B. LIPIDS

What Is a Lipid?

A lipid is a fat-soluble molecule. To put it another way, lipids are insoluble in water but soluble in at least one organic solvent. The other major classes of organic compounds (nucleic acids, proteins, and carbohydrates) are much more soluble in water than in an organic solvent. Lipids do not share a common molecule structure.

Examples of Common Lipids

There are many different types of lipids. Examples of common lipids include butter, vegetable oil, cholesterol and other steroids, waxes, phospholipids, and fat-soluble vitamins. The common characteristic of all of these compounds is that they are essentially insoluble in water yet soluble in one or more organic solvents.

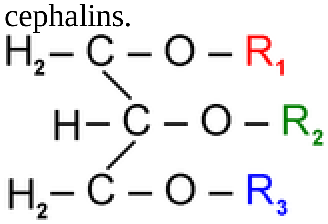
What Are the Functions of Lipids?

Lipids are used by organisms for energy storage, as a signaling molecule (e.g., steroid hormones), and as a structural component of cell membranes.

Lipid Structure

Although there is no single common structure for lipids, the most commonly occurring class of lipids are triglycerides, which are fats and oils. Trigylcerides have a glycerol backbone bonded to three fatty acids. If the three fatty acids are identical then the triglyceride is termed a *simple triglyceride*. Otherwise, the triglyceride is called a *mixed triglyceride*.

The second most abundant class of lipids are the phospholipids, which are found in animal and plant cell membranes. Phospholipids also contain glycerol and fatty acids, plus the contain phosphoric acid and a low-molecular-weight alcohol. Common phospholipids include lecithins and cephalins.



This is the general chemical structure of triacylglycerol, a triglyceride and the most abundant form of lipid. Triglycerides result from the reaction between glycerol and fatty acids.

Types of fatty acids

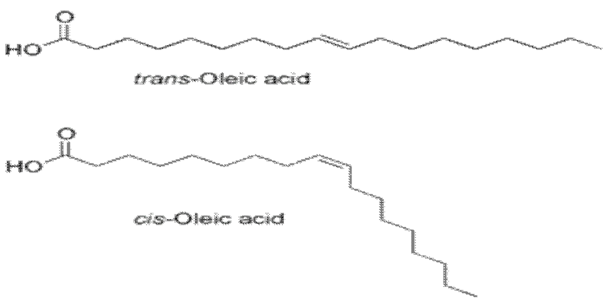
Fatty acids can be saturated and unsaturated, depending on double bonds. They differ in length as well.

Long and short fatty acids

In addition to saturation, fatty acids have different lengths, often categorized as short, medium, or long.

- Short-chain fatty acids (SCFA) are fatty acids with aliphatic tails of fewer than six carbons.
- Medium-chain fatty acids (MCFA) are fatty acids with aliphatic tails of 6–12. carbons, which can form medium-chain triglycerides.
- Long-chain fatty acids (LCFA) are fatty acids with aliphatic tails longer than 12 carbons.
- Very-Long-chain fatty acids (VLCFA) are fatty acids with aliphatic tails longer than 22 carbons

Unsaturated fatty acids



Comparison of the *trans* isomer (top) Elaidic acid and the *cis*-isomer oleic acid.

Unsaturated fatty acids resemble saturated fatty acids, except that the chain has one or more double-bonds between carbon atoms. The two carbon atoms in the chain that are bound next to either side of the double bond can occur in a *cis* or *trans* configuration.

> A *cis* configuration means that adjacent hydrogen atoms are on the same side of the double bond. The rigidity of the double bond freezes its conformation and, in the case of the *cis* isomer, causes the chain to bend and restricts the conformational freedom of the fatty acid. The more double bonds the chain has in the *cis* configuration, the less flexibility it has. When a chain has many *cis* bonds, it becomes quite curved in its most accessible conformations. For example, oleic acid, with one double bond, has a "kink" in it, whereas linoleic acid, with two double bonds, has a more pronounced bend. Alpha-linolenic acid, with three double bonds, favors a hooked shape. The effect of this is that, in restricted environments, such as when fatty acids are part of a phospholipid in a lipid bilayer, or triglycerides in lipid droplets, cis bonds limit the ability of fatty acids to be closely packed, and therefore could affect the melting temperature of the membrane or of the fat.
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> A *trans* configuration, by contrast, means that the next two hydrogen atoms are bound to *opposite* sides of the double bond. As a result, they do not cause the chain to bend much, and their shape is similar to straight saturated fatty acids.

In most naturally occurring unsaturated fatty acids, each double bond has three *n* carbon atoms after it, for some n, and all are cis bonds. Most fatty acids in the *trans* configuration (trans fats) are not found in nature and are the result of human processing (e.g., hydrogenation).

The differences in geometry between the various types of unsaturated fatty acids, as well as between saturated and unsaturated fatty acids, play an important role in biological processes, and in the construction of biological structures (such as cell membranes).