Functional Groups

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Functional groups are those small chemical species you see hanging off the outside of a molecule. Just a handful of these functional groups determine most of the chemical reactions that happen between biological molecules. If you memorize the chemical behavior of these functional groups, you'll be able to predict what kinds of reactions biological molecules can do.

You can't open a lock with a screwdriver–the shape of a screwdriver is quite different from a key, which means it has a different function. "Form determines function" is something you'll hear over and over in biochemistry, and that's because it's true. The overall 3-dimensional shape of a molecule allows it to fit into another molecule, like how a key fits into a lock.

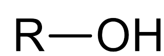
But not all keys are the same. You have to look closely at the *teeth* of a key to see which lock it can open. Similarly, you need to look at the details of the outside of a molecule to understand what kinds of chemical interactions it can do with other molecules.

How the carbon skeleton of a biological molecule is folded up determines its general 3D shape. So that's one level of understanding–this molecule looks like a key, this one looks like a lock, etc. But then you must look closer, at the surface details, to understand *exactly which* key, *exactly what kind* of lock.

When you examine the outside of a biological molecule, you can identify which functional groups are standing out on its surface, like little flags. Those little flags are going to bump into other little flags on the exterior of a different molecule. If they're not the right kind of little flags (functional groups), no chemical reaction takes place. See Table 1 for a summary of their chemical properties.

9 Essential Functional Groups

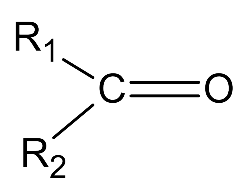
1. Hydroxyl -OH



In these structural diagrams, R stands for the rest of the molecule, starting with a carbon atom.

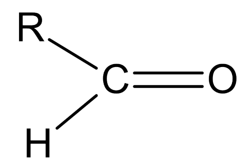
The hydroxyl group is hydrophilic (polar), so if a molecule has a patch of –OH on the outside, that region will be hydrophilic.

2. Carbonyl C=O



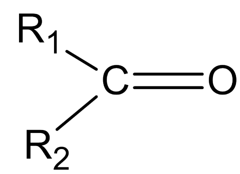
The carbonyl group is a carbon double-bonded to oxygen. This confers hydrophilic chemical behavior.

3. Aldehyde *-CHO*



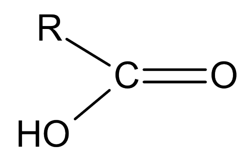
The aldehyde group is what you call a carbonyl group if it's at the end of the carbon skeleton. Hydrophilic.

4. Ketone *>CO*



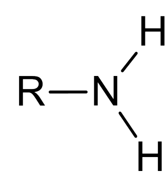
The ketone group is what you call a carbonyl group if it's *not* at the end of the carbon skeleton. Hydrophilic.

5. Carboxyl *-COOH*



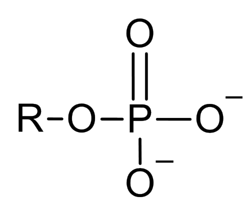
The carboxyl group is a carbon double-bonded to an oxygen and also attached to a hydroxyl group. These tend to donate their H+, and so they confer acidic behavior to molecules.

6. Amine *-NH2*



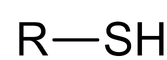
The amine group confers basic behavior to molecules, because it tends to accept a H+.

7. Phosphate *-OPO3 2-*



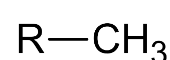
The phosphate group loses H+ ions, so by increasing the H+ concentration, it confers acidic behavior on a molecule.

8. Sulfhydryl *-SH*



The sulfhydryl group is a sulfur atom bonded to a hydrogen. It is moderately polar. Sulfhydryl groups tend to bond to other sulfhydryl groups, forming disulfide bridges.

9. Methyl *-CH3*



The methyl group is hydrophobic (nonpolar), which sets it apart from the other functional groups discussed here.

Functional Group	Properties
Hydroxyl	polar
Carbonyl	polar
Aldehyde	polar
Ketone	polar
Carboxyl	polar and acidic
Amine	polar and basic
Phosphate	polar and acidic
Sulfhydryl	polar
Methyl	nonpolar

Table 1: These are the most commonly observed functional groups in biochemical molecules and their chemical properties.

Additional Resources

Functional Groups (Video)

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