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Catering Middle-School Science: Monomers, Polymers, and Macromolecules

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> "It's not what we eat but what we digest that makes us strong; not what we gain but what we save that makes us rich; not what we read but what we remember that makes us learned; and not what we profess but what we practice that gives us integrity." ~Sir. Francis Bacon

Objective

The first and last units of the seventh grade curriculum in science are respectively, chemistry and food preservation. During the year students progress the complexity of their learning from the atom through the cell, human systems and lastly, food preservation. This unit seeks to make connections by first reviewing simple chemistry and previous lessons on atoms, molecules, compounds and their physical and chemical properties. And then connect those lessons to how elements and inorganic molecules are related to organic or living, things. The lesson plans use food to review the chemical components of living things, with emphasis on the macromolecules. The students will learn to break down the macromolecules into their individual monomer components and be introduced to simple chemical composition of basic food molecules. Students will build on their knowledge of chemistry in living things. Then they will incorporate lessons in physical science into biological processes and bridge the gap between organic and inorganic. The use of food to teach chemistry will further assist students in discovering the connections between elements and living organisms.

Academic setting

The intention of this unit is to introduce monomers, polymers and macromolecules to students in grade seven. Using food will teach students about how molecules are intricately connected to each other and help them link scientific principles to everyday life. The unit assumes students have some prior knowledge of the atom and elements in the periodic table and have discussed the difference between living and non-living things.

Six characteristics define living organisms; they are made of cells, obtain and use energy, grow and develop, reproduce, respond to their environment and adapt to the environment. Something must possess all six characteristics to be considered an organic living thing [1].

While the focus is to engage the middle school student, adaptations of the unit will be suggested for grades six through twelve and elementary teachers can certainly take smaller parts of the unit to use in their classroom. The unit can be taught as a whole or integrated into another part of the curriculum.

Introduction

Food chemistry is about how food is processed, prepared and distributed. Basic food chemistry is a study of how water, carbohydrate, proteins and lipids work together to form the food we consume. This unit explores basic food chemistry and attempts to make connections between the chemistry of food and the complexity of life. Three components of food; carbohydrates, proteins and lipids are each composed from similar chains of monomers, along with some other elements, are organized to create large molecules with unique and specific properties. In food chemistry these are the macromolecules. All macromolecules have as their basic foundation the molecules of hydrogen, oxygen and carbon. The wide variety of the protein macromolecules, add nitrogen and side groups of other molecules. Living things are fundamentally made from carbohydrates, proteins and lipids in a multitude of combinations that, along with water, not only make up unique species but also unique individuals within each of these species.

The fourth macromolecule of biology is the nucleic acids. This macromolecule contains the blueprint to instruct the processes that make each individual unique. This paper will not include this macromolecule because instruction about the nucleic acids would be longer than can be addressed here. While nucleic acids certainly have a place in the formation of foods we eat, nucleic acids are not relevant to food except in the essence of the blueprint which makes up all living molecules. Nucleic acids are the code for long chains of amino acids that make up proteins. The business of amino acids within each individual cell is complex and serves as the intelligence, reasoning library and processing center of life.

Monomers and Polymers

Monomers build into polymers and then connect with other molecules to form the things we eat, the organisms we are. A monomer is a small molecule that through chemical bonding can become a larger molecule. An example of a monomer is methylene (CH_2). Bond some CH_2-CH_2 groups and you get ethylene (ethene), the simplest alkene and the most produced organic compound in the world [2]. Ethylene is a natural hormone in plants and a sweet smelling and tasting gas. Ethylene can be found in natural gas and petroleum. In nature this gas promotes fruit ripening, leaf fall and inhibits growth [3]. Polymerization of ethylene, or adding more monomers, makes polyethylene. Monomers that are bonded together without loss of any atoms of the monomer are named by placing 'poly' in front of the monomer name. Polyethylene terephthalate (PET) is what soda bottles and laundry detergent containers are made from. Ethylene is a starting monomer for other two-carbon compounds; the most common are ethanol (manufactured alcohol) and ethylene glycol, the starting material for polyester, also known as anti-freeze. High density Polyethylene (HDPE) is used for milk jugs, shampoo bottles and landfill liners, while garbage bags, tape and disposable diapers are made from Low Density Polyethylene (LDPE). Poly vinyl chloride (PVC) is formed into pipes, siding and shower curtains; polypropylene (PP) is use for chip and cookie bags as well as Tupperware [4]. Ethylene is also converted to acetic acid and vinyl chloride or added to benzene to make plastics and synthetic rubber.

Synthetic, or man-made, polymers are commonly called plastics. Polystyrene, first made in the 1800s, seemed to have limited uses, until scientist learned to adjust the formula weight and inject gases into the mixture of monomers in the liquid state [5]. Polystyrene can be found in packing foam and disposable cups. Polymers play important roles in both living and non-living things, they are as simple sugar, fat, amino acids and plastics and form living organisms as complex as human beings.

Natural polymers are used as emulsifiers, thickens and stabilizers in the food and medical markets. Natural polymers are derived from the simplest organic compound; a hydrocarbon [6]. Hydrocarbons contain only hydrogen and carbon and can take many shapes. Carbon has an atomic number of six. Six protons in its nucleus, six electrons flying around them. The six electrons are arranged in two orbits, two in the first, which is called 'filled', and four in the second. The second orbit or 'p' orbit is happy as an octet, which means the atom is stable and will remain that way when there are eight electrons circling the nucleus; that means carbon is a friendly atom and is looking to share electrons with four other atoms. Hydrogen has an atomic number of one, like carbon; hydrogen would like a full outer shell as well. Hydrogen atoms are abundant and four of them are willing to bond with carbon making the molecule Methane (CH_4) [7]. What is special about carbon is that carbon likes to bond to many different molecules and form various structures; like rings and branched chains. Carbon also forms double bonds and seems to have a limitless capacity for creating new molecules. Some common natural polymers are gelatin (denatured collagen), keratin (the strong protein in skin, hair, nails, hooves, horns and teeth), silk (protein fiber), wool (hair follicles of animals in the Caprinae family), rubber (derived from plant sap), chitin (shells of shellfish) and DNA (a double helix of polymer chains) [8]. Chains of monomers comprise just about every reaction on earth. The longer the chain the more tangled it becomes and the less mobile the molecule becomes.

Polymers are linked, which makes them slow moving molecules. The larger a polymer is the less movement there is in a molecule [9]. This makes some molecules harder, more brittle and easily shattered and others difficult to break down (like rubber). Some polymers are made by a process called dehydration synthesis. Dehydration synthesis is a way that molecules are joined and a water molecule is removed [10]. When the bond between monomers is broken by enzymes there is addition of a water molecule, this is called hydrolysis.

Hydrolysis is the breakdown of a molecule into smaller components with the addition of water; hydro=water, lysis=to breakdown. Enzymes are known to catalyze, or speed up, reactions by lowering the amount of energy needed to start a reaction. They are therefore the biological catalysts that assist in the breakdown of polymers by reducing start up energy for a reaction [11]. Enzymes are very large protein molecules that resist being altered themselves; therefore they can be used over and over again. Enzymes are, however, specific to particular reactions. Amylases are enzymes that breakdown starch into sugar. They are present in the mouth and pancreas of mammals and are a common component of seeds. Natural polymers owe their diversity to carbon. The abundance of different combinations of molecules is possible because carbon is a molecule with four bonding sites that are always looking to be filled. Carbon is a very friendly molecule that loves to grab onto other molecules to form new bonds. Add water and its special properties into the mix and the combinations are endless.

Carbohydrates

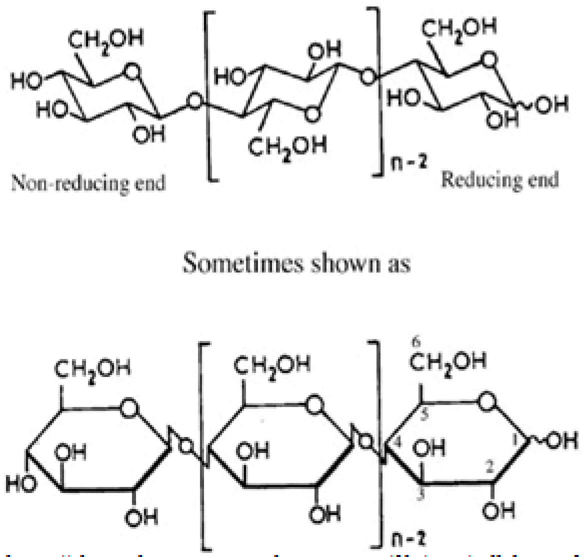
Polymers are long molecules made up of repeating chains of monomers. Add glucose to fructose, the sugar in fruit, and you have table sugar (sucrose). Pretty simple so far! Add many more sugar molecules, also known as saccharides, and you come up with a polymer called starch. Carbohydrates make ideal molecules for storing energy because they are large, making them insoluble in water. They are also known to fold into many shapes and are easily converted into other sugars when needed.

The monomer of carbohydrates is a monosaccharide with the basic formula of a carbon, two hydrogen and an oxygen molecule ($CH_2 0$) [12]. Glucose, a product of photosynthesis, is simple sugar and a monomer with the chemical formula $C_6H_{12}O_{6.}$ Glucose is commonly known as corn sugar or blood sugar. Glucose is a monosaccharide or simple sugar made by plants and some prokaryotes. This molecule is used in cellular respiration by the mitochondria in the cell and produces energy needed to carry out cell processes. Glucose (also known as dextrose) is a basic monomer of carbohydrates [13]. Carbohydrates are classified based on the number of carbons they have. Glucose, galactose and fructose all have a six-carbon ring and the same formula; they are hexoses and isomers of one another. An isomer has the same formula but a different structure. Ribose, arabinose, and xylose have five carbons in their formula and are known as pentoses. There are many more, they generally differ in the number of carbons or in the orientation of the hydroxyl (-OH) group. These seemingly small differences affect a sugar's biochemical properties such as taste, or physical properties, such as the temperature at which they melt [14]. This can make a recipe succeed or fail, if you are cooking, and using a different type of sugar than was called for.

Disaccharides are double sugars ($C_{12}H_{22}O_{11}$). One molecule of water is missing from the formula. A few examples are sucrose (glucose+ 2 fructose), lactose (4 glucose + galactose) and maltose (glucose +4 glucose) [15]. Sucrose is table sugar, lactose is the main sugar in milk [11]. Maltose is not naturally occurring and is the product of hydrolysis. Maltose is the by-product of the principal plant polysaccharide called cellulose. Cellulose is an important carbohydrate in nature.

Polysaccharides are large polymers of sugars and macromolecules ($(C_6H_{10}O_5)_{n.}$ Starch is a king-size polymer of many glucose molecules. A complex form of starch is amylopectin, a branched network of glucose molecules. A simpler form is amylose, which has between 200 and 20,000 glucose units [16]. Starch is the main component of potatoes, bread, rice and corn that gives these foods their sweet taste. Starch is the storage molecule of plants, a main constituent of seeds. Since starch is insoluble (can not be dissolved) in water or alcohol this molecule is easily hydrolyzed by enzymes called amylases. Amylases will break down this gigantic polymer into monomers for energy use quickly and efficiently. Animals store a polysaccharide called glycogen. Glycogen is a polymer of glucose like the amylopectin that makes up starch, but glycogen has many more branches. Hydrolysis of glycogen releases glucose for quick use in animal cells. Cells utilize glucose for energy. When glucose cannot be stored as glycogen it is stored as fat [17]. Stored glycogen does not last long in humans or an animal, that is the reason for the need to eat.

A cousin to starch is cellulose, the connective tissue in plants. Starch and cellulose are both polymers of the monomer glucose and have the same repeated glucose-based monomers. Cellulose is a structural polysaccharide of plants. Cellulose is linear and indigestible in human digestive system, which helps keep it working.



https://chempolymerproject.wikispaces.com/file/view/cellulose.gif

Cellulose

There are two major biological structural polysaccharides; chitin and cellulose. Cellulose may contain more than half of the world's total organic carbon. Wood is mostly cellulose, and cotton is almost pure cellulose [18]. Cellulose is digested by the microorganisms in termites and the stomach of ruminants. Cellulose aids in the smooth working of the digestive track of humans by providing indigestible fiber [19]. Cellulose is an unbranched natural polysaccharide like chitin.

Chitin is a natural polysaccharide and makes up the shells of lobsters, shrimp and insects. The difference between cellulose and chitin is mobility in the molecule. Chitin is an unbranched polysaccharide that is hard and brittle. Chitin's brittleness may be attributed to a side chain containing nitrogen that cellulose lacks. Chitin's extra side chain also increases its size and mobility. Cellulose is soft, but when layered, as seen in the trunks of trees, cellulose can be very strong. Cellulose has a sister component in animals called collagen.

Proteins

Collagen is a polymer of proteins. A protein is a natural polymer made up of amino acid monomers joined by peptide bonds. Amino acids are chains of glucose molecules that have a carboxyl (COOH) and an amine group (NH_3) on either end. Peptide bonds, or amide linkages, are covalent bonds formed between the carboxyl and amine groups. Proteins are also known as polypeptides. A dipeptide is made up of two amino acids, a tripeptide of three amino acids; tetrapeptide of four amino acids, more than four amino acids is referred to as a polypeptide. Polypeptides can be found in four levels of structure; primary, secondary, tertiary and quaternary. Each one is more complex.

Primary structure proteins are a chain of amino acids connected by peptide bonds, like a string of beads. Secondary structures have hydrogen bonds that twist like a telephone cord and form alpha helices or beta sheets. Tertiary structures are formed when folding and bending of amino acid chains causes interaction and bonding between groups. This is when proteins become active. Quaternary structures contain two or more amino acid chains and are even more folded and bent forming fibrous, globular or conjugated (reversibly combined) structures [20]. Collagen has a quaternary structure and is a fibrous or structural (insoluble) protein. Cellulose, a carbohydrate, provides the material for the basic structure of plants and collagen (protein) provides the material for the basic of animals. There are at least sixteen forms of collagen known and their basic structure is a triple helix [21]. These molecules are made of carbon, hydrogen, oxygen and nitrogen with a few other elements, their long chains and myriad of combinations formulate a multitude of parts that constitute all life forms on Earth.

The formation of protein polymers provides the foundation for the construction of living things. Actin is the most abundant protein in eukaryotic cells. Actin allows movement inside and outside the cell. Actin is said to be highly conserved across species, which means that very little difference can be found between actin in the cells in humans or in the cells of algae [22]. Proteins are not lone molecules, of course, carbohydrates, as discussed earlier and lipids play critical roles in the makeup of living things as well. Yes, this is all chemistry! Life is made of molecules the same way plastics are made of long chains of molecules. And most man-made polymers are based on formulas taken from nature.

Lipids

Lipids are a group of polymers that have one major characteristic in common, they are hydrophobic or don't mix with water [23]. Fats, steroids, triglycerides, fatty acids, phospholipids and waxes are important groups of lipids. Lipids store energy in their bonds and therefore animals store fat as an energy source.

Each molecule of fat is made up from two kinds of smaller molecules; glycerol and fatty acids. Glycerol is an alcohol; three carbons molecules with hydroxyl (-OH) groups attached to each. Glycerol absorbs water from the air is used as a sweetener, and in the manufacturing of cosmetics, liquid soap, liqueurs, ink, lubricants and dynamite. Fatty acids are long unbranched chains of hydrocarbons (H-C-H) with a carboxyl group (-COOH) at one end [24]. When a glycerol's hydroxyl group reacts with the carboxyl group of a fatty acid a condensation reaction occurs and a water molecule is removed to form a monoglyceride. A second reaction yields a diglyceride and a third a triglyceride. Triglyceride (triglycerol) is therefore three fatty acids linked to a glycerol.

Saturated fatty acids have the maximum number of hydrogen atoms and are typically solid at room temperature. Unsaturated fatty acids have one or more carbon atoms with a double bond; this produces a bend in the molecules and they are liquid at room temperature. Fats that are liquid at room temperature are oils. There are an abundance of fatty acids that can all serve as one of the three chains in a fat molecule. All three can be saturated, unsaturated or any combination of both; this is what gives fats different physical and/or chemical properties. In general, shorter chains and less saturated fatty acids create softer, homogeneous fats [25]. An example of a fatty acid that is polyunsaturated is linoleic acid (a main component in flax, sunflower and safflower oil). Oleic acid (in olive oil, grapeseed oil, acai) is monounsaturated and stearic acid (in animal fat and cocoa) is a saturated fatty acid.

Connections

Each living molecule has a structure and a function. Man has made many polymers whose structure and functions are based on natural compositions. The lesson plans are designed to help students make the connections between the inorganic and the organic.

Students will first explore man made polymers. Starting with atoms, students build on their knowledge of polymers through a virtual field trip which results in a poster and completed worksheet. Teachers then have the option to extend this lesson by using cooked spaghetti to demonstrate polymer reactions and using a borax solution to make polymers in the classroom. The website for the Virtual Field Trip also has a connection to careers.

The second activity in Lesson Plan 1 is a pre/post test and two worksheets with a supportive website that reviews macromolecules. Following the man-made polymer lesson students should begin to see the similarities between inorganic and organic molecules. This activity is also follow by an optional extension; a polymer game and recipe for making polymers in the classroom, or a 'homework' website that contains a series of puzzles and games to help memorize facts about macromolecules.

Lesson plan 2 is intended to help the student see macromolecules in foods using a few reagents as indicators of the presence of carbohydrates, starch, lipids, and proteins. The reagent kit was purchased and the information of how to get one is provided. Teachers would need to acquire Benedict's solution, Iodine, Biuret reagent and Sudan IV as reagents if they do not purchase the kit. This lesson was planned to be completed over a few days with these specific foods; turkey slices, cheese, lettuce, tomato, a sandwich wrap, and mayonnaise.

A handout is provided in the appendix and students will test for a different macromolecule over one or two days. The ingredients chosen are specific because they are used in the inquiry lesson at the end of the unit where the students is given a sandwich wrap and have to determine which macromolecules the wrap contains. The ingredients can also help the teacher lead into a lesson about nutrition to complement the lesson. The third activity is an inquiry lesson where student use what they learned about testing for macromolecules to determine and compare the components in different types of milk.

Lesson Plan 3 has students building monomers and polymers. The first activity is teacher driven. The teacher models how to build a monomer and then make a series of monomers into polymers using either multicolored marshmallows or gumdrops and toothpicks. The second activity has students using vegetables to build models of macromolecules from line drawings on a worksheet (provided in the appendix). From these activities students will discover the differences in physical and chemical structure of the macromolecules.

Lesson Plan 4 is an inquiry based lesson plan where pairs of student receive a multi-ingredient food item and plan how to find out which macromolecules are present. The added reward is the students get to eat the 'leftovers' there were untested. Lab Activities are planned for one 45 minute period each.

Lesson plans

Lesson Plan 1 Monomers & Polymers

Introduce students to monomers and polymers by explain that one is made up of the other. The links between molecules are called bonds and some molecules are straight, others can be curved, folded or bunched. The simplest molecule to start with is methane(CH_2). Methane bonds to itself and other molecules and is the monomer basis for hundreds of polymers. Draw the carbon atom on the board for students (6 proton nucleus, 2 electrons in one shell and four in the second shell. Show how carbon has four binding

sites, so it is happily trying to attract other atoms. Explain to students that molecules like to feel complete and that means all their sites are attached to others. Binding sites are where bonds form between molecules. Add four hydrogen atoms to the carbon, explaining how hydrogen has one electron its outermost shell. Explain to the students that this is a monomer and when you link more monomers to it you form polymers. Students should now be ready to explore monomers and polymers on their own through the Virtual field trip.

Objectives

Identify the chemical components of monomers, polymers & macromolecules

Connect monomers and polymer with things used in everyday life

Reason about the similar components of all things; living and non living

Explore polymer science

Lab Activity 1.1

Virtual Field Trip can be downloaded from the website for James Hillhouse High School at http://www.nhps.net/hillhouse/academics.htm#Science

Scroll down to Mrs. Beitler's Science and click on the Polymer webquest with hyperlinks. The outcome of the field trip is a page of notes from which students can join in a group to make a poster about monomers and polymers. Teachers may want to print the sheet for students to fill in. The answer sheet can be found in Appendix B.

Extension: Teachers can visit the website Playing with Polymers at http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/polymer.html to find a quick, fun hands on activity for students to support this lesson.

Lab Activity 1.2

Review of the Macromolecules with student worksheet. Print Pre/Post test, Monomers of Macromolecules work page, and Tree of life worksheet for students

Tree of Life to Macromolecules. All can be found at:

http://www.concord.org/~btinker/workbench_web/unitIV_revised/act1.htm

There is good visualization of progression of monomers to polymers and connections to biological macromolecules.

Extension: Visit http://www.kids.union.edu/makingPolymers.htm for a polymer game and recipe for making polymers in the classroom. Alternatively use Study Stack at http://www.studystack.com/studystack-7111 where you can find a series of printable puzzles and games with answers that can help students memorize facts about macromolecules.

Lesson Plan 2 Identifying Macromolecules in Foods

Using chemical reagents students will test six foods for the presence of glucose and starch. Before these activities, introduce the macromolecules. I ordered a reagent kit for around $ 30 from http://www.hometrainingtools.com/chemistry-of-food-experiment-kit/p/KT-CHEMFD/ . The kit contains all you need to do approximately 10 tests for glucose, starch, protein and Vitamin C and a few added items. The basic reagents are Benedict's solution for glucose, iodine for starch, Biuret reagent for protein. I would purchase Sudan IV for lipids in addition. The directions for these tests are simple and easily found on the internet or in any good biology book. Below you will find basic instructions for quick macromolecule labs.

As the lesson begins remind students that monomers are small molecules that are linked to make polymers. Ask questions like; what is a monomer? (Molecules built from smaller, simple molecules.) What is a polymer? (Repeated, linked units.) Show monomers turning into polymers on the board. Tell students that this is a very important concept, if they learn to categorize in this manner that they will understand biology! Print Worksheet 1 and hand out to all the students. Ask volunteers to read the definitions. As each definition is read, give examples and draw structures on the board. Have students copy structures into their handout.

Objectives

Identify carbohydrates, lipids and proteins in foods.

Determine the different types of carbohydrates in food

Understand the hydrophobic nature of lipids.

Discover the variety that exists among proteins.

Describe the effects of heating molecules- denaturing proteins (enzymes)

Lab Activity 2.1 Test for Carbohydrates (Student worksheet in Appendix B)

Ask students 'What is another name for carbohydrates?' Assign each student a definition from the handout and ask them to come up with as many examples as they can for each type of molecule. List them on the board and discuss how each example fits the category. Ask student how they came up with their examples.

Prepare test solutions: Give students 1/4 teaspoon of tomato, lettuce, cheese, turkey and a sandwich wrap with a mortar and pestle. Instruct them to clean the mortar and pestle well and then mash one of the food items until it is a paste. Ask the students to add the item to 1 teaspoon of water in a small cup and stir well. Have them clean the mortar and pestle and mash the next item until all six have been placed in cups. (Alternatively, student groups can do different items and report the results to the class.) These liquids are the test materials for all test reagents.

Test for Glucose

Materials; Benedict's solution, pipettes, 6 small test tubes, test tube rack, test tube clamp, 250 mL beaker, small pan, burner or hot plate

1. Label 6 test tubes with the names of each of the foods given.
2. Add 5 ml of Benedict's solution to each of the 6 labeled test tubes
3. Add 15 drops of each food solution to the corresponding labeled test tube, stir.
4. Make a chart to record two results for each food; Beginning color, ending color.
5. Record beginning colors for all 6 test tubes after adding the 15 drops
6. Place the beaker in the sauce pan, add water to equal levels inside and out of the beaker and set on the burner to boil.
7. When big bubbles rise to the top, turn the burner to low & place all six test tubes in the beaker
8. After three minutes, turn the burner off, remove the pan from the heat and using the test tube clamp, remove the test tubes from the beaker back to the tube rack.
9. Allow the solutions to cool five minutes, swirl to mix and record colors in a chart.
10. Compare results with class mats. Green, yellow, orange or red indicates the presence of glucose. Dark red indicates more sugar then the others

Lab Activity 2.2 Test for Proteins and Lipids

Assign students each a definition and ask them to come up with as many examples as they can for each type of molecule. List them on the board and discuss how each example fits the category. Ask student how they came up with their examples.

Other procedure and reagents can be explored for alternative labs at these sites;

Glucose Test strips procedure can be found at:
http://www.nutrition.org.uk/upload/Test%20foods%20for%20glucose.pdf

Benedict's solution for starch a procedure can be found at: http://www.miniscience.com/projects/starch1/

Identifying Lipids and Proteins; Ideas for procedures and materials can be found here:

http://www.scienceteacherprogram.org/biology/Lillien02.html

and

http://chem.lapeer.org/Bio1Docs/ProteinLipidLab.html

or

http://seplessons.ucsf.edu/node/362

Where is the Protein?

Materials; Biuret solution; test sample solutions

1. Label 6 test tubes with the names of each of the foods given.

2. Add 15 drops of each test solution to each of the 6 labeled test tubes

3. Add 3 drops of Biuret to the corresponding labeled test tube, stir.

4. Make a chart to record two results for each food; Beginning color, ending color.

5. Record beginning colors for all 6 test tubes after adding the 15 drops

6. Record ending color after stirring.

Looking for Fat; Lipids tests

Materials: Sudan IV, brown paper bag, test sample solutions, oil, water

1. Label 6 test tubes with the names of each of the foods given.
2. Add 15 drops of each test solution to each of the 6 labeled test tubes
3. Add 3 drops of Sudan IVs food solution to the corresponding labeled test tube, stir.
4. Make a chart to record two results for each food; Beginning color, ending color.

5. Record beginning colors for all 6 test tubes after adding the 15 drops
6. Record ending color after stirring.
7. Using a wax pencil draw a circle the size of a quarter for each solution on a brown paper bag. Add one circle for water and one for oil.
8. Put one drop of each solution into the labeled wax circle, add one drop oil to oil circle and water to water circle and allow to dry
9. Record the appearance of the circles by comparing them to oil and water.

Lab Activity 2.3 - Spin Test for Milk (worksheet Appendix B)

Using the reagents and a microcentrifuge, students develop a procedure for finding the macromolecules in milk. This activity has students comparing the level of fat, water and protein in 3 types of milk. Students measure the layers and write a procedure to determine the macromolecule in each layer. Format and print Worksheet 2 for students.

Objectives

Write a procedure for lab experimentation using known reagents

Explore centrifugation and separation of a liquid

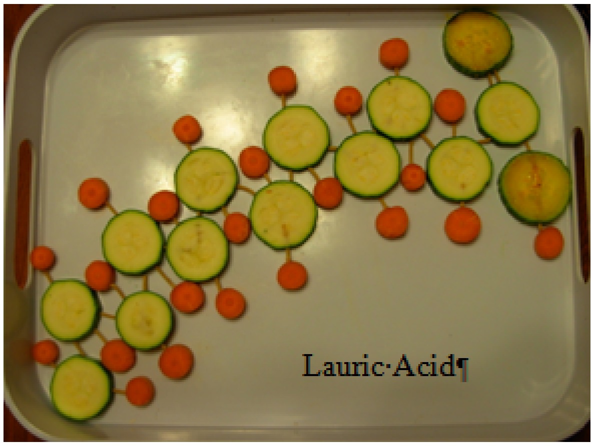
Identify layers in a centrifuged specimen

Determine the macromolecules in milk

Extension: Students can read and answer questions at http://bioweb.wku.edu/

courses/biol115/Wyatt/Biochem/macromolecules.htm for a review of this lesson.

Lesson Plan 3 - Building Macromolecules



In this lesson, students form the structure of the macromolecules using foods. The first activity has the teacher modeling each monomer using either colored marshmallows or gumdrops and toothpicks cut in half. In the second activity students use vegetable slices and create models from drawings. Common vegetables represent elements found in the macromolecules and spaghetti is used to represent the bonds between the molecules. Students will recognize the way macromolecules are put together and discover how smaller molecules are repeated to form polymers.

Objectives

Name the four types of macromolecules.

Identify the formula of water, carbohydrates, lipids and proteins

Identify the terms monomer and polymer

Lab Activity 3.1 - Building Polymers from Monomers

Mini marshmallows of four colors or gumdrops (4 colors), toothpicks

Teacher models monomers & polymers, student copies models

Lab Activity 3.2 - Vegetable Macromolecules

In this activity students form the physical structure of the macromolecules using vegetable slices. Common vegetables represent elements found in the macromolecules; spaghetti is used to represent the bonds between the molecules. Students will recognize the way macromolecules are put together and discover how smaller molecules are repeated to form polymers. Format and print Worksheet 3 for each student.

Materials: Vegetable slices; Carrots (larger are easier to slice), zucchini, cucumber, radishes, toothpicks, spaghetti (uncooked), paper plates or cutting boards, napkins, plastic knives, protractor(optional).

1. Draw the structure of four simple macromolecules (Virtual Chembook - Teacher Resource 11)
2. Draw a key on the board; Hydrogen - carrots
   Carbon - zucchini
   Oxygen - cucumber

Nitrogen - radishes
(or other vegetables such as; parsnips, yellow squash, young and thin, green bananas, anything that slices into circles can be used instead of above)
3. Formulas; Water - H2O
Carbohydrate - $C_6H_{12}O_6$ (glucose)
Protein - NH_2-CH_2-COOH (glycine)
Lipid - $CH_3(CH_2)_{10}CO_2H$ (lauric acid)

4. Ask students to slice vegetable in thin slices, less than 1 cm.
5. Tell students use the vegetables to make each molecule on their plate.
6. Ask students to use the toothpick to 'stick' molecules holes in the vegetable slice before inserting a piece of spaghetti to form bonds between atoms.
7. Students can eat each molecule after the teacher checks it for accuracy.
8. An extension could be to measure the angles of the bonds using a protractor- The teacher might even give a prize for the molecule that is closest to the actual one.
9. Use Virtual Chembook http://www.elmhurst.edu/~chm/vchembook/index.html or Natural Products at http://www.cem.msu.edu/~reusch/VirtualText/biomol.htm to show students other carbohydrates, proteins, and lipids if possible.

Lesson Plan 4 Wrap it up!

Objectives

Identify three macromolecules in a wrap sandwich

Describe how each macromolecule contributes to the cell

Identify questions that can be answered through scientific investigation

Use appropriate tools and techniques to make observations and gather data

Lab Activity 4.1

1. Using flour tortillas make a wraps students
2. Cut the wraps into slices and give each student a piece to experiment with.
3. Ask the students to unroll the wrap and describe the contents in terms of macromolecules (see Worksheet 3 in Appendix B)

4. Suggested 'stuffings'; lettuce (water), tomato (carbohydrate, water), cheese (lipid, protein)-turkey (protein, lipid) and mayonnaise (protein, lipid).
5. After the students have completed the worksheet (and if you can afford it!) let them make a wrap of their own to eat, this is a great lead into nutritional eating!

Endnotes

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[1] Solomon, Eldra P. Berg, Linda R. Martin, Diana W. (2005). Biology. Belmont, CA Brooks/Cole-Thomson Learning 7th ed. p. 2-5

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Appendix A. Implementing District Standards

C0. Describe matter and its properties - observation & description of matter throughout activities
C 1. Describe the properties of common elements, such as oxygen, hydrogen, carbon, iron and aluminum. - unit thoroughly describes carbon, oxygen, hydrogen & nitrogen
C 2. Describe how the properties of simple compounds, such as water and table salt, are different from the properties of the elements of which they are made.- unit addresses properties
C 3. Explain how mixtures can be separated by using the properties of the substances from which they are made, such as particle size, density, solubility and boiling point.- Separation of milk activity addresses this standard
C7. Describe the effect of heating on the movement of molecules in solids, liquids and gases- discussion on movement of molecules in protein enzyme section
D 17. Explain how the chemical structure of polymers affects their physical properties. - polymer section covers this
D 13. Explain how the structure of the carbon atom affects the type of bonds it forms in organic

and inorganic molecules.- throughout unit standard is addressed

D 14. Describe combustion reactions of hydrocarbons and their resulting byproducts.- natural polymers discussed after polymers

D 15. Explain the general formation and structure of carbon-based polymers, including synthetic polymers, such as polyethylene, and biopolymers, such as carbohydrate. - unit contains hands-on activities to address this standard

D 16. Explain how simple chemical monomers can be combined to create linear, branched and/or cross-linked polymers.1 st lesson plan

Identify questions that can be answered through scientific investigation. -addressed throughout activities and lessons

Read, interpret and examine the credibility of scientific claims in different sources of information.- addressed throughout activities and lessons

Design and conduct appropriate types of scientific investigations to answer different questions.- last two activities are inquiry based

Identify independent and dependent variables, and those variables that are kept constant, when designing an experiment.- all activities should address this

Use appropriate tools and techniques to make observations and gather data.- lab report

Use mathematical operations to analyze and interpret data. - lab report

Identify and present relationships between variables in appropriate graphs.- lesson plan 2

Draw conclusions and identify sources of error.-lesson plan 2

Provide explanations to investigated problems or questions. - all activities

Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.- all lessons

Appendix B. Student worksheets

Answer sheet for Virtual Field Trip

Linked in l-o-n-g chains of m-o-n-o-m-e-r-s ! TEACHER NOTES

This lesson follows an introduction to polymers -The first site in this tour is unfinished as of this writing; but students can use the "View sample" to get important facts; then they can "play" in Macrogalleria. Teachers can contact the UMass-Amherst PS&E Outreach site to gain information & develop a unit. http://www.pse.umass.edu/outreach/#outreach . Links will only work on the student's page if they are online - email them the instruction sheet or link it to your web page! Links are below.

Virtual Field Trip - Polymers. Target audience- grades 7-12. Outcome - Poster about polymers

As we continue our unit in biotechnology we will be looking at what scientists are making to mimic natural systems. The advantages of using a synthetic product that the body will not recognize as foreign are enormous. First, let's take a virtual tour and discover what a polymer is! Go to http://www.pse.umass.edu/outreach/#outreach . Scroll down Click on View some sample slides from our Outreach presentation . Read the presentation. Answer the questions below:

What is a polymer? Many units of monomers

What are two molecules found in most polymers? Carbon and hydrogen

Name six synthetic polymers and give an example of each:

1. polyethylene terephthalate (PET)- soda bottles, laundry detergent containers

2. High density polyethylene (HDPE) - milk jugs, shampoos bottles, landfill liners

3. Poly vinyl chloride (PVC) - shower curtains, siding, piping

4. Low Density Polyethylene (LDPE) - garbage bags, tape, disposable diaper liners

5. Polypropylene (PP) - chip and cookie bags, Tupperware

6. Polystyrene (PS) - packing foam, disposable hot cups

Name six natural polymers and where they are found; (8 are listed)

1. Collagen - protein in connective tissue

2. gelatin -is made from the boiled bones, skins and tendons of animal; Jell-O, jelly

3. keratin - skin, fingernails

4. silk -protein fiber from the cocoon of silkworm larva

5. wool -fiber from sheep and goats

6. cellulose - plant cell wall

7. natural rubber - an elastic milky latex in the sap of a rubber tree

8. DNA - double helix nucleic acid inside the nucleus of a cell

Why is the motion in polymers s-l-o-w? polymers are linked molecules this

makes them slow

Polymer (http://www.pslc.ws/mactest/maindir.htm) facts Poster project. Visit each

level of polymer education at - answers will vary

Level 1 - pick at store & write about 2 things you find there & the polymer they

are made from.

Level 2 - find the two polymers from Level I here- write the chemical formula & 3

facts about it

Level 3 - Follow the directions, write about what you learned & define 2 new

vocabulary words!

Level 4 - Summarize 2 methods of making polymers

Level 5 - Describe 2 methods of characterization of polymers

Level 6 - Answer 2 of the questions posed on this page.

Explore the fun facts in the last section. Pick one to add to your poster. There are fun activities and games to explore on this website; please feel free to visit them and gain information to enhance your poster! Check this out: A Sweet Way to Make Plastic. http://dsc.discovery.com/news/2006/06/30/sweetplastic_tec.html?category=technology&guid=20060630123000 What did James Dumesic and his colleagues at the University of Wisconsin, Madison make plastic from? High fructose corn syrup

Name two processes they used. Dehydration and boiling Click on the back arrow - chose one or more articles and write 1-2 sentences about the use of polymers.

Visit the website Playing with Polymers at http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/polymer.html

Worksheet 1 - Macromolecules

Carbohydrates - organic molecules formed from the elements carbon, hydrogen

and oxygen; monosaccharides, disaccharides, & polysaccharides

A. Monosaccharides all $C_6H_{12}O_6$ isomers (same formula, different structure)
1. Glucose
2. Fructose
3. Galactose

B. Disaccharides
1. sucrose (glucose+ 2 fructose)
2. lactose (4 glucose + galactose)
3. maltose (glucose +4 glucose)

C. Polysaccharides
1. Starch - storage molecules of plants
2. Glycogen - storage carbohydrate of animals
3. Cellulose - structural carbohydrates-of plants
4. Chitin - structural carbohydrate of animals and some fungi

II. Proteins -organic molecules made of carbon, hydrogen, oxygen, and nitrogen.

A. Monomers of proteins are amino acids

B. Protein polymers- proteins and enzymes

III. Lipids -large, organic non-polar molecules of carbon, hydrogen and oxygen. They do not dissolve in water.

A. Fatty Acids- Unbranched carbon chains with a carboxyl group (-COOH) on one end.

B. Fats - branched carbon chains made from glycerol and fatty acids, solid at room temperature
1. saturated
2. mono-unsaturated- one hydrogen attached to tail
3. poly-unsaturated- more than one hydrogen attached to tail

C. Oils- branched carbon chains made from glycerol and fatty acids

D. Triglycerides- glycerol and three fatty acids

Worksheet 2 - Spin test for Lipids and Protein in Milk

Name ________________

Outcome - graph of layers of lipids and protein in milk

Problem - to determine the differences in lipids and protein in milk

Hypothesis -

Procedure:

Materials: skim milk, 2% milk, whole milk (soy or organic can be added),

mini centrifuge tubes and centrifuge, see-through rulers, paper towel

1. Pour 1mL of each milk into a labeled centrifuge tube, 2 per student pair
2. Place centrifuge tubes in holders and compare layer of lipid at the top (lipids are less dense than water and will float)
3. Examine the layers in the centrifuge tube
4. Measure the height of each layer in the tubes for the different types of milk and record in a chart.
5. Open the tube and use your finger to scoop out the top layer - what does it feel like?
6. Pour off the next layer onto a paper towel
7. Examine what is left in the tube - what does this feel like?
8. Answer the questions below and write a procedure for determining the components of each layer.
9. Write a procedure for determining the macromolecules in each layer of milk.

1. Procedure:

Answer the following questions on another sheet of paper;

1. Were their differences in the amount of lipids in the different types of milk? Explain.
2. What do lipids feel like? Why do you think so?
3. Were their differences in the amount of water in the different types of milk? Explain.
4. What does the water look like? Does this layer look the same in all samples?
5. What color is this layer? Why do you think so?
6. Were their differences in the amount of protein in the different types of milk? Explain.

7. What do proteins feel like? Why do you think so?
8. Suggest reasons for any differences you have observed.
Graph the measurements in the layers seen in difference types of milk.
Chart results of macromolecule tests.
11. What does your graph show?
12. Write the results of your macromolecule tests. and explain your results.

Worksheet 3 - Vegetable Macromolecules

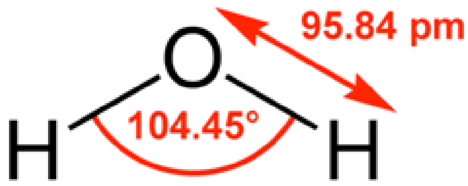
Materials: Vegetable slices; Carrots (larger are easier to slice), zucchini, cucumber, radishes, toothpicks, spaghetti (uncooked), paper plates, napkins, plastic knives.

Formulas: Key:

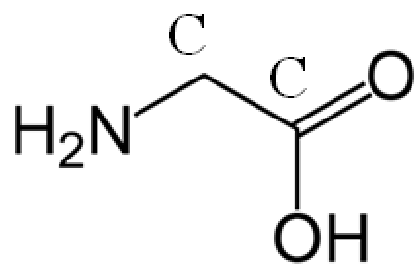
Water H2O		Hydrogen - carrots
Carbohydrate $C_6H_{12}O_6$ (glucose)	Carbon - zucchini	
Protein NH_2-CH_2-COOH (glycine)	Oxygen - cucumber	
Lipid $CH_3(CH_2)_{10}CO_2H$ (lauric acid)	Nitrogen - radishes	

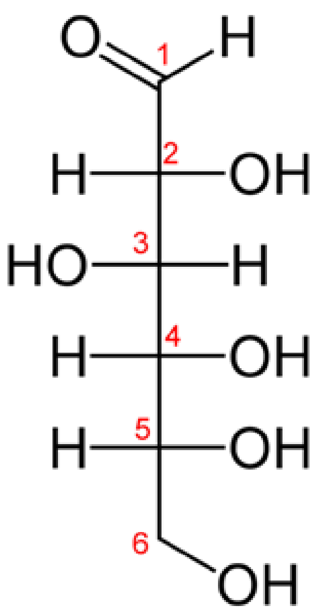
1. Slice vegetable in thin slices, less than 1 cm.
2. Use the vegetables to make each molecule on your plate.
3. Use the toothpick to 'stick' holes in the vegetable slice where bonds should be.
4. Insert a piece of spaghetti to show the number of bonds.
5. Attach molecules until you have made a macromolecule.
6. Remember to check the formula; sometimes a drawing does not have a label for all the molecules present.
7. Count the number of each atom in the formula and then check that your model has the same number of molecules.

8. You can eat each molecule after it is checked for accuracy by your teacher.



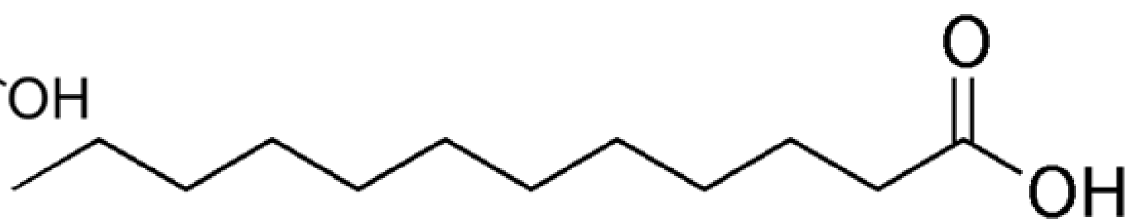
Water
http://en.wikipedia.org/wiki/File:Water-2D-labelled.png





Simple Protein - Glycine
http://upload.wikimedia.org/wikipedia/commons/thumb/6/61/Glycine.pn g/800px-Glycine.png

Carbohydrate - Glucose (# 1-6 are Carbon)
http://upload.wikimedia.org/wikipedia/commons/2/27/D-glucose-chain-2D-Fischer.png



Lipid - Lauric Acid

http://images.google.com/imgres?imgurl=http://upload.wikimedia.org/wikipedia/commons/7/7fLauric_acid.png &imgrefurl=http://commons.wikimedia.org/wiki/

---Cut here and hand in for grading-------------------------

Teacher check sheet Student Name ________________

- ❑Water
- ❑Protein
- ❑Carbohydrate
- ❑Lipid

What did the molecules have in common?

What was different about the molecules?