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5.111 Principles of Chemical Science
Fall 2008

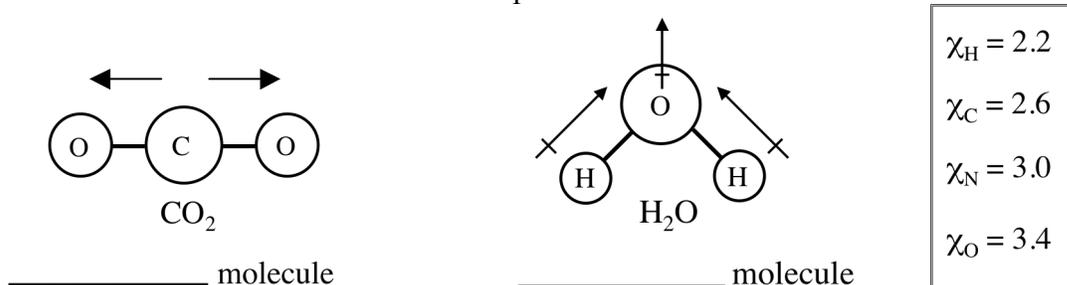
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Polar Covalent Bonds/Polar Molecules

See lecture 13 for an discussion of polar covalent bonds and polar versus non-polar molecules.

A polar covalent bond is an **unequal sharing** of electrons between two atoms with different electronegativities (χ). In general, a bond between two atoms with an χ difference of **0.4 to 1.7** (on the Pauling scale) is considered polar covalent.

Polar molecules have a non-zero net dipole moment.



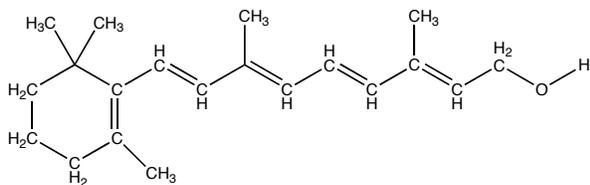
Both CO₂ and H₂O have two polar bonds. However the dipoles in the linear CO₂ molecule cancel each other out, meaning that the CO₂ molecule is non-polar. The polar bonds in the bent H₂O molecule result in a net dipole moment, so H₂O is polar.

In large organic molecules, such as drugs and vitamins, and in biomolecules, such as proteins, we often consider the number of polar groups within the molecule to determine the extent to which the overall molecule is polar.

Example 1) from page 1 of Lecture 13 notes: The significance of polarity in vitamins

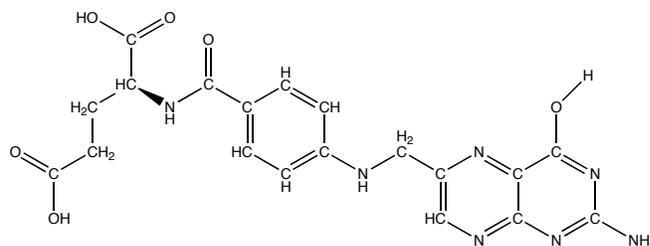
For example, let's compare vitamin A to vitamin B9

Which vitamin contains a higher number of polar bonds? vitamin _____



Vitamin A

_____ soluble

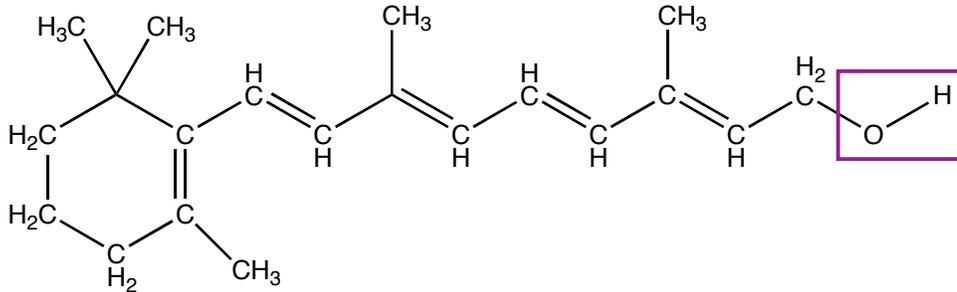


Vitamin B9 (folic acid)

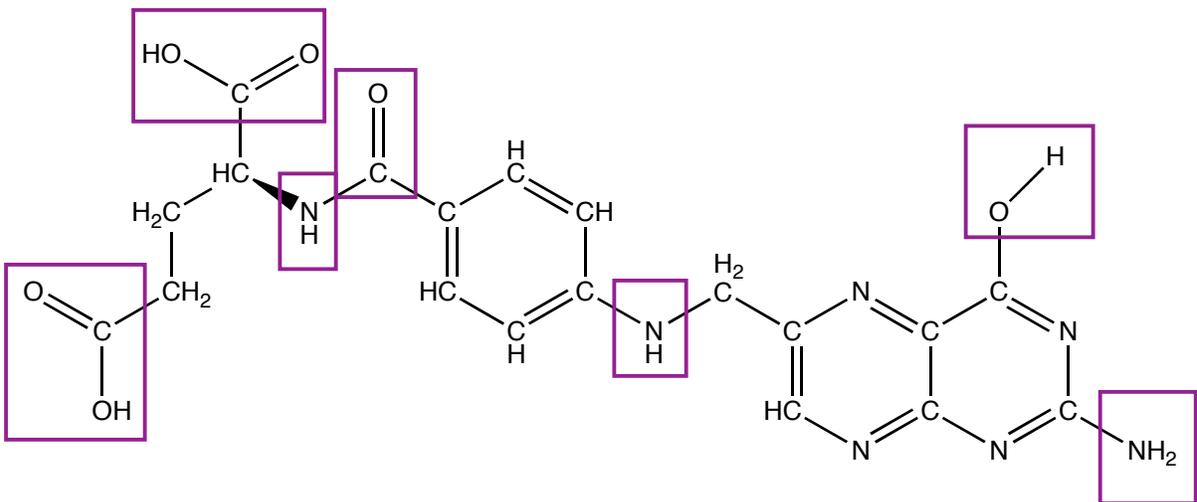
_____ soluble

Vitamin B9 (**folic acid**) has many more polar bonds than vitamin A. Since fat is non-polar and water is polar, **vitamin A is water soluble** and **vitamin B9 is fat soluble** (like dissolves like).

Polar bonds in vitamin A:



Polar bonds in folic acid (vitamin B9):



Let's think about what this means in terms of our daily multivitamins.

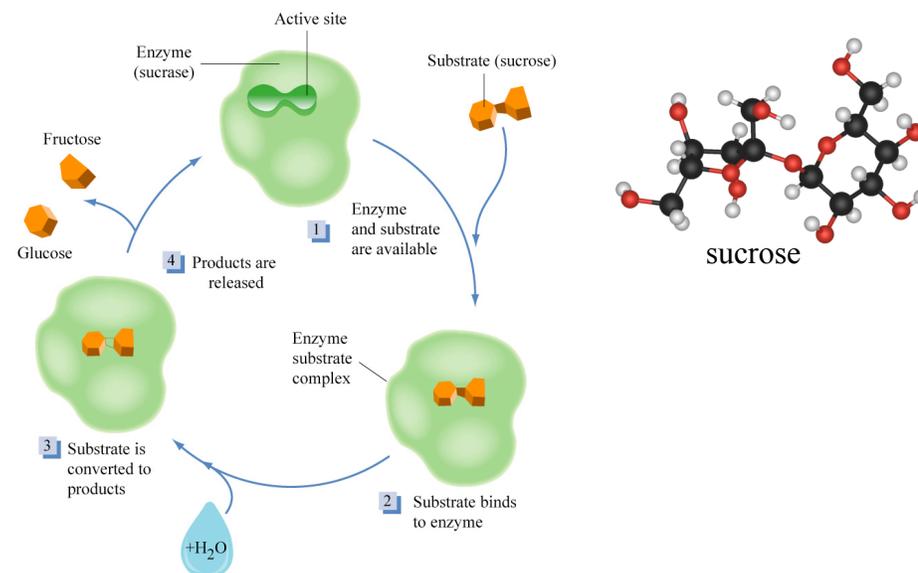
- Folic acid (vitamin B9) is water soluble, which means it is excreted in our urine comparatively quickly from our bodies.
- Since folic acid and other water soluble vitamins, such as vitamin C, are excreted in our urine, it is important to get a regular supply of those vitamins. Also, we don't need to worry about overdosing. Any excess vitamin will end up in our urine.
- Vitamin A is not water soluble, so it can be stored in fat cells and build up in our bodies.
- It is possible to get too much of a good thing with fat-soluble vitamins (such as vitamin A and vitamin E). Recent studies looking for health benefits from megadoses of vitamin E have instead shown that excesses of vitamin E can lead health problems.

Valence Shell Electron Pair Repulsion (VSEPR) Theory

Example 2) from lectures slides associated with page 2 of Lecture 13 notes: molecular shape in enzyme-substrate complexes

The shape (geometry) of molecules influences physical and chemical properties, including melting point, boiling point, and reactivity.

Shape is particularly important in biological systems where, for example, a molecule must fit precisely into the active site of an enzyme.



Shown above is the hydrolysis of the sugar molecule sucrose into fructose and glucose. This reaction is catalyzed by an enzyme called sucrase, and the catalysis depends on the sucrose molecule fitting into the active site of the sucrase enzyme.

For examples of other enzyme-substrate pairs, see Lecture 35 notes.