Functional groups

What a functional group is. Some of the key types of functional groups found in biological molecules.

Introduction

Pure hydrocarbons, made up of just carbon and hydrogen atoms, make wonderful combustion fuels, such as propane, butane, and the bulk of commercial gasoline. But can you build a living organism out of just combustion fuels? Probably not. Most of the large biological molecules (macromolecules) that make up humans and other organisms are not pure hydrocarbons, but instead contain additional atoms that provide important types of functionality.

Functional groups

Although large biological molecules typically have a skeleton made of carbon atoms linked to hydrogen's, some other atoms, such as oxygen, nitrogen, or sulfur, are usually present as well. Hydrocarbons have a limited range of chemical behavior, so if a biological molecule needs, for instance, to be soluble in water or undergo an acid-base reaction, it will need some other atoms in addition to hydrogen and carbon.

Often, these atoms appear in the context of **functional groups**, chemical motifs that appear in various molecules but display consistent "function" (properties and reactivity) regardless of where they are found. Different types of functional groups are found in different macromolecules, and a macromolecule's particular set of groups will affect many of its properties, including what shape it takes, what other molecules it interacts with, and what kinds of chemical reactions it can participate in.

Some of the most important functional groups in biological molecules are shown in the table below. Functional groups are usually classified as hydrophobic or hydrophilic based on their charge and polarity characteristics. An example of a hydrophobic group is the methyl group, which is nonpolar. The remaining six functional groups all have varying degrees of hydrophilic character.

One example of a strongly hydrophilic group is the carboxyl group, which can act as an acid and lose a proton to form a negatively charged carboxylate (CO^-)ion. Carboxyl groups are found in amino acids and fatty acids. Other functional groups, such as the carbonyl group, are uncharged but polar (carry partial positive and negative charges), which makes them moderately hydrophilic.

Common functional groups in biology

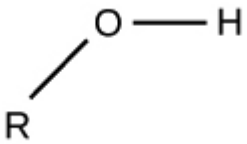
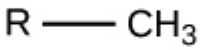
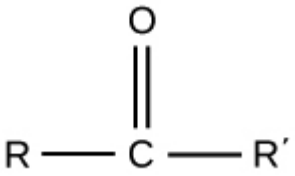
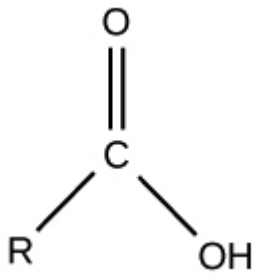
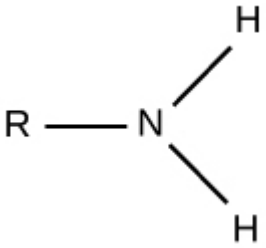
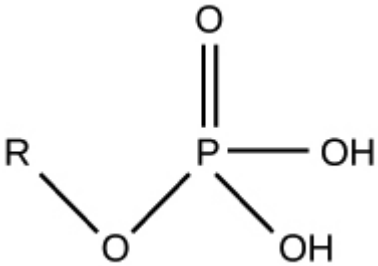
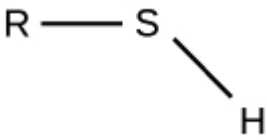
Functional Group	Structure	Properties
Hydroxyl		Polar
Methyl		Nonpolar
Carbonyl		Polar
Carboxyl		Charged, ionizes to release H+. Since carboxyl groups can release H+ ions into solution, they are considered acidic.
Amino		Charged, accepts H+ to form R-NH3_. Since amino groups can remove H+ from solution, they are considered basic.
Phosphate		Charged, ionizes to release H+. Since phosphate groups can release H+ ions into solution, they are considered acidic.
Sulfhydryl		Polar

Table modified from: OpenStax Biology.

In the table above, the letter R is used to represent the rest of the molecule that the group is attached to. For instance, R might be a methyl (CH_3) group, in which case the first entry in the table would correspond to methanol. But R could also be a much larger molecule, such as a protein. The letter R is often used in biology and chemistry as a compact way to represent a portion of a molecule that can come in different forms.