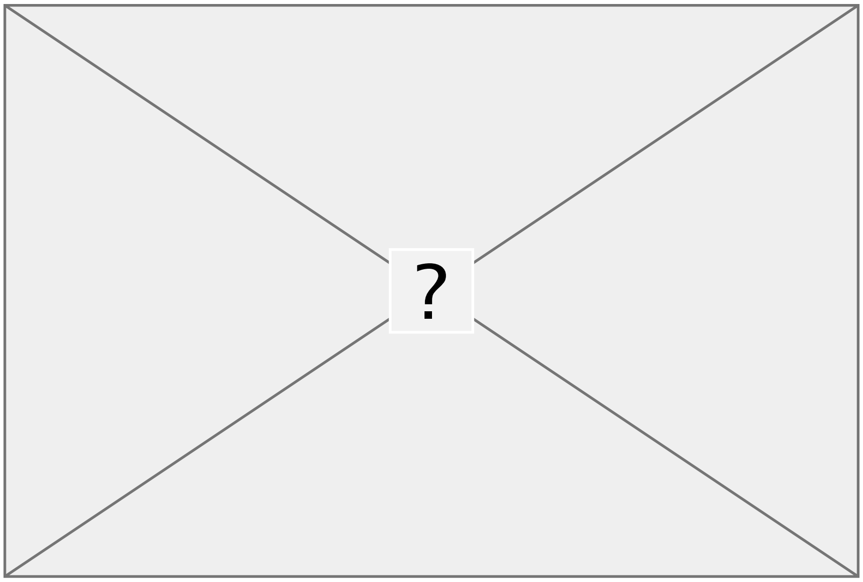
PART 3 - Saturated and Unsaturated Fats

Although you may not know what they are, chances are you've heard of saturated and unsaturated fats. Fats are long molecules that can have more than 20 carbon atoms in their backbone. A saturated fat has only single bonds in its carbon backbone. An unsaturated fat has one or more double bonds.

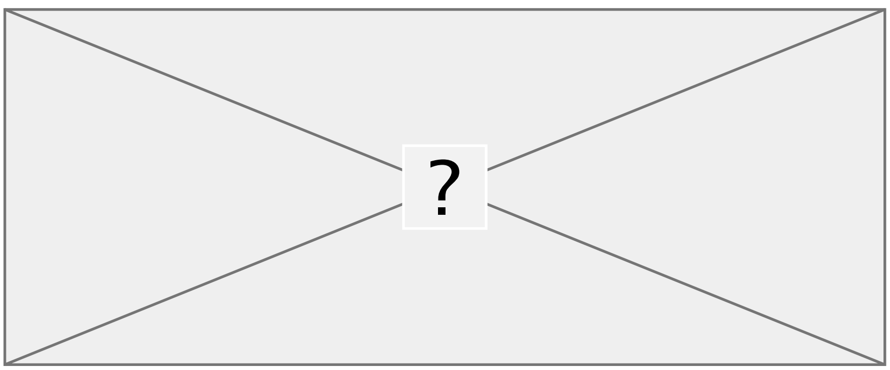
1. Construct a chain of four carbon atoms.



2. Add two hydrogen atoms to each carbon atom. Place a toothpick at both ends of the chain to represent the bond that connects this section to the rest of the fat molecule.



3. Now construct a version of this carbon backbone that contains an unsaturated carbon.



DATA TABLES, OBSERVATIONS, AND NOTES:

Check the molecule diagram by making sure each of the atoms within the molecule have the amount of atoms connected to them they need, for instance hydrogen needs one, so there would be one atom connected to it. Depending on how the molecule is structured, some rotate ones with only one bond. Ones with more than one bond wouldn't rotate because the can spin.

Amino has to have a nitrogen in it. Acids always have double bonds. Ones with double bonds have a more fixed design. Acids are reactive because they have an extra bond, and any atom can join. Generally the solid objects have molecules that can spin, because they spin and get tangled with each other and get very compact.

Generally the liquid objects have molecules that can't spin, and have to roll over each other. A saturated fat is when all of the atoms are attached to a different type of atom, and none of the molecule is double bonded. Saturated fats are always solid at room temperature. Unsaturated fats are liquid at room temperature. Monounsaturated means that the fat or molecule is unsaturated in one place.

Polyunsaturated means that the molecule is unsaturated in more than one place. Transfat where the hydrogen is on the is on the opposite side of the double bond. The body cannot break transfats down. Cisfats can be broken down by your body, and has the hydrogen in the opposite place as a transfat, and is naturally occurring.

Illustration of Glucose Molecule:

DATA ANALYSIS AND RESULTS:

In this lab my group created three glucose molecules. We did this using Styrofoam balls, and attached them with toothpicks. Each Styrofoam ball represented a certain atom, in this case a red Styrofoam ball was an oxygen atom. A black Styrofoam represented a hydrogen atom, which was significantly smaller than the other Styrofoam balls because hydrogen has a smaller atomic mass.

Carbon was represented by a grey Styrofoam ball, and nitrogen was represented by a green Styrofoam ball. Every atom contains a specific number of protons, neutrons, and electrons. The number of protons and electrons determines the type of atom. For instance an atom with one electron and one proton is a hydrogen atom. A proton is a positively charged particle whence the name proton, and an electron is a negatively charged particle.

And Protons are neutrally charged, the atomic mass of an atom is mainly determined by the amount of neutrons in contains in its nucleus. However the amount of neutrons an atom contains can also change it's classification. For instance a hydrogen atom contains 1 proton, 0 neutrons, and 1 electron. But if you have an atom with 1 proton, 1 electron, and 1 neutron it would be a deuterium atom.

All atoms are neutral, if you were to have an atom with more electrons than protons it would be called a negative ion. And if you had an atom with more protons than electrons it would be a positive ion. Electrons orbit the nucleus of the atom which is the densest part, which contains the protons and neutrons. The electrons orbit in shells or also known as clouds. It is true for all atoms that the first shell can only contain 2 electrons, the second can only contain 8 electrons, and this continues for a while.

Atoms are always looking for something to attach to, so that they have there shell “finished.” For instance a hydrogen atom has a total of 1 electron, and it wants to fill up its shell, so its attracted to anything that offers one electron that it can share. Which means that one hydrogen atom would be attracted to another hydrogen atom, because they both need one more electron to be “happy.” When two or more atoms are connected they make a molecule.

This means that when we were connecting all of the Styrofoam balls together we were creating a molecule. And each of the toothpicks represented a bond of electrons (two electrons). I found that one of the ways to check and make sure that the molecule is correctly assembled is to make sure that each atom had the correct number of bonds. For instance Oxygen is in need of two more electrons to complete its second shell. Therefore there should be two toothpicks attached to it.

The first molecule we assembled was a Glucose molecule. This required six carbon atoms, twelve hydrogen atoms, and six oxygen atoms, (C6H12O6). After we assembled our three dimensional glucose molecule, we demonstrated dehydration synthesis. Which is a process where water (H2O) is taken from one or multiple molecules. In this case we dehydrated two sugar molecules. In doing this we removed one hydrogen and one oxygen atom from one Glucose molecule, and took another hydrogen atom from the other glucose molecule.

This process was extracting water from two glucose molecules. Once the water had left we had two glucose molecules, one had a carbon with an open bond. And the other had a oxygen molecule with an open bond. Each of them needed one electron in there second shell to be complete. So they were attracted to each-other. A molecule such as this one is called a Disaccharide. If the same thing were to happen to three glucose molecules it would be a Trisaccharide, if it were to happen to more than three it would be considered a Polysaccharide.

Next we discussed amino acids. All amino acids contain a carboxyl , COOH, (1 Carbon, 2 Oxygens, and 1 Hydrogen.) And an Amine (NH2), the reason scientist write COOH the way they do is because it is easily recognized as an amino acid. The acid molecule we created was glycine, which contained 2 Carbon atoms, 2 Oxygen atoms, 5 Hydrogen atoms, and 1 Nitrogen atom.

Once we had created the model we learned that Glycine could also go through dehydration synthesis. Through the same process, simply by removing one hydrogen atom and one oxygen atom from one Glycine molecule. And another hydrogen atom from the other molecule, leaving a carbon atom with an open bond, and a nitrogen atom with an open bond.

Which means each of these atoms needs to bond with one more atom, and the bond together. This process can be repeated to create long chains of Glycine. I found that in general molecules that have the ability to rotate within themselves, (ones without double bonds) are solids. This is because they have more of a chance of getting stuck together and compact with the other molecules around them, and are thus solid. And the molecules that make up a liquid generally do not spin and have double bonds making each individual very fixated. And the rest of the molecules roll over each-other, resembling a liquid.

Once we had explained all that we began to talk about starch, which is just glucose molecules stuck together in a long chain. As I stated in my questions to consider if you were to add water to starch each glucose molecule would split off of the next and absorb the water. And in the end you would have a bowl of glucose molecules and the left over water, this process is called re-hydration.

The action of building the molecules allowed me to better understand that molecules are not flat, but are three dimensional. It also allowed me to better understand the relationship between each atom, and how double bonds take place. I also learned about the different types of fats and which are bad and which are good for you. I learned that saturated fats are solid at room temperature. And unsaturated fats are liquid at room temperature.

I learned that mono unsaturated means unsaturated in only one place. And poly unsaturated means unsaturated in more than one place. I learned that your body can break down cisfats, which are the naturally occurring fats. And transfats are not naturally occurring but is a small variation in the cisfats (a hydrogen atom is located in a different place). And your body cannot break down transfats.

I was surprised to discover the simplicity of how things are solid and how they are liquid. It would be interesting to conduct further research in finding how your body disposes of the transfats that you eat. I do not think there were any sources of error.

QUESTIONS TO CONSIDER:

What type of molecule is removed during dehydration synthesis?

A water molecule, one hydrogen atom and one oxygen molecule is removed from one glucose molecule and another hydrogen atom is removed from the other glucose molecule.

What happens to the "open" bonds that are created as neighboring sugar molecules lose component atoms?

Once the glucose molecules have lost a combination of atoms, on one molecule there is an oxygen atom that is in need of one electron. And in the other glucose molecule there is a carbon atom that is in need of one electron, therefore the two molecules are attracted to each other and join.

What might happen if you added water to a starch molecule?

Starch is a chain of glucose molecules that have undergone dehydration synthesis, therefore if you were to add water to a starch molecule the starch would split apart into two or more glucose molecules, depending on how long the chain of starch is.

When saturated, to how many different atoms can a carbon bond?

Carbon has a total of 6 electrons orbiting around it, there are two in its inner shell, and 4 in the second shell. In all atoms the second shell requires eight electrons in it's outer shell. This means that carbon requires four electrons.

What must be added to an unsaturated chain, in order to make it saturated?

Hydrogen atoms.

Infer the structural feature of a "polyunsaturated fat."

An unsaturated fat contains a double bond, therefore a polyunsaturated fat contains more than one double bond.

What are common features to all amino acids?

Amino acids must contain one nitrogen atom in the molecular arrangement. They also contain water and a double bond.

Compare and contrast the composition of an amino acid to a sugar.

They all have a group of COOH (1 Carbon, 2 Oxygen, and one Hydrogen atom). And they both have NH2 (1 Nitrogen, and 2 Hydrogen atoms).

From what you can observe in the molecular structure, can dehydration synthesis also produce long chains of amino acids? Explain.

Yes, because in a glycerin you could extract one hydrogen and oxygen atom from one molecule and another hydrogen atom from a different glycerin molecule and get join them.

CONCLUSION:

My hypothesis was mostly correct. I had a few areas that were not specific but overall the information given was correct. I learned that mono unsaturated means unsaturated in only one place. And poly unsaturated means unsaturated in more than one place. I learned that your body can break down cisfats, which are the naturally occurring fats. And transfats are not naturally occurring but is a small variation in the cisfats (a hydrogen atom is located in a different place). And your body cannot break down transfats.

I was surprised to discover the simplicity of how things are solid and how they are liquid. It would be interesting to conduct further research in finding how your body disposes of the transfats that you eat. This lab triggered a few additional questions:

On a molecular level what happens when water freezes? Do the atoms within the molecule rearrange? If so does that rearrangement enable the molecule to spin? Allowing it to compact?

WEB LINKS:

Computer Modeling

There are all sorts of computer molecular modeling programs on the web. Many are free to use and offer powerful construction and manipulation tools. Check out some of these free tools at http://ep.llnl.gov/msds/dvc/viewrs.html.

For MACs running under OS X, iMOL is a powerful program that you can download it at http://www.pirx.com/iMol.

3D Models From a 2D Image

By "free-viewing" two side-by-side images, you can experience the stereoscopic illusion of depth. This technique is sometimes used by scientists to help illustrate three dimensional layout of molecules. Check out this URL for some screen-popping examples of the free-viewing effect: http://valhalla.chem.udel.edu/3-D.html.

EXTRA CREDIT

Custom Model Building

Use the Internet and print resources to identify additional types of molecules that play a role in nutrition. Then, using either computer-assisted drawing programs or common materials construct models of these atomic arrangements. From their composition and structure, make inferences about their role in nutrition.