7.5: Lipids - Fats, Oils, and Hormones

Lipids differ from most other kinds of biomolecules in that they are repelled by water. Lipids can be extracted from biological matter by organic solvents, such as diethyl ether or toluene. Recall that proteins and carbohydrates are distinguished largely by chemically similar characteristics and structures. However, lipids have a variety of chemical structures that share the common physical characteristic of solubility in organic solvents. Many of the commonly encountered lipid fats and oils are esters of glycerol alcohol, $CH_2(OH)CH(OH)CH_2(OH)$, and long-chain carboxylic acids (fatty acids), such as stearic acid, $CH_3(CH_2)_{16}CO_2H$. The glycerol molecule has three -OH groups to each of which a fatty acid molecule may be joined through the carboxylic acid group with the loss of a water molecule for each linkage that is formed. Figure 7.5shows a fat molecule formed from three stearic acid molecules and a glycerol molecule. Such a molecule is one of many possible **triglycerides**. Also shown in this figure is cetyl palmitate, the major ingredient of spermaceti wax extracted from sperm whale blubber and used in some cosmetics and pharmaceutical preparations. Cholesterol shown in Figure 7.5 is one of several important lipid **steroids**, which share the ring structure composed of rings of 5 and 6 carbon atoms shown in the figure for cholesterol.

Although the structures shown in Figure 7.5 are diverse, they all share a common characteristic. This similarity is the preponderance of hydrocarbon chains and rings so that lipid molecules largely resemble hydrocarbons. Their hydrocarbon-like molecules make lipids soluble in organic solvents.

Some of the steroid lipids are particularly important because they act as **hormones**, chemical messengers that convey information from one part of an organism to another. Major examples of steroid hormones are cholesterol, testosterone (male sex hormone), and estrogens (female sex hormones). Steroid lipids readily penetrate the membranes that enclose cells, which are especially permeable to more hydrophobic lipid materials. Hormones, start and stop a number of body functions and regulate the expression of many genes. In addition to steroid lipids, many hormones including insulin and human growth hormone are proteins. Hormones are given off by ductless glands in the body called **endocrine glands**. The locations of important endocrine glands are shown in Figure 7.6.

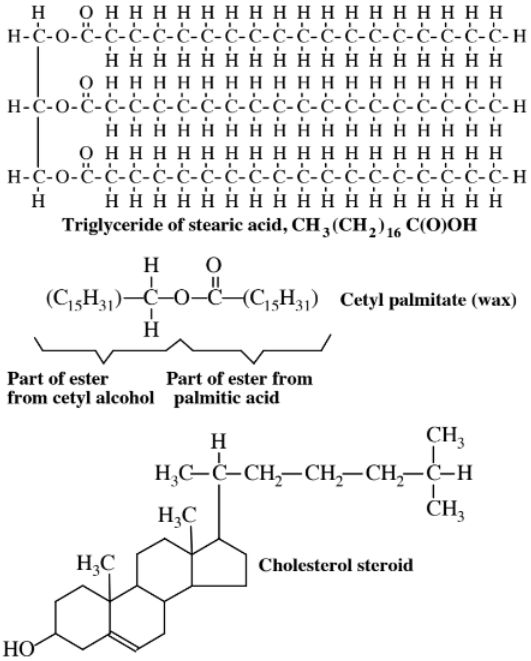

Figure 7.5. Three examples of lipids formed in biological systems. Note that a line structure is used to show the ring structure of cholesterol. The hydrocarbon-like nature of these compounds which makes them soluble in organic compounds is obvious.

Lipids are important in green chemistry for several reasons. Lipids are very much involved with toxic substances, the generation and use of which are always important in green chemistry. Poorly biodegradable substances, particularly organochlorine compounds, that are always an essential consideration in green chemistry, tend to accumulate in lipids in living organisms, a process called bioaccumulation. Lipids can be valuable raw materials and fuels. A major kind of renewable fuel is made by hydrolyzing the long-chain fatty acids from triglycerides and attaching methyl groups to produce esters. This liquid product, commonly called biodiesel fuel, serves as a substitute for petroleum-derived liquids in diesel engines. The development and cultivation of plants that produce oils and other lipids is a major possible route to the production of renewable resources.