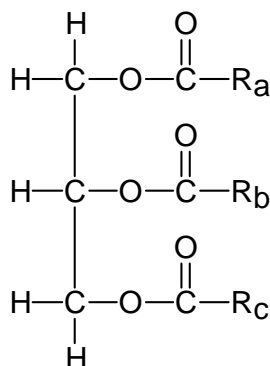


Chemical of the Week

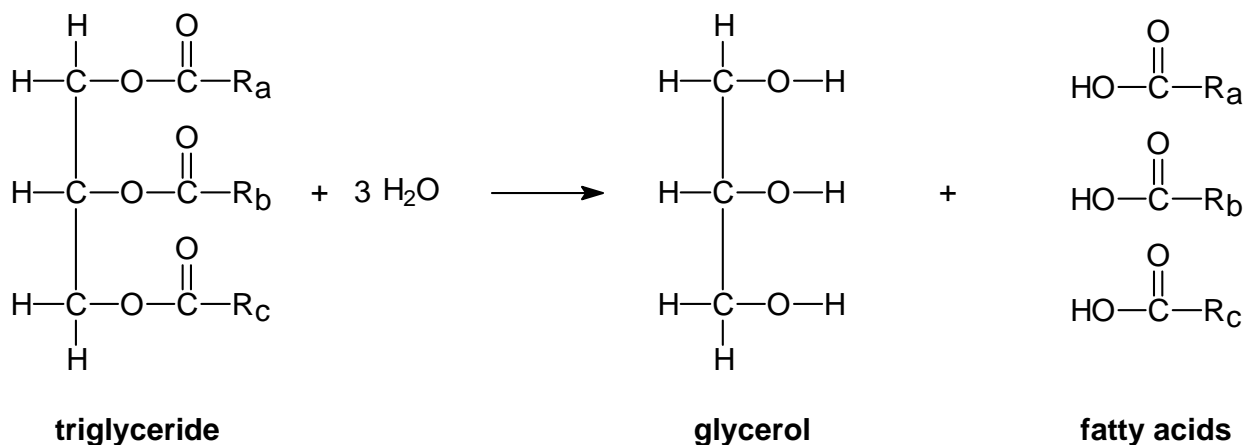
FATS AND OILS

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, 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.

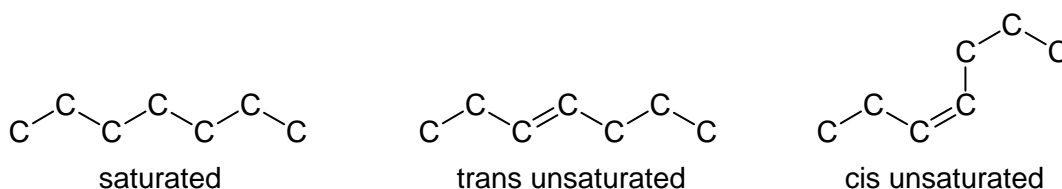


This hydrolysis reaction produces glycerol and fatty acids, which are carboxylic acids derived from fats and oils. In the fatty acids, R_a , R_b , and R_c , represent groups of carbon and hydrogen atoms in which the carbon atoms are attached to each other in an unbranched chain.

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.

Most of the trans fats in our diet originate from partially hydrogenated vegetable oils which are a mainstay in margarines, commercially baked goods, and in the fats used for deep-frying in many restaurants. Vegetable oils contain a mixture of saturated, monounsaturated, and polyunsaturated fatty acids. The monounsaturated and polyunsaturated fatty acids have carbon-carbon double bonds in the normal *cis* configuration. In the process of hydrogenation, hydrogen atoms are added to the carbon-carbon double bonds. If all the carbon-carbon double bonds are saturated with hydrogen, the product is a saturated fat. If some of the carbon-carbon double bonds remain, the product is a partially hydrogenated vegetable oil. When vegetable oil is partially hydrogenated, some of the *cis* double bonds are converted to trans double bonds, producing trans fats.

Partially hydrogenated oils don't spoil as easily as unsaturated vegetable oils and they can withstand repeated heating without breaking down, which makes them economical to use in the food industry. Prior to the production of partially hydrogenated oils, most trans fats consumed by humans came from beef or dairy products. In ruminants, like cows, trans fats are produced by bacteria living in the forestomach that help ruminants digest their foods.

Eating trans fats increases the risk of coronary heart disease. Trans fats increase blood levels of low-density lipoprotein (LDL) or "bad cholesterol". The role of LDL is to transport cholesterol to body tissues; however, as it travels through the arteries, it can deposit some of the cholesterol leading to plaques and atherosclerosis. Trans fats also lower levels of high-density lipoprotein (HDL), or "good cholesterol". HDL scours blood vessels for bad cholesterol and carries it to the liver, where it is destroyed and excreted from the body.