

The Making of Macromolecules

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 Date Created: Aug. 6, 2009
 Subject: Life Science
 Level: 7-12 grade
 Standards: 4.1.2, 1.1.1
Schedule: ~60 minutes

Objectives:

With the same elements, different chemical structures may be formed. Different structures of compounds will yield different functions.

Students will:

- Understand that there are four types of biomaterial: carbohydrates, lipids, amino acid, and nucleic acids.
- Understand that these organic compounds have basically the same chemical elements.
- Understand that polymers are made from a series of monomers bonded together.
- Understand that organic compounds composed of the same elements differ in function based on the structural orientation of the compound.

Vocabulary:

Monomer	Chemical Bond
Polymer	Dehydration
Amino Acid	Polypeptide
Protein	Polysaccharide
Lipid	Monosaccharide
Carbohydrate	
Nucleic Acid	
Glucose	

Materials:

For Each Pair:

- One set of 4 cards, each with a structure of a biomaterial
- A molecular model kit
- A dichotomous key (see p.4)
- Science Journal
Notebook

Safety:

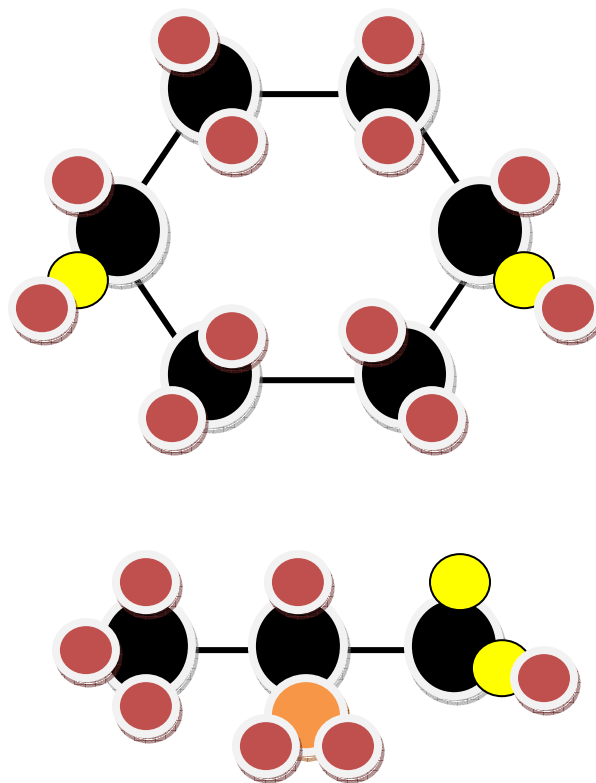
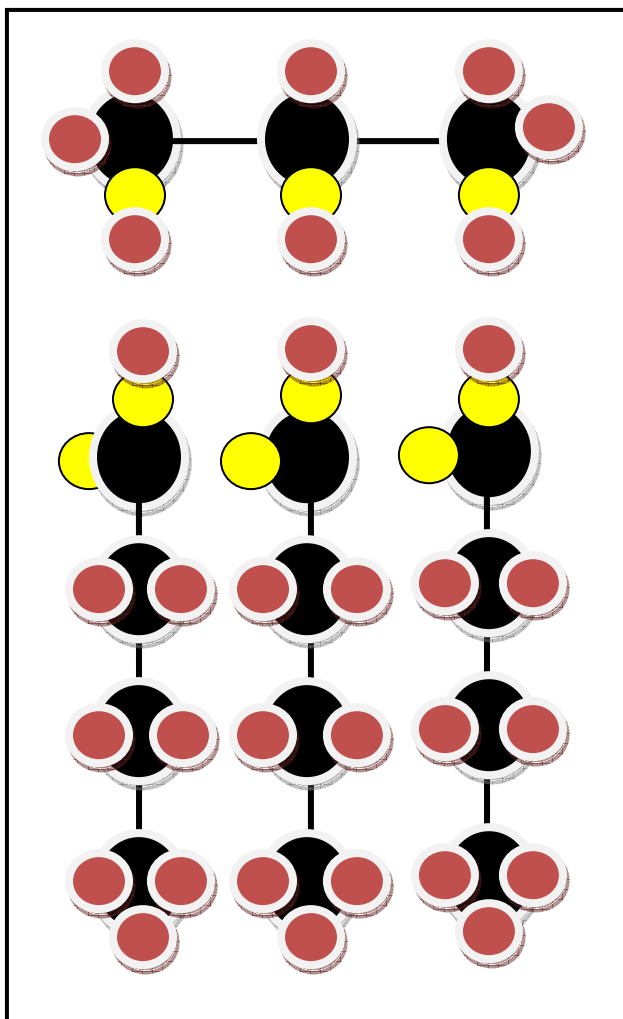
There are no safety concerns for this activity.

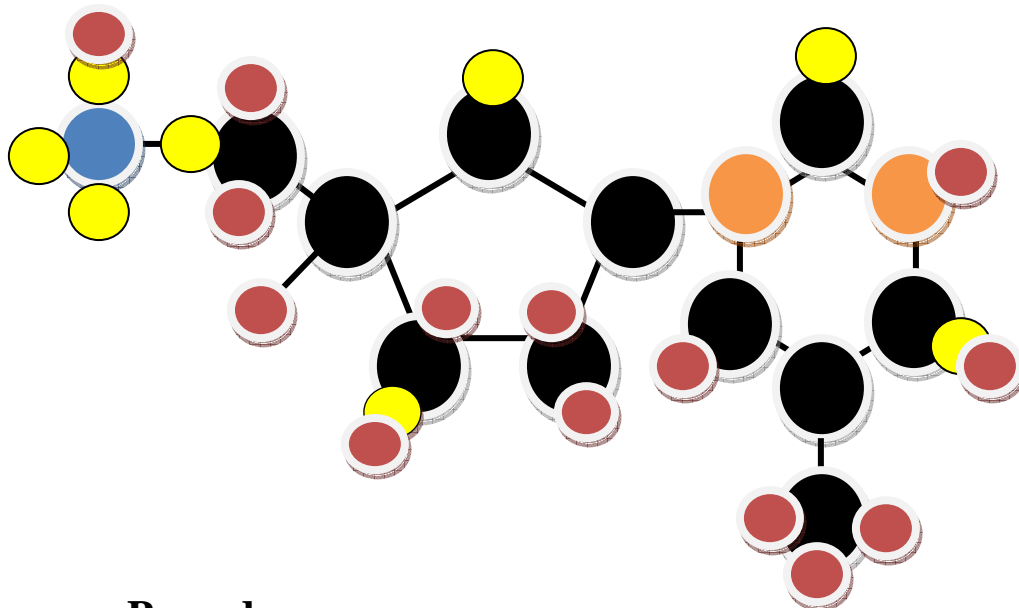
Science Content for the Teacher:

The basic chemistry of life is based mostly on carbon, oxygen, hydrogen, nitrogen, and phosphorus. These elements make up the four important molecules that make biological processes possible: carbohydrates, lipids, proteins, and DNA.

Preparation:

- 1) Prepare 4 cards, each card with structural formula one type of biomaterial (lipid, carbohydrate, protein (amino acid-alanine), nucleic acid (thymine))
- 2) The structural formula will only compose of color-coded atoms (w/o element symbols of each atom of molecule and w/o the name of each type of molecule), See page 3.
- 3) Prepare each group with a molecular model kit
- 4) Students should know that organic compounds are mainly made up of C, H, O, N, and P.
 Compounds are bound together by various types of bonds (covalent, ionic, hydrogen, van der Waals)





Classroom Procedure:

Engage (Time: 8 min):

Pre-Lesson/Research Homework: List one everyday use of each of the following elements – carbon, hydrogen, oxygen, nitrogen, and phosphorus.

For ex: carbon – riding on bus (carbon emission)

hydrogen – atoms in water

oxygen – breathing

nitrogen – breathing; fertilizers

phosphorus – matches, fertilizers, food additives

Do Now Assignment (Two options depending on the level of the students):

Option A: 1) What is a monomial?

2) What is a polynomial?

Option B: 1) What do each of the following symbol represent:

C, H, O, N, P?

Ask students to list a few facts from students' homework. Write them on the board.

“Did you know that phosphorus is used as a food additive? or Did you know that you are using a carbon right now as you are writing with your pencil? Well all these elements are used to keep us alive. These elements are not only useful in fertilizers and breathing, but they also take part in making our proteins, fats, carbohydrates, and most importantly our DNA.”

Explore (Time: 30 min):

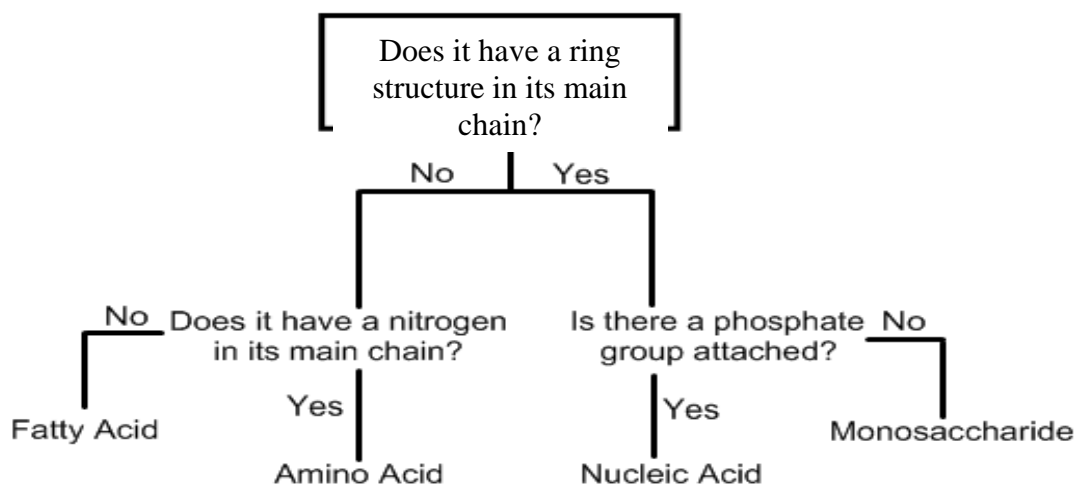
To familiarize students with the molecular structure of each of these biological monomers, students will build each type of molecule using molecular kits provided. This activity may be done in groups of 2-4 students. Give each group four monomer molecule cards and have students build the model of the molecule. Each group will have an image of a ball-stick model of one type of molecule. Students will not be told which molecules is which until the end of the lesson. Each card will also have a color key: Black = Carbon, Red = Hydrogen, Yellow = Oxygen, Orange = Nitrogen, Blue = Phosphorus.



Once groups are done with building their molecules, have students draw the structural formula of each type of macromolecule into Science Journal Notebook. Also have students write a description of their model. (Is there an overall shape of the monomer? What elements are present in the monomer? Make comparisons between the four monomers.

Explain (Time: 5 min):

Provide students with a simple dichotomous key to find out what types of monomers they built.

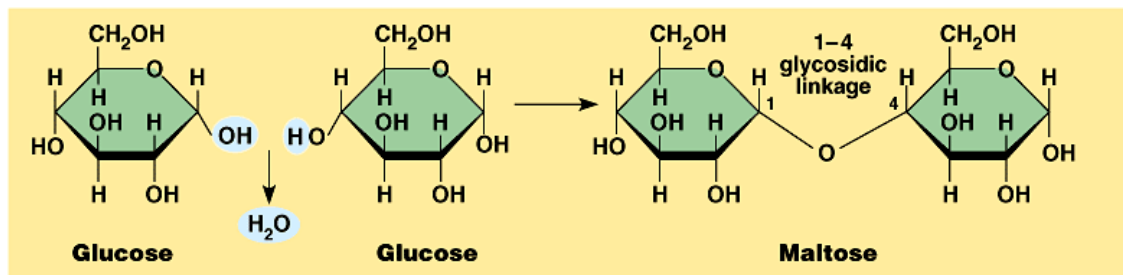


Expand (Time: 20min)

Now that we know what type of molecule we built, we can then construct polymers of each type of molecule and produce a macromolecule. Our bodies use chemical reactions to combine biological monomers together to form macromolecules that are useful to our bodies.

- Monosaccharide (glucose) → polysaccharides (starch)
- Amino Acid → proteins
- Nucleic Acid → deoxyribose nucleic acid
- Fatty Acid → Lipid (phospholipid)

How can we replicate that process? Present the image below for students to help answer the question:



(a) Dehydration synthesis of maltose

<http://io.uwinnipeg.ca/~simmons/cm1503/Image71.gif>

Why is this reaction called a “dehydration” reaction?



Model to students on how a dehydration reaction can be replicated using the models they have constructed, starting with the glucose molecules in Group 1 and Group 2. Have students with the glucose molecules from Group 1 and Group 2 to bond together while taking away one molecule of water. Setting the now bonded students from group 1 and 2, call up glucose molecules from group 3 and group 4. Link those together again using the same dehydration reaction. Once all the glucose molecules are bonded together, the class has produced a polysaccharide macromolecule (A POLYMER!)

Perform the same bonding procedure in front of the class using amino acids, nucleic acids, and fatty acids.

Have students summarize the class demonstration into their Science Journal Notebooks. Emphasize that DNA, proteins, fats, and carbohydrates are polymers formed from monomers that are chemically bonded together. The process that they undergo is called a dehydration reaction. This reaction results in the joining of two monomers and the release of a water molecule.

Assessment:

The following rubric can be used to assess students during each part of the activity. The term “expectations” here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

- 4= exceeds expectations
- 3= meets expectations consistently
- 2= meets expectations occasionally
- 1= not meeting expectations

	Engage	Explore	Explain	Expand/Synthesis
4	Shows leadership in the discussion and offers creative understanding of the science behind the making of biomolecules.	Completes work accurately while providing an explanation for what is observed. Works very well with group.	Provides an in-depth explanation of findings, making good use of vocabulary terms. Writes a detailed description in science journal.	Shows understanding of how polymers are made in the body. Writes detailed description of the process in science journal.
3	Participates in the brainstorm and shows an understanding of the science of biomolecules.	Completes work accurately and works cooperatively with group.	Provides clear explanation of findings. Writes a good description of observations and procedure.	Shows understanding and can express a good description of the process of creating a polymer
2	Contributes to the brainstorm, but shows little understanding of biomolecules.	Works cooperatively with group, but makes some mistakes with the procedure.	Provides a limited explanation of findings in science journal.	Shows some understanding of the process in making polymers. Records the process in science journal.
1	Does not participate in brainstorm. Shows no understanding of biomolecules.	Has trouble working with group. Does little to complete the procedure.	Is not clear in explanation of findings. Incomplete explanation in science journal.	Does not understand how polymers are formed. Incomplete description of the process.



Extension Activities: Use the models built by the students to later demonstrate the specific structure and orientation of atoms in the molecule will determine its function in the body.

Supplemental Information: Double bonds are not shown in the molecular structures on page 2-3. This activity only involved one amino acid, alanine and one type of nucleic acid, thymine. The lipids are slightly different. Instead of attaching the fatty acids together, 3 fatty acid chains are linked to one glycerol molecule.

Safety: There are no safety concerns associated with this activity.

Acknowledgments: Jane Earle, Kevin Dilley, Nev Singhtoa

