Functional Groups

Watch the following video on Functional Groups. https://www.youtube.com/watch?v=Z_nQZzqn7No.

Biochemically important molecules contain only a few different kinds of atoms: carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. The bonding between these atoms is always covalent.

Properties of Carbon:

- Tetravalent (4 bonds)
- Can form single, double and triple bonds
- Can form long chains, sheets, and rings with other atoms
- Can bond with many other atoms/atom groups (aka *functional groups*)

Hydrocarbon → a compound containing only carbon and hydrogen.

- names end in '**ane**' Propane, methane, etc
- IMPORTANCE: Biologically unreactive
  ↖ In our body

Saturated Hydrocarbons

Saturated hydrocarbons are stable and unreactive. The molecule contains a backbone of carbon atoms bonded to hydrogen atoms. All the covalent bonds are single, so that each carbon has four bonds. These molecules have the maximum number of hydrogen atoms possible.

Functional Groups

- Organic compounds are usually made of a carbon skeleton with reactive or **functional groups** attached.
- Functional groups are often involved in **chemical reactions**, and play an important role in the structure and function of the molecule.
- Functional groups have definite chemical properties that they retain no matter where they occur.
- These functional groups determine the characteristics and chemical reactivity of molecules. For example:
  - Amino groups make a molecule more basic.
  - Carboxyl groups make a molecule more acidic.
- Most chemical reactions that occur in organisms involve the transfer of a functional group as an intact unit from one molecule to another.

Common Function Groups found in Biological Molecules:

Table 1 Functional Groups in Biomolecules

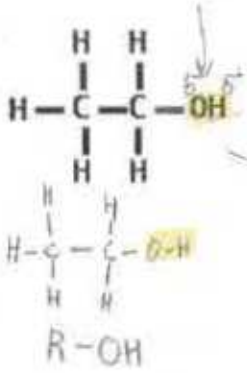
Group	Chemical formula	Structural formula	Ball-and-stick model	Found in
hydroxyl	—OH	—OH		alcohols (e.g., ethanol)
carboxyl	—COOH			acids (e.g., vinegar)
amino	$—NH_2$			bases (e.g., ammonia)
sulfhydryl	—SH	—S—H	—S—H	rubber
phosphate	$—PO_4$			ATP

R ← Symbolizes something is attached (usually hydrocarbon)

HYDROXYL (-OH)

- The hydroxyl group consists of an oxygen atom joined by a single covalent bond to a hydrogen atom.
- Organic molecules containing hydroxyl groups are **alcohols**.

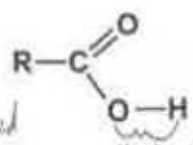
* Makes them more soluble (like dissolves like)



R-OH

CARBOXYL (-COOH)

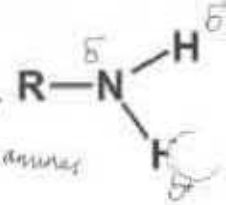
- The carboxyl functional group consists of a carbon atom joined by covalent bonds to two oxygen atoms, one of which in turn is covalently bonded to a hydrogen atom.
- Organic molecules containing carboxyl groups are called **carboxylic acids** (organic acids). ← Because it releases H when dissolved
- One valence electron on the carbon is available for bonding to another atom so that the carboxyl group can form part of a larger molecule



Hydroxyl but because it's attached to C=O, it's part of a carboxy

AMINO ($-NH_2$)

- An amino group consists of one nitrogen atom attached by covalent bonds to two atoms of hydrogen. A lone valence electron on the nitrogen is available for bonding to another atom.
- Organic molecules containing amino groups are called **amines**.
- Amines are weak bases. ← We can pull H from solutions using amines
- The amino group is common to all amino acids, which in turn are the building blocks of proteins.



Both amines

SULFHYDRYL (-SH)

- A sulfhydryl group consists of a sulfur atom bonded to a hydrogen atom.

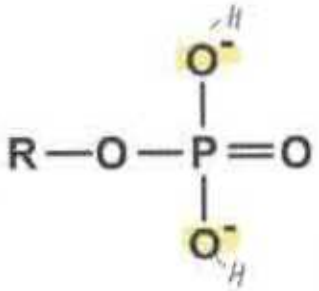
Polar

* Not as polar as Hydroxyls

Can pick up hydrogen

PHOSPHATE ($-PO_4$) Acidic

- A phosphate group composed of one phosphorous atom bound to four oxygen atoms.
- Organic molecules containing phosphate groups are called organic phosphates. ← DNA, ATP
- The phosphate group is one of the three components of **nucleotides** and often attached to proteins and other biological molecules.
- A free phosphate ion in a solution is called inorganic phosphate (denoted P_i) to distinguish it from phosphates bound in molecules. (More on this later)



ATP ⇒ Adenosine Triphosphate
Energy

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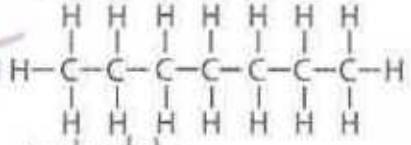
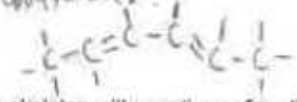
Saturated Hydrocarbons

Saturated hydrocarbons are stable and unreactive. The molecule contains a backbone of carbon atoms bonded to hydrogen atoms. All the covalent bonds are single, so that each carbon has four bonds. These molecules have the maximum number of hydrogen atoms possible. (See diagram to the right)

saturated:



unsaturated:



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- Functional groups are often involved in **chemical reactions**, and play an important role in the structure and function of the molecule.
- Functional groups have definite chemical properties that they retain no matter what larger molecule they are found on.
- Functional groups determine the characteristics and chemical reactivity of molecules. For example:
  - Amino groups make a molecule more basic.
  - Carboxyl groups make a molecule more acidic.
- Most chemical reactions that occur in organisms involve the transfer of a functional group as an intact unit from one molecule to another.

↑ Allows hydrocarbons/biological molecules to react.

★ Functional group can only attach to a backbone of carbon atoms.

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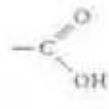
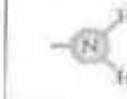
carboxyl	—COOH			acids (e.g., vinegar)
amino	$-NH_2$			bases (e.g., ammonia)
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- The hydroxyl group consists of an oxygen atom joined by a single covalent bond to a hydrogen atom.
- Organic molecules containing hydroxyl groups are **alcohols**.

★ Functional groups are groups of atoms that attach to carbon backbone molecules and make them reactive. Multiple functional groups can attach to one hydrocarbon.

★ Functional groups are not molecules but are groups of atoms that attach to hydrocarbon

★ When a hydrocarbon reacts it is due to a functional group.

R= anything that fits

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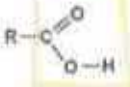

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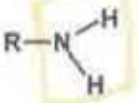

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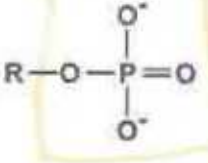
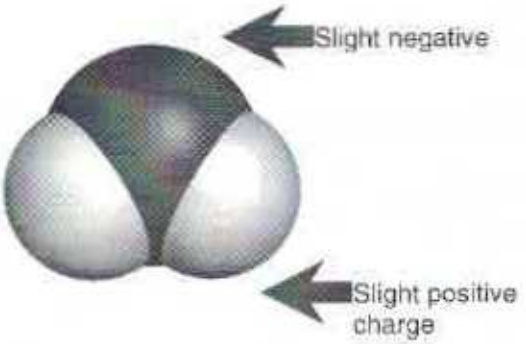


Water



The water molecule contains polar covalent bonds

- It is a dipole

DIPOLE means it has two separate charges within the molecule:

- A slight positive charge on each two hydrogen
- A slight negative charge on the oxygen

The Importance of Molecular Polarity in Biology:

1. "Like dissolves like"
2. Polarity of water organizes molecules into cells

'Like Dissolves Like'

- Polar liquid dissolves polar solid
- Nonpolar liquid dissolves non-polar solid
- Nonpolar and polar do not dissolve
- If two substances will dissolve, they are said to be soluble
- If two substances will not dissolve, they are said to be insoluble

The Relevance of Water:

- Water is referred to as universal solvent
- Excellent solvent because of its polarity.
- Ionic solids readily dissolve in water:
  http://preparatorychemistry.com/Bishop_NaCl_frames.htm

  Explain why:
  Water pulls apart the negative & positive ends, dissolving it

Will is Dissolve?

Water and salt Polar Polar	Yes
Water and oil Polar Non-polar	No
Water and Nail Polish Polar Non-Polar	No
Acetone and Nail Polish Non-polar Non-polar	Yes
Acetone and Oil Non-polar Non-polar	Yes

Properties of Water

Resource: https://www.youtube.com/watch?v=3jwAGWky98c

Property	Brief Description	Why is it important in bio?
Adhesion	Water sticks to other substances	Water transport (blood, xylem, etc)
Cohesion	Bonds with other water molecule via Hydrogen Bonding	"
Surface Tension (high)	Property allowing liquid to resist external force (caused by cohesion)	Allows animals to walk on water
Solvent Properties	Universal solvent Ability to dissolve other molecules	- Important to bodily functions as solvent (kidneys)
Density	Water expands when frozen & gets less dense. Hydrogen bonds are further away.	Allows fish and aquatic life to survive underneath
Specific Heat Capacity (high)	Amount of heat which needs to absorbed to raise its temperature.	Stablizing for aquatic life Stays relatively stable temperature so fish don't get cooked or frozen.