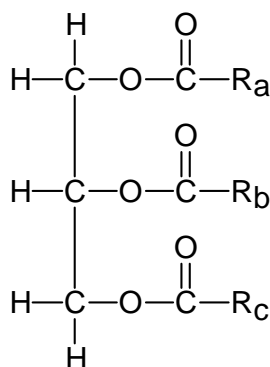


# Chemical of the Week

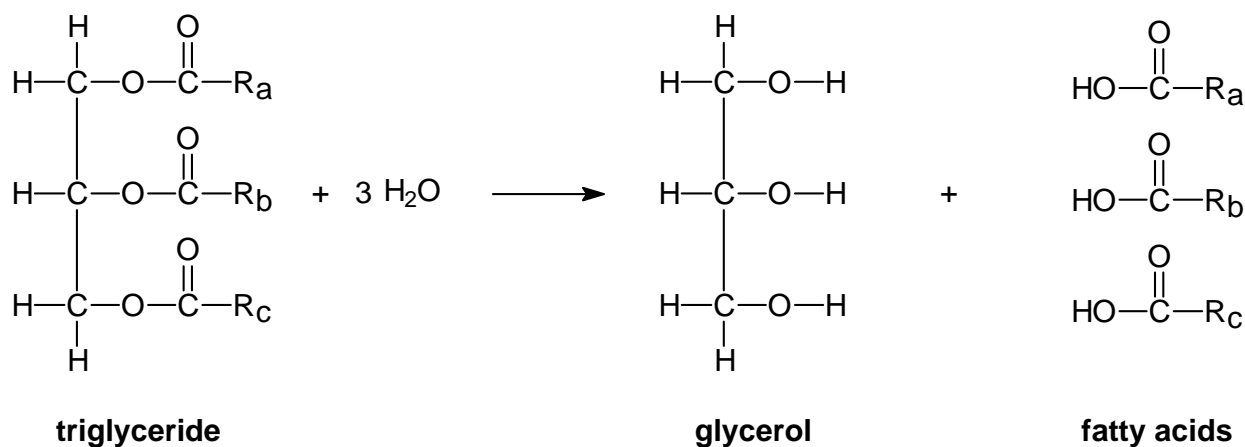
## FATS & OILS

It seems that every week brings new reports of the effects of dietary fats and oils on health. Many of these reports indicate that a diet high in fat is unhealthy, leading to heart disease and circulatory problems. As a result, grocery shelves are filled with food packages that proclaim their contents to be “low fat” or “fat free.” However, other reports caution that dietary fats are necessary for health, and that the chemical nature of the fats is important. We are admonished to be concerned about saturated versus unsaturated fats, to avoid the former and consume the latter. Furthermore, with regard to unsaturated fats, we need to be concerned whether they are “trans” fats.

The terminology applied to fats is based on the chemical structure of their molecules. Fats and oils belong to a group of biological substances called lipids. Lipids are biological chemicals that do not dissolve in water. They serve a variety of functions in organisms, such as regulatory messengers (hormones), structural components of membranes, and as energy storehouses. Fats and oils generally function in the latter capacity. Fats differ from oils only in that they are solid at room temperature, while oils are liquid. Fats and oils share a common molecular structure, which is represented by the formula below.



This structural formula shows that fats and oils contain three ester functional groups. Fats and oils are esters of the tri-alcohol, glycerol (or glycerine). Therefore, fats and oils are commonly called **triglycerides**, although a more accurate name is triacylglycerols. One of the reactions of triglycerides is hydrolysis of the ester groups.

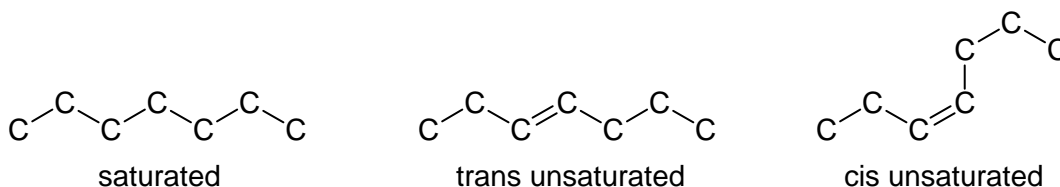


This hydrolysis reaction produces glycerol and fatty acids, which are carboxylic acids derived from fats and oils. In the fatty acids,  $\text{R}_a$ ,  $\text{R}_b$ , and  $\text{R}_c$ , represent groups of carbon and hydrogen atoms in which the carbon atoms are attached to each other in an unbranched chain.

The hydrolysis reaction is promoted by acids and by bases. When a strong base such as NaOH (lye) is used, the product contains salts of the fatty acids. These salts of fatty acids are the functional ingredient in soap. The ingredients lists of some soaps include sodium tallowate, a generic name for the mixture of fatty acid salts obtained from tallow (animal fat), and sodium cocoate, obtained from coconut oil.

Triglyceride molecules contain mostly carbon and hydrogen atoms, with only six oxygen atoms per molecule. This means that fats and oils are highly reduced (that is, un-oxidized). They are, in this way, similar to the hydrocarbons in petroleum, and like petroleum they are good fuels. The main biological function of triglycerides is as a fuel. The normal human body stores sufficient energy in fat for several weeks survival. This storage ability helps the organism deal with unpredictable variations in the food supply. Plants, too, store energy in fats and oils. Oils are particularly common in seeds, where the stored energy helps seedlings during germination, until they can exploit solar energy through photosynthesis.

Fatty acids contain an even number of carbon atoms, from 4 to 36, bonded in an unbranched chain. Most of the bonds between carbon atoms are single bonds. If all of these bonds are single bonds, the fatty acid is said to be **saturated**, because the number of atoms attached to each carbon atom is the maximum of four. If some of the bonds between carbon atoms are double bonds, then the fatty acid is **unsaturated**. When there is only one double bond, it is usually between the 9th and 10th carbon atom in the chain, where the carbon atom attached to the oxygen atoms is counted as the first carbon atom. If there is a second double bond, it usually occurs between the 12th and 13th carbon atoms, while a third is usually between the 15th and 16th.



Double bonds between carbon atoms in fatty acids can cause kinks in the chains of atoms. This is particularly true for *cis* double bonds. These kinks prevent the molecules from stacking together well. Because they do not fit together well, unsaturated fatty acids and triglycerides have lower melting points than saturated ones. Thus fats, which are solids, are usually more saturated than oils, which are liquids at room temperature.

Highly unsaturated oils undergo a chemical reaction in the presence of oxygen and light. In this reaction the unsaturated carbon atoms become saturated by reaction with oxygen. This reaction causes separate molecules of oil to become linked by oxygen atoms. Linking from molecule to molecule causes the oil to solidify. Oils that undergo this process are called drying oils and are used in oil paints. Oils that are rich in double bonds are most able to undergo this process. Among the most unsaturated of vegetable oils is linseed oil, the preferred medium for artists' oil paint.

Recently, the dietary effects of a particular fatty acid have received a good deal of attention. This fatty acid is conjugated linoleic acid (CLA). Linoleic acid contains 18 carbon atoms and two double bonds. In normal linoleic acid the double bonds are between the 9th and 10th and between the 12th and 13th carbon atoms. In *conjugated* linoleic acid, they are between the 9th and 10th and between the 11th and 12th. (When two double bonds are separated by one single bond, they are called conjugated double bonds.) The CLA isomer of interest is the one that is *cis* at 9–10 and *trans* at 11–12. In 1987, Michael Pariza of the UW-Madison's Food Research Institute found that CLA has anti-carcinogenic properties and significantly reduces heart disease. More recently, Pariza, together with Mark Cook, a UW-Madison poultry nutritionist, found that CLA reduces the percentage of body fat in mice, rats, and chickens, while increasing muscle tissue and bone density. Whether these benefits extend to humans is currently under investigation.