17 LIPIDS

Lipids are fats, waxes, and similar molecules that do not dissolve well in water.

Color titles A, B, C, H, O, D, and D^1 and the Space-Filling Model headings. Color the projection formulae and the space-filling models of glycerol and the saturated and unsaturated fatty acids. It is recommended that you use the same colors as in previous plates for the carbon, hydrogen, and oxygen atoms. Choose light colors for A, B, and D.

Fats are composed of *glycerol* and *fatty acids.* Glycerol always has three *carbon atoms* and three hydroxyl (OH) groups, but there are several dozen kinds of fatty acids, ranging in size from 4 carbon atoms to 24. On one end of a fatty acid we find a carbon atom with a double bond to an oxygen atom and a single bond to a hydroxyl group. This entire group of four atoms, often written as —COOH, is called a carboxyl group and is able to ionize to release a hydrogen ion into solution, thus acting as an acid. (The ionized carboxyl group is symbolized as $—COO^-$.) In any group of such molecules, only a few are ionized at any one time, so fatty acids are all weak acids. All the rest of a fatty acid molecule is pure hydrocarbon (hydrogen and carbon). Fatty acids are designated as *saturated* or *unsaturated* according to whether they are filled to capacity with hydrogen atoms or not. In a saturated fatty acid, all of the carbon atoms are joined to one another by single bonds, and each one (other than the carboxyl carbon) is bonded to at least two hydrogen atoms. (The one on the end has three.) In an unsaturated fatty acid, at least one pair of carbon atoms is joined by a *double bond,* so that each of those carbon atoms is bonded to only one hydrogen atom, leaving the fatty acid with at least two fewer hydrogen atoms than it would have if it were saturated. The double bond often throws a kink in the hydrocarbon chain as shown in the space-filling model here.

Color title E and the projection formula of the triglyceride. The broken ring (E) is to illustrate that the triglyceride is composed of glycerol, saturated fatty acids, and an unsaturated fatty acid.

A fat—chemically known as a *triglyceride*—consists of a molecule of glycerol joined to three fatty acid molecules by the same kind of dehydration condensation we saw in the formation of disaccharides and polysaccharides. The three fatty acids may be all the same or any combination of different ones. Note that in the triglyceride illustrated, two of the fatty acids are saturated and one is unsaturated. This would be called a monounsaturated fat, because it is unsaturated (has a carbon double bond) at only one point in the entire triglyceride molecule. If it were unsaturated at two or more points, it would be called a polyunsaturated fat. Since hydrocarbons are nonpolar, the entire triglyceride molecule is nonpolar except for a slight polarity around the oxygen atoms. For this reason, triglycerides (fats) are not much attracted to water molecules. If you have ever tried to wash butter or other animal fat off of your hands with just water, you have noticed that.

Color titles F, G, and H, and the projection formula of the phospholipid. The broken ring (F) is for illustrative purposes only.

In molecular structure *phospholipids* are like triglycerides except that in place of the third fatty acid they have a *phosphate group* and some other *polar group.* This results in a molecule with a dual nature. The hydrocarbon chains of the fatty acids are not attracted to water and are called hydrophobic ("water-fearing"). The phosphate and the other group are attracted to water and are called hydrophilic ("water-loving"). It is precisely this dual nature that allows phospholipids to form membranes, as we shall see in a later plate.

Color title I and the projection formula of the steroid nucleus.

The *steroid nucleus* consists of four interlocking rings of carbon atoms with numerous hydrogen atoms attached. It forms the core of a wide variety of important molecules including many hormones, which differ in the groups of atoms substituted for the hydrogen atoms at various points on the rings.

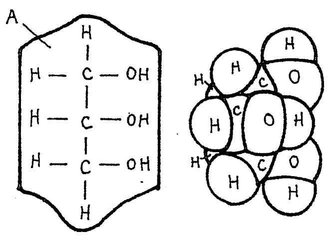
Color titles J and K and the projection formula of beeswax. The broken ring (J) is for illustrative purposes only.

Waxes provide protective coatings for various plant and animal tissues and for bees to make honeycombs. They are formed by the dehydration condensation of a long-chain *alcohol* (hydrocarbon with a hydroxyl group at one end) and a long-chain fatty acid.

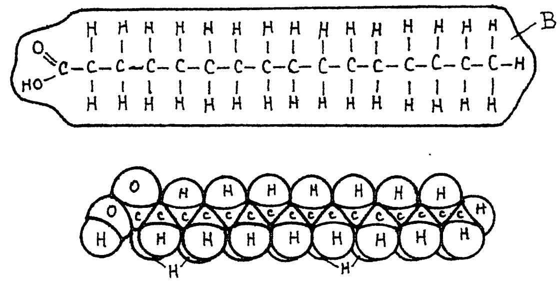
Other, less common lipids (not illustrated) combine fatty acids with various other groups, such as sugars and amino acids.

LIPIDS$_{\bullet}$

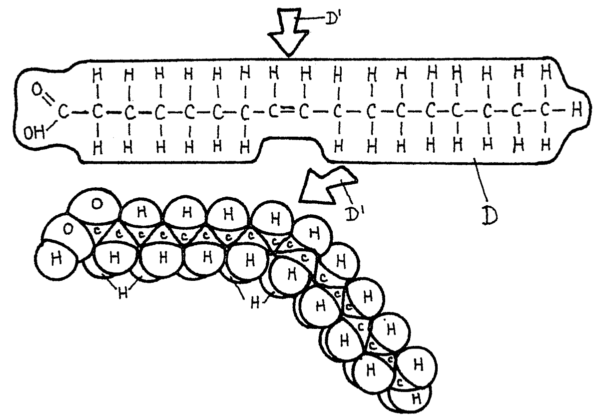
GLYCEROL
PROJECTION FORMULA$_A$
SPACE-FILLING MODEL$_\star$
CARBON$_C$
HYDROGEN$_H$
OXYGEN$_O$



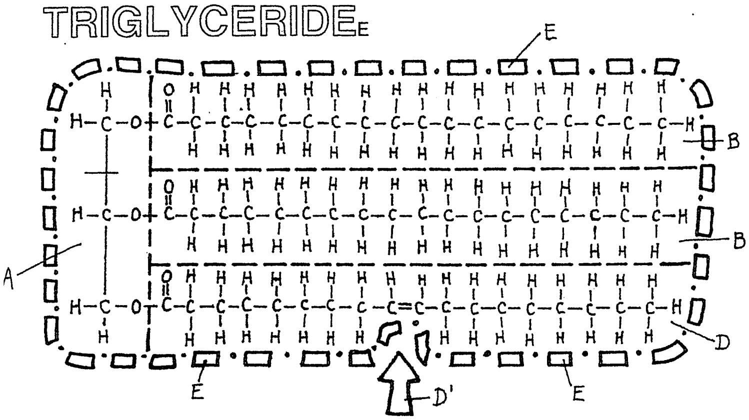
SATURATED FATTY ACID
PROJECTION FORMULA$_B$
SPACE-FILLING MODEL$_\star$



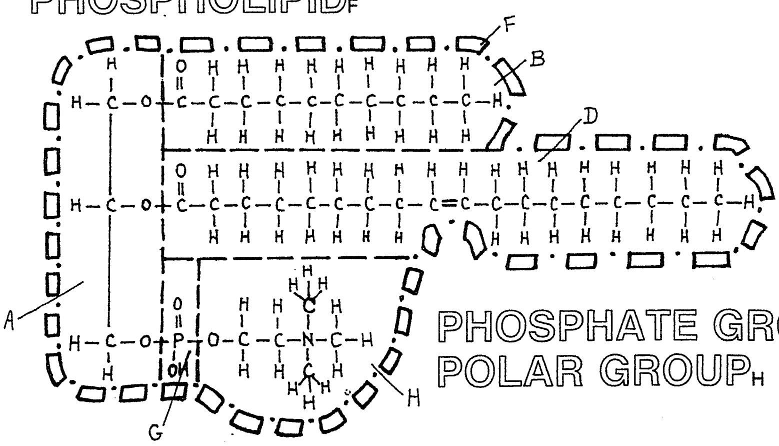
UNSATURATED FATTY ACID$_D$
CARBON DOUBLE BOND$_{D^1}$



TRIGLYCERIDE$_E$

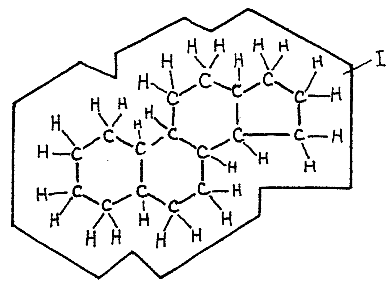


PHOSPHOLIPID$_F$



PHOSPHATE GROUP$_G$
POLAR GROUP$_H$

STEROID NUCLEUS$_I$



BEESWAX$_J$
ALCOHOL$_K$