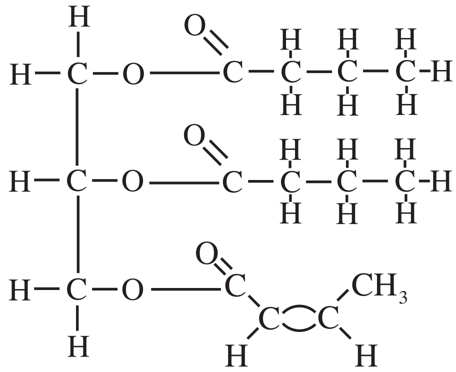
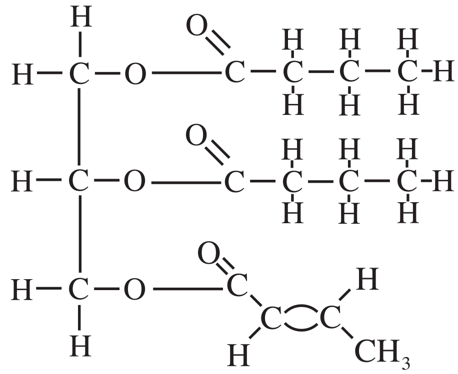


cis

✔ **EAT THIS**



trans

✗ **NOT THIS**

Glycerides
Molecular Model Kit
Recommended for ages 10 – adult.

Caution: Atom centers and vinyl tubing are a choking hazard. Do not eat or chew model parts.

Kit Contents:

33 white 1-peg hydrogen atom centers
10 red 2-peg oxygen atom centers
16 black 4-peg carbon atom centers
1 purple 5-peg phosphorus atom center
50 clear, 1.25” single bonds
10 clear, 4 cm tubes to make double bonds
5 white, .87” tubes for ester bonds

Phone: 806-438-6865
E-mail: etishler@rylerenterprises.com
Website: www.rylerenterprises.com
Address: 5701 1st Street, Lubbock, Texas 79416

GLYCERIDES LAB INSTRUCTIONS

Background Information

The class of biochemicals called lipids includes such substances as fats and oils, steroids, waxes, some plant spices, some vitamins, phospholipids, prostaglandins, etc.. What qualifies a substance as a lipid is its solubility. Lipids are not water soluble.

Fats and oils are both esters of the alcohol glycerol and fatty acids. Oils, which come mainly from plants, contain fatty acids which are unsaturated (lacking in two or a multiple of two hydrogen atoms). Oil molecules do not fit well together on a molecular level, so their melting points are usually very low, and they tend to be liquids at room temperatures. Fats, mostly found in animal tissues, have fatty acids which are saturated, i.e. they are not missing hydrogen atoms. Saturated fatty acids fit well together on a molecular level, so their melting points are high, and they are solid at room temperature.

Most fatty acids are composed of long chains of carbon atoms, but a few, such as butyric acid, found in butter, are short chains. In this kit we will use butyric acid to learn about the structure of glycerides.

If three fatty acids are esterified (bonded) with one glycerol molecule, the resulting compound is called a triglyceride (more technically, a triacylglycerol). Two fatty acids bonded to glycerol produce a diglyceride (diacylglycerol) and one fatty acid esterified with a glycerol alcohol make a monoglyceride (monoacylglycerol).

Now we will take time to examine the functional groups that make an acylglycerol.

An alcohol is composed of an –O-H, called a hydroxyl group, bonded to a carbon atom. Some alcohols, such as glycerol can have more than one hydroxyl group.

In order to facilitate a discussion for making glycerides, chemists call the first carbon away from the acid group (-COOH) of a fatty acid, alpha (α), the second beta (β), the next gamma (γ), and so on. In another system, the acid carbon is called C1, the next is C2, and so on.

The following diagrams illustrate an alcohol (Fig. 1), an acid (Fig. 2a and Fig. 2b), and an acyl group (Fig. 3).

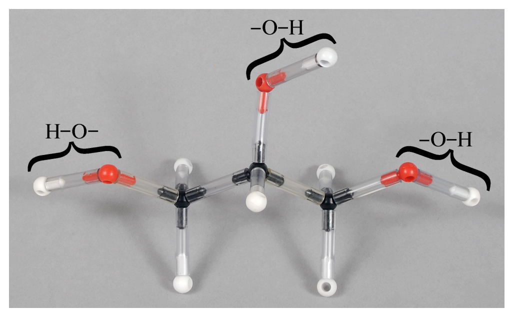


Fig. 1 Glycerol with three hydroxyl groups.

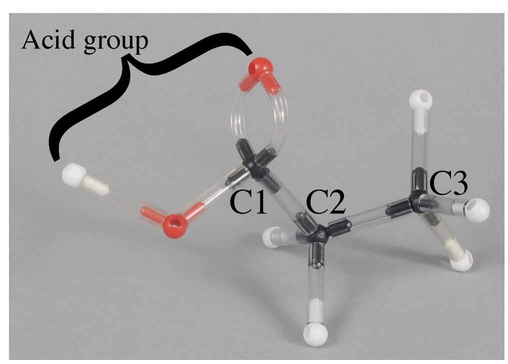


Fig. 2a Propionic acid with numbered carbons.

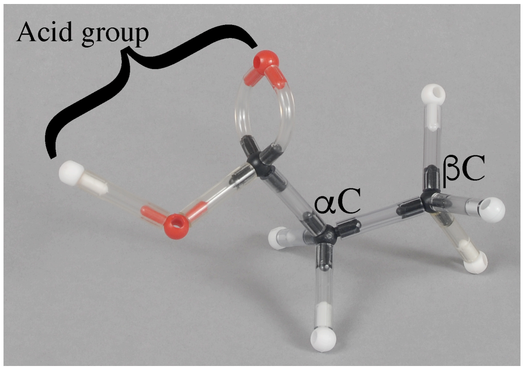


Fig. 2b Propionic acid with Greek lettered carbons.

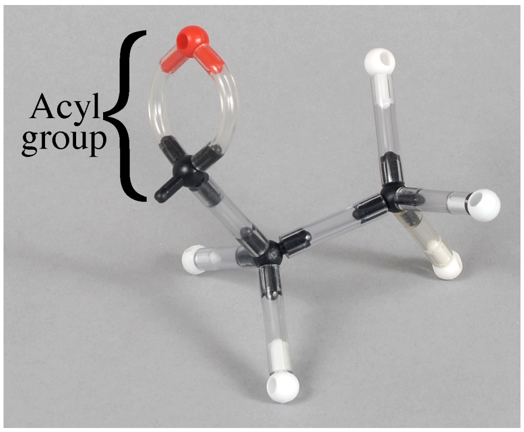


Fig. 3 An acyl group is an acid with the –O-H removed.

In Fig. 4, an acid molecule and a molecule of glycerol are placed side by side. The acid group is near an alcohol group.

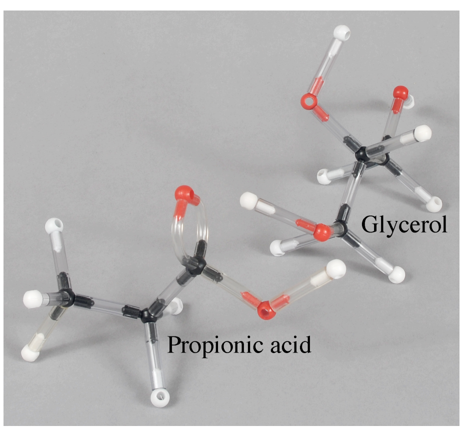


Fig. 4 Propionic acid next to glycerol.

When an acid group and an alcohol group are close enough to react with one another, the oxygen of the alcohol becomes attracted to and bonded with the carbon of the acid group. As the reaction proceeds, the alcohol loses its hydrogen atom, and the acid loses its hydroxyl group forming a molecule of water. The combining of the acid and alcohol also forms an ester.

Since water is lost from the reactants, the reaction is called a dehydration synthesis. It is also called a condensation reaction.

In Fig. 5, propionic acid on the left has lost its hydroxyl group in reaction 1. In reaction 2, the glycerol has lost a hydrogen atom from a hydroxyl group. Reaction 3 is the bonding of the hydrogen atom with the eliminated hydroxyl group to form water.

In reaction 4, an ester is formed as the the oxygen of the alcohol bonds to the acyl group carbon.

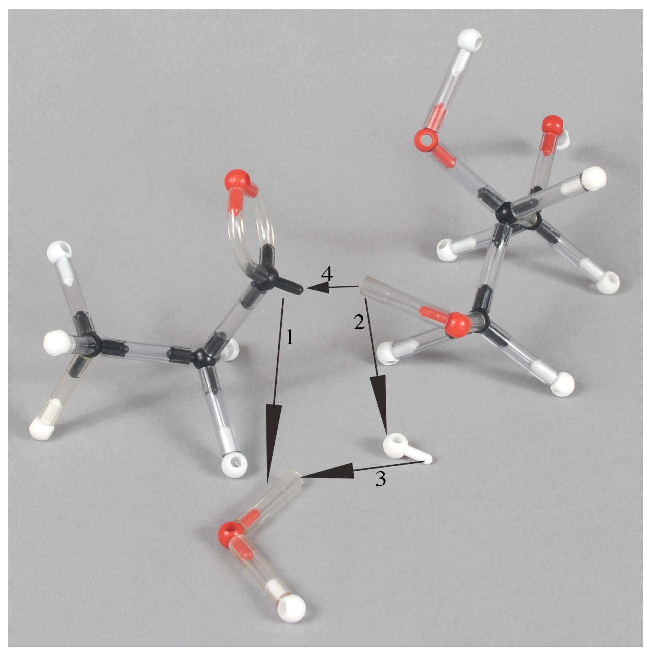


Fig. 5 Forming an ester and water.

The resulting ester and water are pictured in Fig. 6.

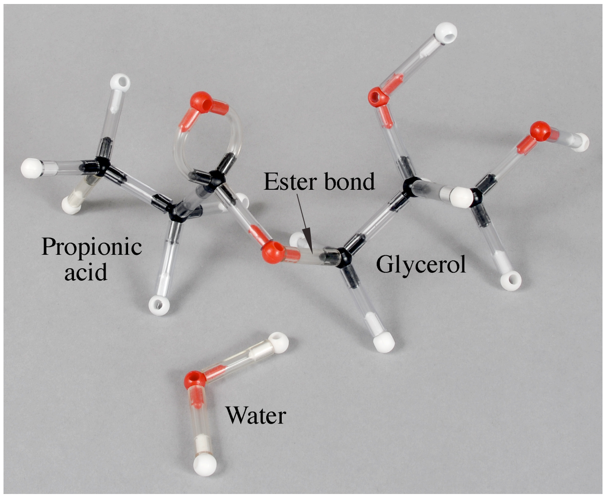


Fig. 6 An ester is formed along with water.

Phospholipids are a very important type of glyceride found in the membranes of cells and membranous organelles of all living things. The basic structure of all phospholipids is called phosphatidic acid. See Fig. 7.

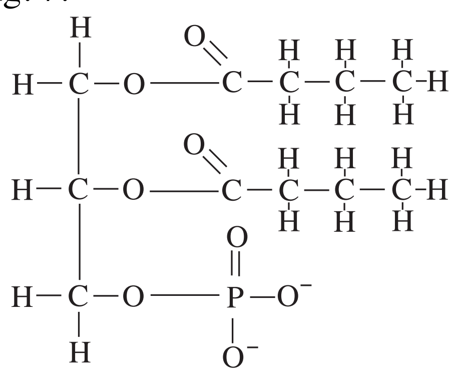


Fig. 7 Phosphatidic acid.

Different phospholipids have different groups of atoms bonded to the phosphate.

A simplified diagram of a phospholipid (Fig. 8) explains why it can be used in a double layer in living membranes. It has a hydrophilic and a hydrophobic end.

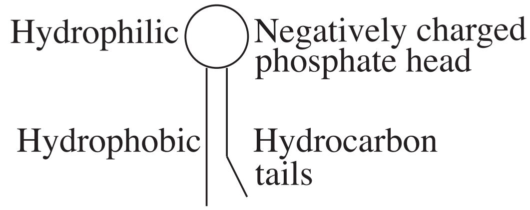


Fig. 8 The amphiphilic nature of phospholipids.

Soaps are prepared from fats and a base, usually lye, in the process known as saponification. When heated with the strongly basic solution, the fatty acids are hydrolysed forming glycerol and salts of the fatty acid. The hydrocarbon ends can be inserted into a fatty globule, and the hydrophilic, charged ends embed in the surrounding aqueous environment. See Fig. 9.

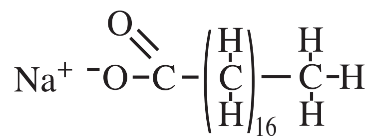


Fig. 9 Soap.

Laboratory procedure

A. Make a model of glycerol based on the structural formula below, and Fig. 1, and have your instructor check the model. See Fig. 10.

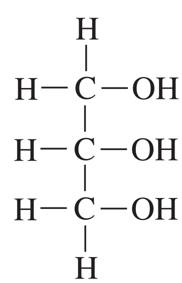


Fig. 10 Structural formula of glycerol.

B. Make a model of butyric acid, as shown below, in Fig. 11. Use the long, thin tubes to connect the double bonded oxygen to the first carbon. Have the model checked. This fatty acid molecule is saturated (i.e. it holds as many H–atoms as possible).

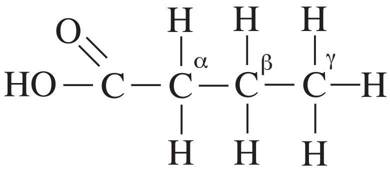


Fig. 11 A four carbon fatty acid (butyric acid).

C. Make two more butyric acid models, but this time use two long tubes for the bonds between the α and β carbons, and only place one hydrogen atom on each of these two carbons. Attach the unoccupied pegs of the two carbons using a long tube. You have now made a double bond between the two carbons, and the molecule is unsaturated. See Fig. 12.

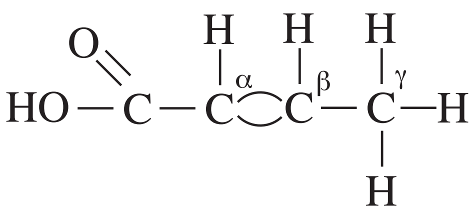
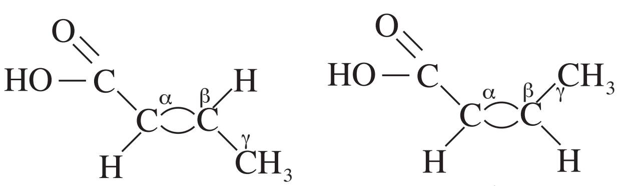


Fig. 12 An unsaturated fatty acid.

You might have noticed that two forms of the unsaturated molecules are possible. One is the *cis* configuration, and the other is called *trans*. See Fig. 13. Make sure you have made both the *cis* and the *trans* forms, and have them checked.



trans *cis*

Fig. 13 *Trans* and *cis* configurations of a fatty acid.

Cis fatty acids are more common in nature. *Trans* fats and fatty acids are found naturally in meat and dairy products of ruminant animals such as cattle, sheep, and goats, but in small amounts. By far, the greatest amounts of *trans* fats are in partially hydrogenated oils and they are not a healthy part of our diets.

D. Before making glycerides, saturate the two unsaturated fatty acids. Then remove a hydrogen atom and the bond from one of the end oxygens of glycerol, and take off an -OH (including the bond) from one of the acids. Using the short, white tube connect the peg of the acid carbon to the peg of the oxygen on the glycerol. You have just made an ester bond in your model (represented by the short white tube), and the resulting molecule is a monoglyceride. Compare your model with the following illustration (Fig. 14), and then show the model to your instructor.

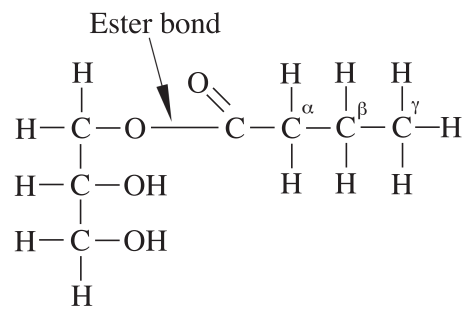


Fig. 14 A monoglyceride.

E. Repeat the formation of an ester bond on the middle carbon of the monoglyceride to make a diglyceride (Fig. 15), and have your model checked.

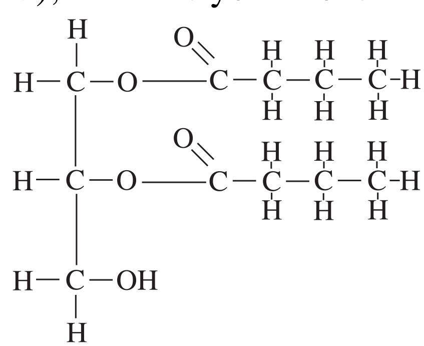


Fig. 15 A diglyceride.

F. Now do the same with the remaining acid and the diglyceride to make a triglyceride. See Fig. 16. Have your model checked.

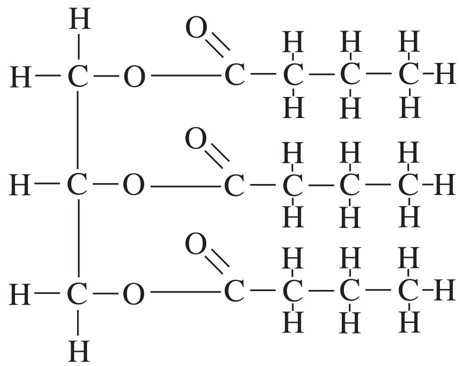


Fig. 16 A triglyceride.

G. Phospholipids are very important in the biology of membranes in cells of living things. Use the purple atom for a phosphate ion. See Fig. 17.

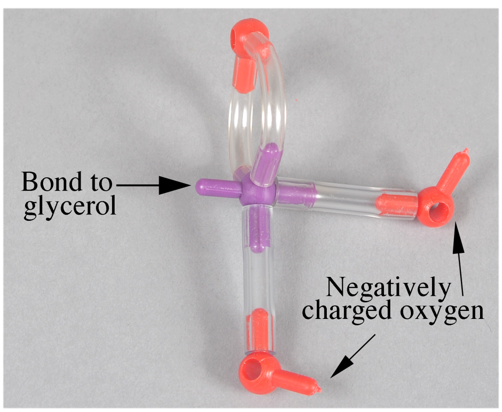


Fig. 17 Phosphate for bonding to glycerol.

Make a molecule of the basic kind of phospholipid called phosphatidic acid as you see in Fig. 18.

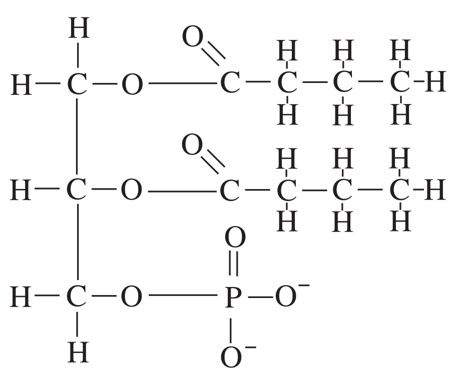


Fig. 18 Phosphatidic acid.

H. Soaps are made from fats by boiling them along with lye, which is a strong hydroxide base of sodium or potassium. The process causes the hydrolysis, that is, the breaking of the fatty acids and glycerol bonds. The fatty acid ion that is a soap is a very long chain of hydrocarbons, but you can make a simulated soap model by simply making the structure you see in Fig. 19.

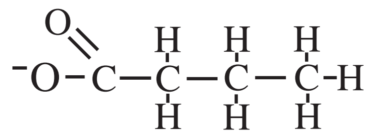


Fig. 19 A soap.

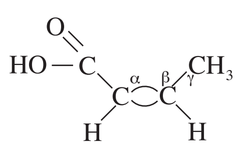
A soap has one end that mixes with water (the charged end) and one that mixes with lipids (the hydrocarbon end).

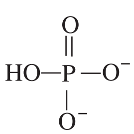
I. Answer the questions on the student response sheet.

Student Response Sheet

Name__________________ Date_________

Models Checked:

1. Glycerol model.___________
2. Butyric acid model.__________
3. *Cis* unsaturated fatty acid model.__________
4. *Trans* unsaturated fatty acid model.__________
5. Monoglyceride model.__________
6. Diglyceride model.__________
7. Triglyceride model.__________
8. When joining butyric acid and glycerol, a monoglyceride forms as well as the small molecular substance_____________
9. What is the name of the bond between an acid and an alcohol?________________
10. The labels on some manufactured foods indicate the inclusion of mono-, and diglycerides into the product. These foods are usually called fat free. Are the items actually fat free?_________
11. Explain your answer to question nine.____________________________________
____
12. Is this a *cis* or *trans* fatty acid?  _______
13. What is the name of this ion?

 __________________

14. What is one function of phospholipids? ___________________________________
15. When a fat is treated with lye, what two products form?______________ and ___________________