

# Student activity sheet

## Making biofuel molecules

This activity will guide you through constructing models of the molecules that are important for plants to grow and make biomass as well as more complicated molecules that are formed from plants and used as biofuels.

You will need to work in small groups to begin with making the smaller molecules and then work in larger groups to make the larger molecules.

### What you will need

A pack of **basic organic chemistry** Molymod® molecular models.

Each pack contains:

- Ten hydrogens (white)
- Four carbons (black)
- Two oxygens (red)
- Two chlorines (green)
- One nitrogen (blue)
- Twenty single bonds
- Four multiple (flexible) bonds
- Carbon atoms are **Black** 
- Oxygen atoms are **Red** 
- Hydrogen atoms are **White** 

Diagrams are provided to help you construct your molecules.

Once you have made each molecule and it has been checked you will need to take it apart in order to construct the next one.

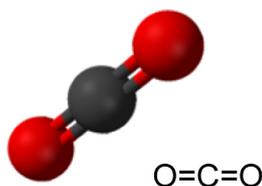
Once your group has made the butanol molecule you will need to join with another group to be able to make the larger molecules.

### Instructions

#### Carbon dioxide

Carbon dioxide is essential to photosynthesis. Photosynthesis converts carbon dioxide and water into organic compounds including sugars using the energy from sunlight. Combustion of fuels produces carbon dioxide and it is one of the greenhouse gases contributing to climate change.

To make a model of carbon dioxide you will need two oxygen atoms (red), one carbon atom (black) and four multiple (flexible) bonds. Once you have made your molecule and had it checked, take it apart.

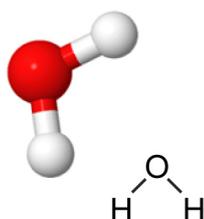


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## Water

Water is essential to photosynthesis. Water covers approximately 70% of the world's surface but only 2.5% is fresh water and most of that is frozen or found underground.

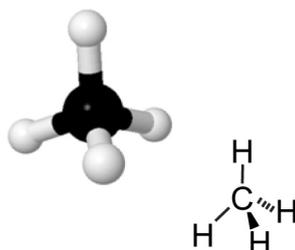
To make a model of water you will need two hydrogen atoms (white), one oxygen atom (red) and two single bonds. Once you have made your molecule and had it checked, take it apart.



## Methane

Biogas is produced by anaerobic digestion and the main constituent is methane. Biogas can be burnt to produce heat for cooking, warming homes and producing electricity. It can also be compressed and used as a transport fuel in specially converted vehicle engines.

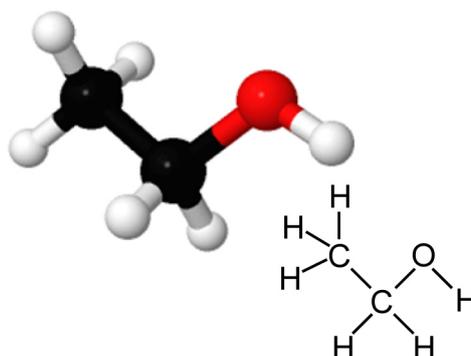
To make a model of methane you will need four hydrogen atoms (white), one carbon atom (black) and four single bonds. Once you have made your molecule and had it checked, take it apart.



## Ethanol

Bioethanol is produced from fermentation of carbohydrate feedstocks and the final product is just the same as the ethanol found in alcohol. Bioethanol is compatible with existing vehicle engines and can be mixed with fossil fuels. Up to 10% blends with petrol can be used without modifying vehicle engines.

To make a model of ethanol you will need six hydrogen atoms (white), two carbon atoms (black), one oxygen atom (red) and eight single bonds. Once you have made your molecule and had it checked, take it apart.

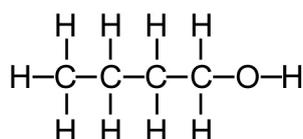
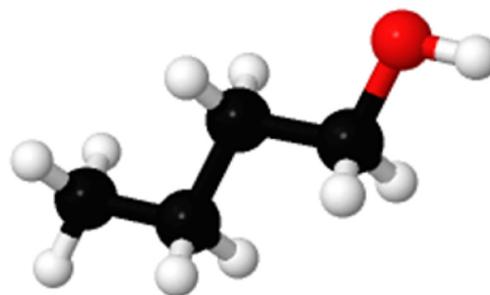


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## Butanol

Butanol is a superior transport fuel to ethanol due to its higher energy content and the ability to use it in existing pipelines, infrastructure and engines without it needing to be blended with fossil fuels. However, further research is required to increase the range of feedstocks that can be used as well as the yield and the tolerance of the microorganisms to biobutanol before it can be produced on an industrial scale.

To make a model of butanol you will need ten hydrogen atoms (white), four carbon atoms (black), one oxygen atom (red) and fourteen single bonds. Once you have made your molecule and had it checked, take it apart.

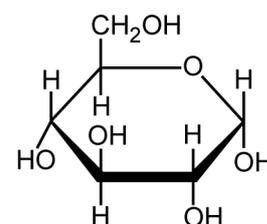
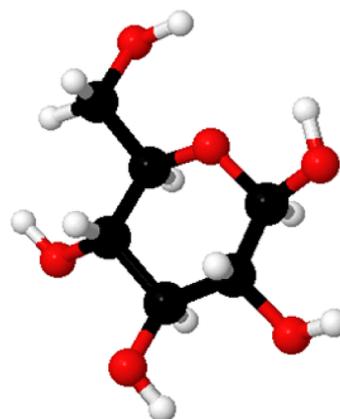


## Glucose

Glucose is a monosaccharide sugar produced by plants through photosynthesis. Glucose is the main source of energy for cells and is one of the sugars used by yeast in fermentation to produce ethanol.

You will now need to work with another two groups to make a glucose molecule. Three packs are required to provide enough oxygen atoms to make a molecule of glucose.

To make a model of glucose you will need twelve hydrogen atoms (white), six carbon atoms (black), six oxygen atoms (red) and twenty single bonds. Important: Once completed and checked, do not take the model apart.

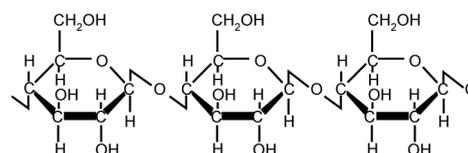
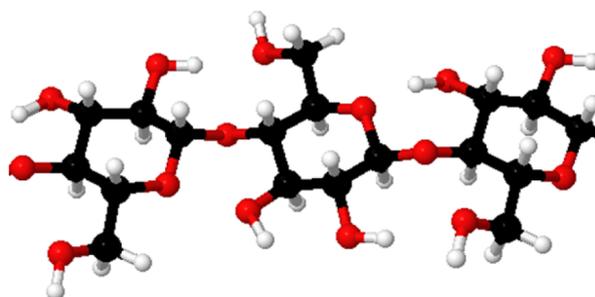


## Cellulose

Cellulose is a polysaccharide formed by plants from glucose molecules. It is the main structural component of cell walls in the form of lignocelluloses and research is being undertaken to enable it to be fermented to produce biofuels.

To be able to make a portion of a cellulose molecule you will now need to work together with three other groups to make a cellulose molecule featuring three repeating glucose subunits.

To make the model of cellulose join together the glucose molecules already made. There are sufficient oxygen atoms (fourteen) to form the two connections between the glucose molecules but not the oxygens on the ends of the chain. You will need to take the model apart to be able to construct the next model – biodiesel!

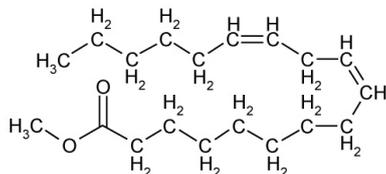
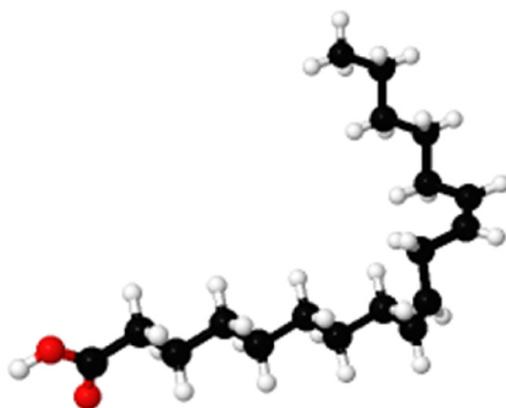


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## Biodiesel (Methyl Linoleate)

Biodiesel is produced from oils and fats mixed with methanol and a catalyst. Biodiesel can replace diesel or be further refined to produce synthetic kerosene suitable for use in aviation fuel.

You will need to work together as one large group to make a biodiesel (methyl linoleate) molecule. To make the model of biodiesel you will need thirty four hydrogen atoms (white), nineteen carbon atoms (black), two oxygen atoms (red), six multiple (flexible) bonds and fifty single bonds.



**IMPORTANT:** Ensure that all the atoms and bonds are counted up and returned at the end of the session so that lost parts can be identified and replaced before repeating the activity.