the risk of heart disease, and they also reduce your body's production of a type of cholesterol that protects against heart disease.

Because of the well-documented links between dietary fats and heart disease, many people are trying to reduce their fat intake. "Fake fats" make this possible. They are designed to be similar to fats in taste and texture, but have one big difference: they cannot be digested by humans. One such "fake fat" is olestra. Olestra, instead of being a triglyceride fat with three fatty acid tails linked to a glycerol molecule, has eight separate hydrocarbon fatty acids attached to a molecule of sucrose. This octopus-like molecule allows the fatty acids to stimulate their usual taste buds on your tongue, telling your brain that you are eating a fat. The complex shape of the molecule, however, prevents your body's digestive chemicals from grabbing onto it and breaking it down. As a consequence, it passes through your digestive system without being digested. It's not a perfect solution, however. Olestra reduces absorption of some vitamins, and in some people causes abdominal cramping.

Q *Olestra is a recently developed "fake fat" chemical that gives foods the taste of fat, without adding the calories of fats. What chemical structure might make this possible?*

TAKE-HOME MESSAGE 2·12

Fats, including the triglycerides common in the food we eat, are one type of lipid. Characterized by long hydrocarbon tails, fats effectively store energy in the many carbon-hydrogen and carbon-carbon bonds. Their caloric density is responsible for humans' preferring fats to other macromolecules in the diet, and is also responsible for their association with obesity and illness in the modern world.

2·13 Cholesterol and phospholipids are used to build sex hormones and membranes.

Not all lipids are fats, nor do lipids necessarily function in energy storage. A second group of lipids, called the **sterols,** plays an important role in regulating growth and development (**FIGURE 2-33**). This group includes some very familiar lipids: cholesterol and the steroid hormones such as testosterone and estrogen. These molecules are all variations on one basic structure formed from four interlinked rings of carbon atoms.

Cholesterol is an important component of most cell membranes. For this reason, it is an essential molecule for living organisms. Cells in our liver produce almost 90% of the circulating cholesterol by transforming the saturated fats in our diet. Cholesterol is also present in foods and has a bad reputation in most Western cultures that is mostly well deserved. When we ingest too much cholesterol (present in animal-based foods such as egg yolks, red meat, and cream) and high levels of cholesterol circulate in our bloodstream, the cholesterol can attach to blood vessel walls and cause them to thicken. In turn, this thickening can lead to high blood pressure, a major contributor to strokes and heart attacks. For these reasons, nutritionists advise limiting the consumption of foods high in cholesterol and saturated fats.

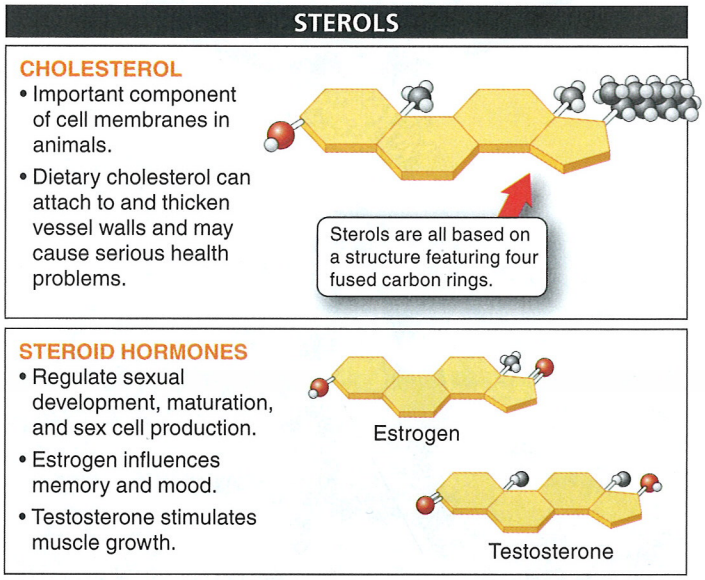

FIGURE 2-33 Not all lipids are for energy storage. Cholesterol, estrogen, and testosterone are all lipids.

The steroid hormones estrogen and testosterone are built through slight chemical modifications to cholesterol. These hormones are among the primary molecules that direct and regulate sexual development, maturation, and sperm and egg production. In both males and females, estrogen influences memory and mood, among other traits. Testosterone has numerous effects, one of which is to stimulate muscle growth. As a consequence, athletes (particularly bodybuilders) have often been found to take synthetic variants of testosterone to increase their muscularity. But the use of these supplements is often accompanied by dangerous side effects, including extreme aggressiveness ("'roid rage"), high cholesterol, and, following long-term use, cancer. As a consequence, nearly all athletic organizations have banned their use (**FIGURE 2-34**).

Phospholipids and waxes are also lipids. **Phospholipids** are the major component of the membrane that surrounds the contents of a cell and controls the flow of chemicals into and out of the cell (**FIGURE 2-35**). They have a structure similar to

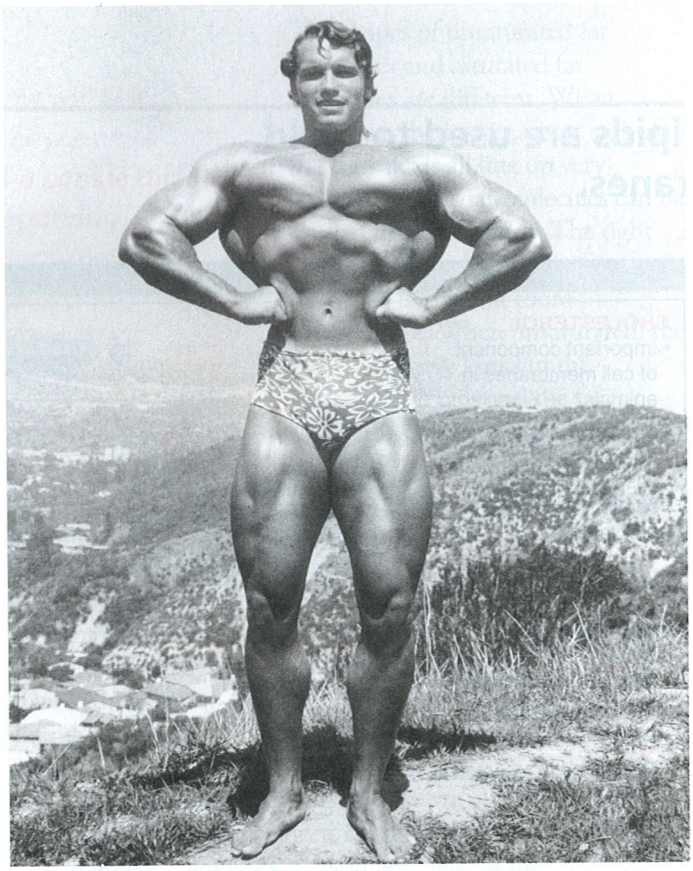

FIGURE 2-34 Dangerous bulk. Steroids can increase muscularity, but with serious health consequences.

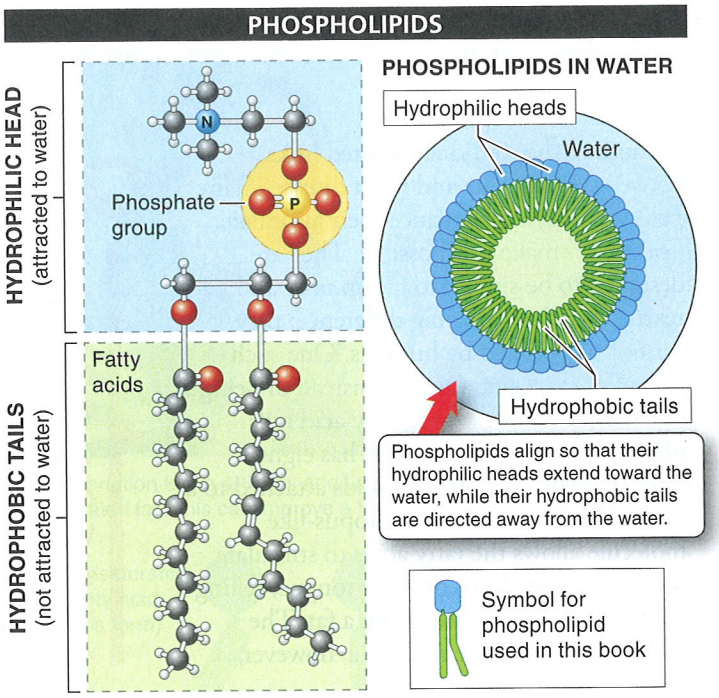

FIGURE 2-35 Dual nature. Phospholipids have a head region that is attracted to water and a tail that is not.

fats, but with two differences: they contain a phosphorus atom (hence *phospho*lipids) and they have two fatty acid chains rather than three. We explore the significant role of phospholipids in cell membranes in the next chapter.

Waxes resemble fats but have only one long-chain fatty acid linked to the glycerol head of the molecule. Because the fatty acid chain is highly nonpolar, waxes are strongly hydrophobic; that is, these molecules do not mix with water but repel it. Their water resistance accounts for their presence as a natural coating on the surface of many plants and in the outer coverings of many insects. In both cases, the waxes prevent the plants and animals from losing the water essential to their life processes. Many birds, too, have a waxy coating on their wings, keeping them from becoming water-logged when they get wet.

TAKE-HOME MESSAGE 2·13

Cholesterol and phospholipids are lipids that are not fats. Both are important components in cell membranes. Cholesterol also serves as a precursor to steroid hormones, important regulators of growth and development.