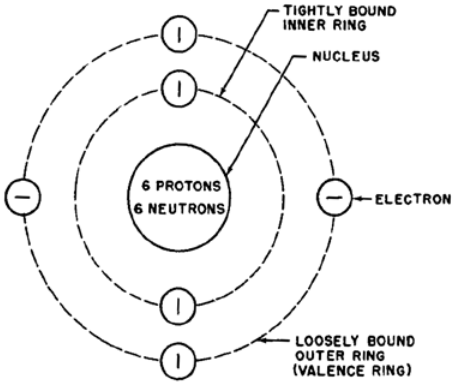
Biomolecules and Biofuels -- a background

There is no denying it. We are reliant on energy sources to cook our food, heat our homes, power our vehicles, light our buildings…the list goes on and on. Many of the fuels we use are limited in supply because they were generated from dead plant material that is millions of years old. In addition, burning these "fossil fuels" releases pollutants into the atmosphere that affect air quality and contribute to climate change. It may seem like a hopeless situation, but exploration of "alternative" energy sources is a feasible solution to supply more of our energy and to reduce outputs of pollution.

In this lab, we will discuss the possibility of using biofuels as an "alternative" energy source. Biofuels are developed from renewable fuel sources (recently-living plant material as opposed to petroleum, coal, or natural gas). You may have heard that biofuel production requires as much energy to create—energy to power tractors, to create fertilizer, to harvest and ship plant material—as it would make available to our vehicles. If this were true, the economy and the current supply of fossil fuels would not be able to support the use of biofuels. Fortunately, there is a massive research effort in place to develop the biofuel industry into something that is sustainable. Many scientists and government officials predict that biofuels will create a wealth of new jobs in biology, chemistry, agriculture, machinery, transportation, and business.

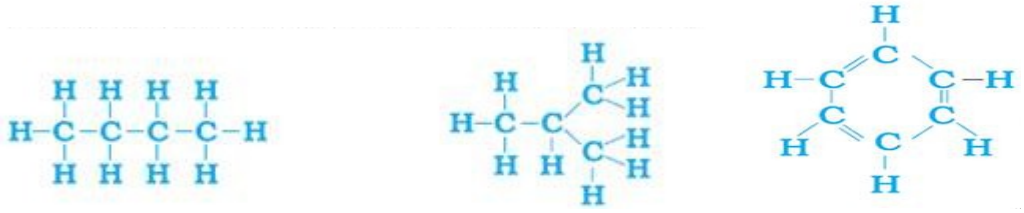
Part I. What is a Biomolecule?

Remember that cells are the most basic form of life, and that these cells are "built" with molecules. Life on Earth relies on a variety of molecules based on a carbon skeleton. Biomolecules are also called "organic" molecules—not because they are produced by organic farms but because they are produced by living things. A carbon atom is shown below.



Atoms are the most stable when they have a full outer shell. In order to fill its outer shell (with 8 total electrons), carbon will try to form four bonds with other atoms. A variety of carbon-

based biomolecules are shown below. The molecules shown below have a simple structure in comparison to some of the complex molecules that living things build with carbon.



In order to build some of the large and complex molecules, living things piece together smaller molecules to build larger molecules. The small subunit molecules are called **monomers** and they are assembled to form larger molecules called **polymers**.

Types of Biomolecules

There are four major types of biomolecules.

1) **Carbohydrates.** Based on subunits (monomers) of _____.

You have probably heard about "good carbs" and "bad carbs". Carbohydrates are often used as an energy storage molecule, and when we eat carbohydrates we break them down and release energy that our cells can use.

But some carbohydrates are structural. The shells of insects and lobsters are made of carbohydrates, and the rigid structural materials of plants are also made of carbohydrates.

Draw a monomer of a carbohydrate here →

2) **Proteins**. Based on subunits (monomers) of _____.

Proteins can have a variety of functions, depending on their shape. Some proteins are structural (your hair is mostly protein called keratin), other proteins speed up chemical reactions, while still other proteins are involved in muscle contraction. You will learn about other varied protein functions as the class progresses.

3) **Lipids**. (Also known as _____ and _____) do not mix with water.

The chemistry of lipid molecules makes them hydrophobic ("water-fearing"). Some lipids are hormone messengers, but many lipids store energy. In fact, the gasoline that you burn in your car or in your furnace is lipid-based. Burning these fuels release energy.

Draw a lipid here→

4) Nucleic acids. Based on subunits (monomers) of

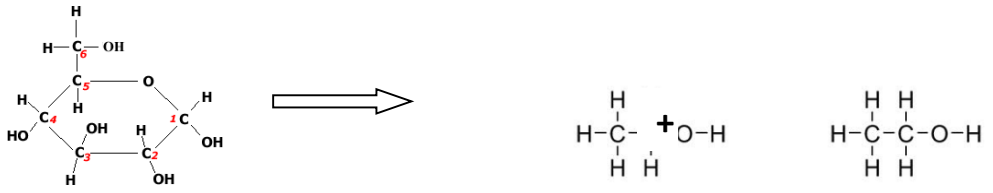
_____

Nucleic acids contain the genetic information needed for cells to reproduce. Nucleic acids include deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). The sequence of DNA and RNA varies somewhat between species and between individuals of the same species.

Draw a monomer of DNA here, labeling its major parts (sugar, phosphate, nitrogenous base) →

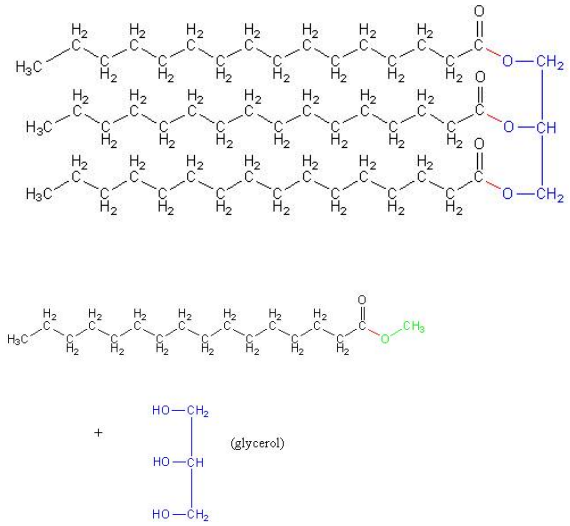
Different types of Biofuels.

Recall that biofuels are "alternative" energy sources. There are two major categories of biofuels: ethanol (which requires fermentation of a carbohydrate source) and biodiesel (which requires processing of lipids).



(& byproducts)

Glucose ethanol ethanol



Fat or oil (pre-processing) 3 biodiesel molecules + glycerol

Making Biofuels

As shown on the previous page, a carbohydrate or lipid source is needed to produce ethanol or biodiesel, respectively. We will focus on the production of ethanol from carbohydrates in this lab.

Humans have been making ethanol from sugar for thousands of years. What kind of organism is required to make ethanol? _____.

The challenge in producing ethanol is getting an inexpensive source of readily-available sugar.

Corn starch. Pro: The polymer is easily broken down into its sugar monomers.

Con: _____

Sugar cane. Pro: Cane sugar is already in sugar form

Con: _____

Algae. Pro: Also can be used as a source for biodiesel

Con: Many other useful products are produced from algae that have more economic value than ethanol.

Cellulose. Pro: A polymer found in the cell walls of plant cells and reinforcing the stems of many plants. Very abundant and easy to acquire.

Con: Conversion of cellulose to sugar monomers is challenging.

----------**GOOD NEWS**!!!!!!!!!!!!!!!!----------

Scientists have discovered a chemical mixture called "Accellerase" that can convert cellulose into glucose (a sugar). They obtained the "Accellerase" from a bunch of fungi and bacteria, so it is pretty likely that it is a biomolecule.