Welcome to Biology 111: "The Unity of Life"

Today's topic: a tiny taste of chemistry as it applies to living things.

25 January 2008

Session #2

Some Course Mechanics

- **Important to turn in the "first assignment" surveys---about five of you did not. It helps me better work with each of you!**
- **Great comments and helpful concerns.**
- **First three people to have responded get a treat in class: *Kim D-M*, *Chris S.*, and *Molly G.***
- **Don't forget lab next week!**
- **Notetaking and reading assignments.**
- **PowerPoint presentations available online now.**

Handouts and Format!

- **Outline of lecture (notice study questions, summary, and hints throughout).**
- **Extra handout on the foot of the gecko and how that topic relates to weak chemical bonds.**
- **Don't forget to prepare for lab next week, especially Monday folk.**
- **Also on Monday: spot check assignment at end of class (please think about this over the weekend).**
- **Reading assignments, again: skim before lecture (why?) then go over the portions we covered in lecture in greater detail.**

Let's think about the last lecture for a moment!

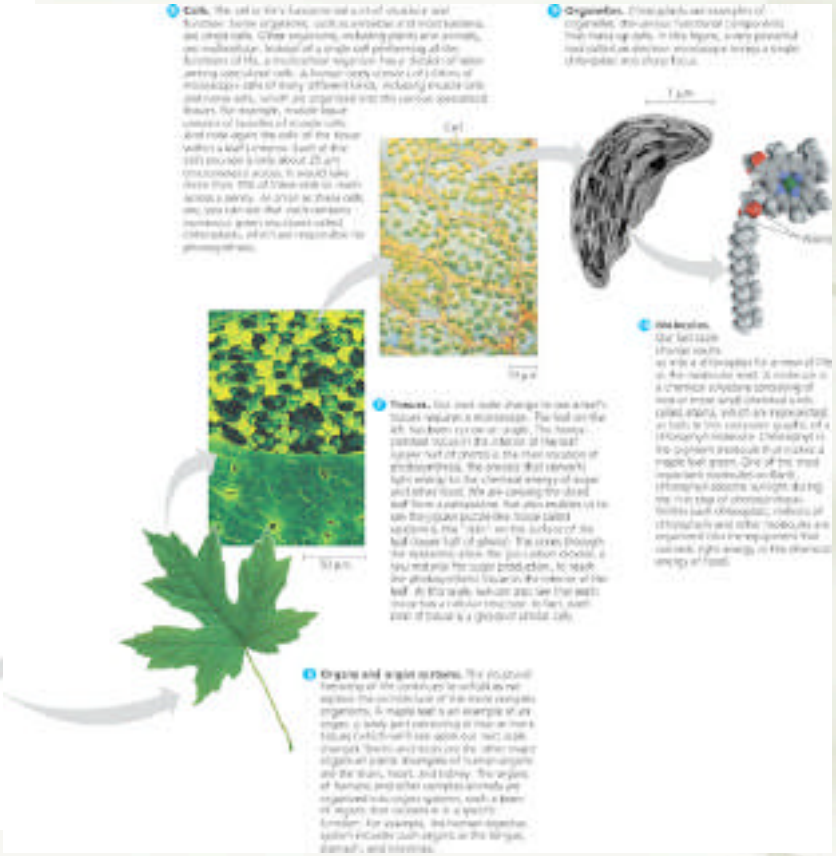
- **Remember our six "unifying principles" of biology?**
- **Order, Hierarchical organization, emergent properties, cellular basis of life, energy requirement, and information.**
- **Let's talk a bit more about some of these and some other concepts, but the six principles above are key.**

What are the characteristics of "life"?

- **Figure 1.2 in your textbook. PLEASE REVIEW THIS FIGURE. Here they are:**

- **Order.**
- **Evolutionary adaptation.**
- **Response to the environment.**
- **Regulation.**
- **Energy processing.**
- **Growth and development.**
- **Reproduction.**

There are different levels to organization



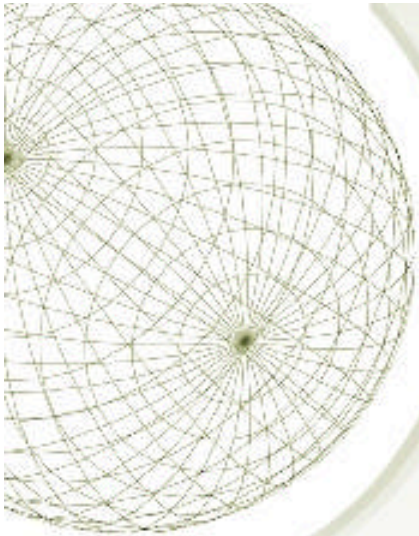
Notice how we go from least complex to most complex, in terms of organization?

Other thoughts….

- **Regulation is a key concept to living things; they respond to environmental changes. This is often part of organization, in fact.**

- **Evolution (relatedness) is a basic principle in all modern biology---bat's wings versus arms, etc. "Cows and *E. coli*."**

- **Don't forget the six themes that "unify" biology covered the last time!**



Time to think about a little chemistry and physics, friends…

Some basic thoughts: what are we made of?

Table 2.1 Naturally Occurring Elements in the Human Body

Symbol	Element	Atomic Number (See p. 34)	Percentage of Human Body Weight
O	Oxygen	8	65.0
C	Carbon	6	18.5
H	Hydrogen	1	9.5
N	Nitrogen	7	3.3
Ca	Calcium	20	1.5
P	Phosphorus	15	1.0
K	Potassium	19	0.4
S	Sulfur	16	0.3
Na	Sodium	11	0.2
Cl	Chlorine	17	0.2
Mg	Magnesium	12	0.1

Trace elements (less than 0.01%): boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn)

- **Element versus compound.**
- **Most common elements of life are oxygen, carbon, hydrogen, and nitrogen.**
- **Necessary for life as we know it.**
- **We can call the Big Four "CHON."**

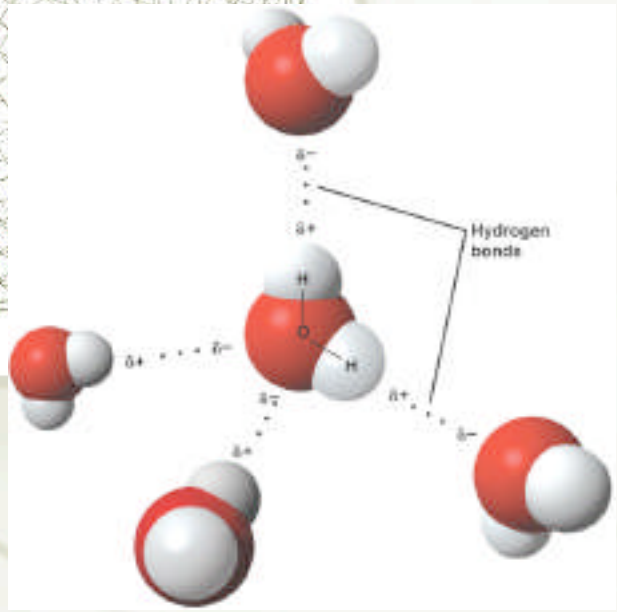
Atomic structure and isotopes?

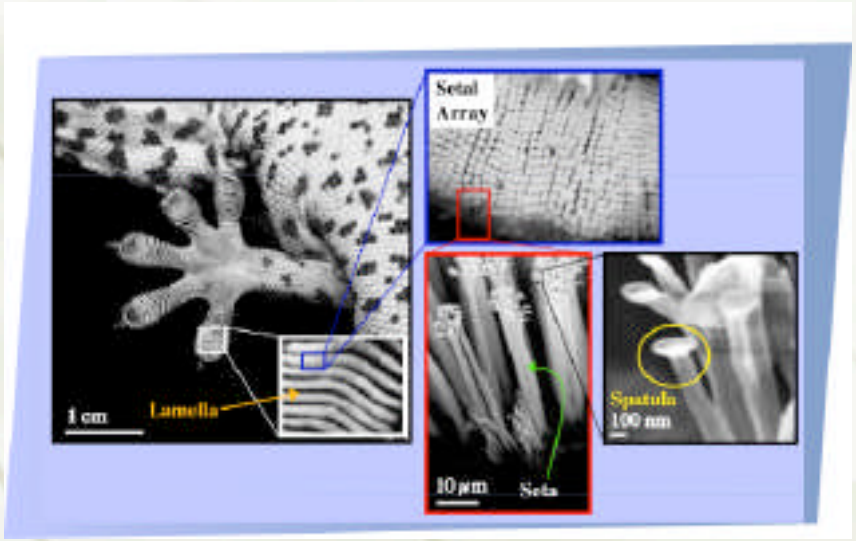
- **Atoms are made up of protons, electrons, and neutrons. Number of protons = number of electrons.**
- **Atomic number (# of protons) versus atomic mass (# of protons + # of neutrons).**
- **Here is an example: $^{12}_{6}C$ versus $^{13}_{6}C$ and $^{14}_{6}C$**
- **Isotopic issues---radioactive and nonradioactive.**
- **Role of electrons in bonds between atoms (electronegativity).**
- **Concept of valence.**

Bonds between atoms…

- Covalent bonds (polar and nonpolar)
- Ionic bonds
- Van der Waals forces
- Hydrogen bonds

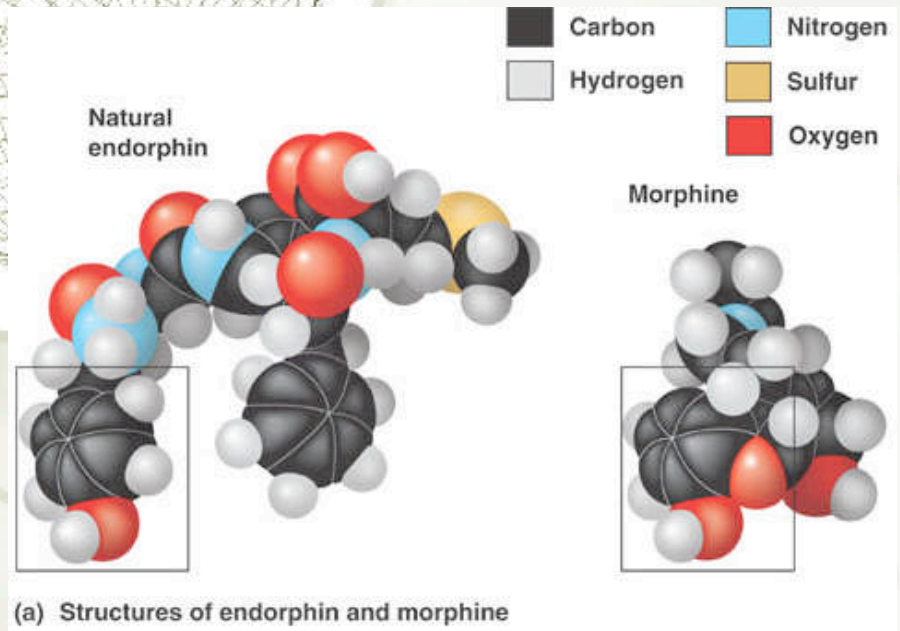
Weak forces can be strong!



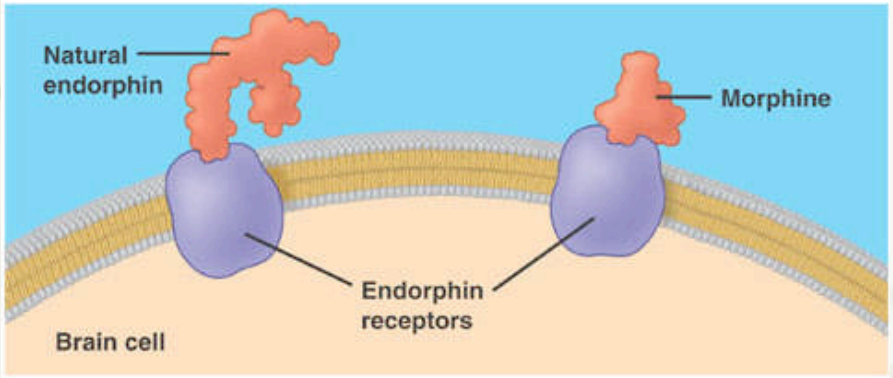


- **Covalent and ionic bonds are very strong.**
- **Polar versus nonpolar covalent bonds a key concept.**
- **Hydrogen bonds are weak, but act in concert (and are vital to biology, as you will learn).**
- **Van der Waals forces are individually weak, but can act in concert to be very, very strong (gecko foot example and handout)**

Stericity revisited: molecular shape



(a) Structures of endorphin and morphine

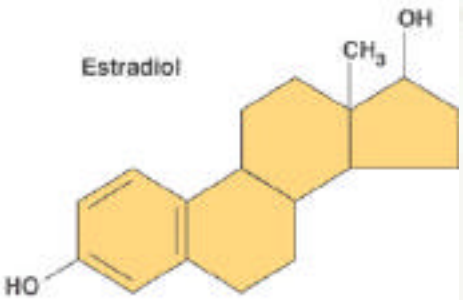


(b) Binding to endorphin receptors

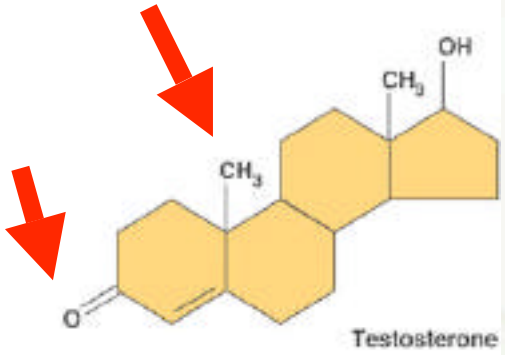
- Molecules have a "shape."
- Shape often fits into receptors, and causes changes.
- Notice that other molecules can "mimic" the shape in question!
- Endorphins versus morphine.

More stericity: small changes in a molecule can make a BIG difference

Female lion

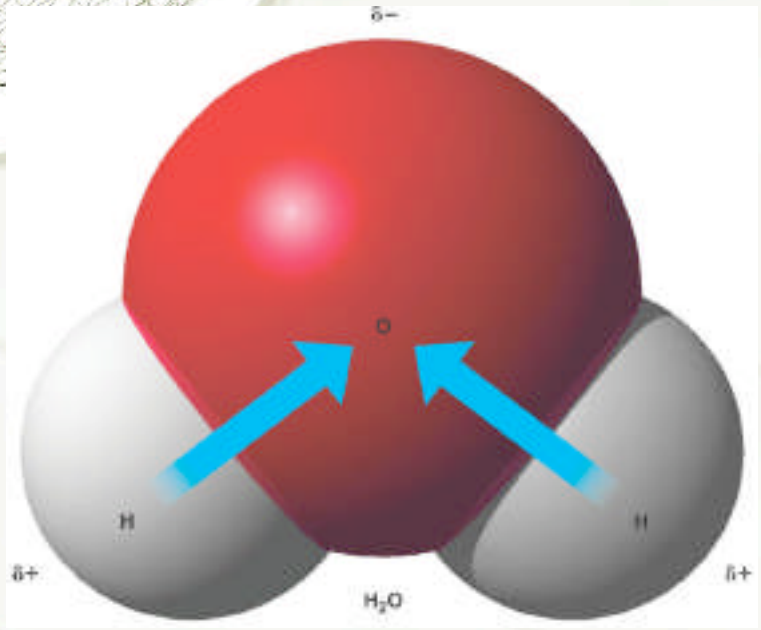


Male lion



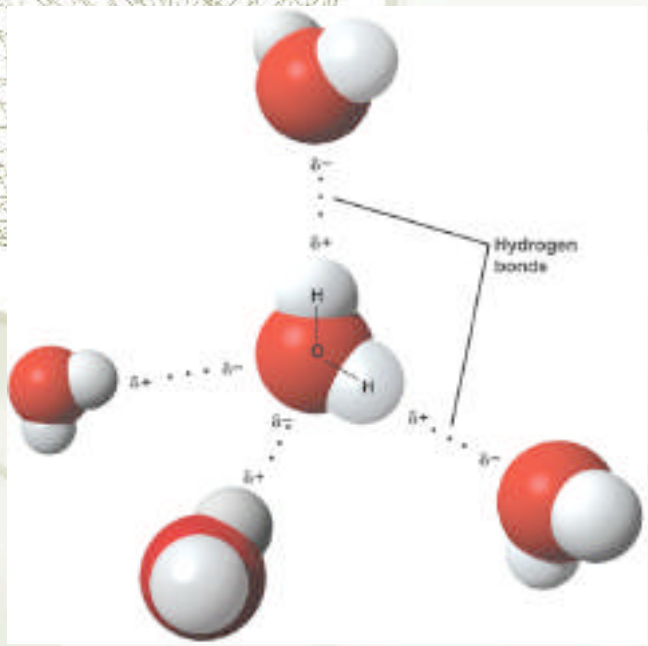
- Notice how the molecules are put together.
- Mostly a framework of linked carbon atoms.
- "Functional groups" add…functionality!
- Look for what is the same between the two, and what is different!

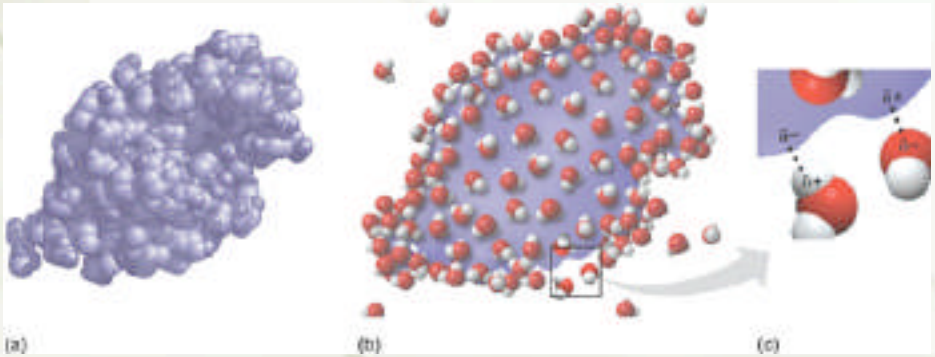
Water is funny stuff!



- H_2O as usual.
- Covalent bonds between the hydrogens and oxygen.
- Oxygen is more electronegative, so it pulls electrons away---a **polar covalent bond**.
- Gives partial charge to different parts of the same molecule!
- All this gives water remarkable properties!

Unusual things about water



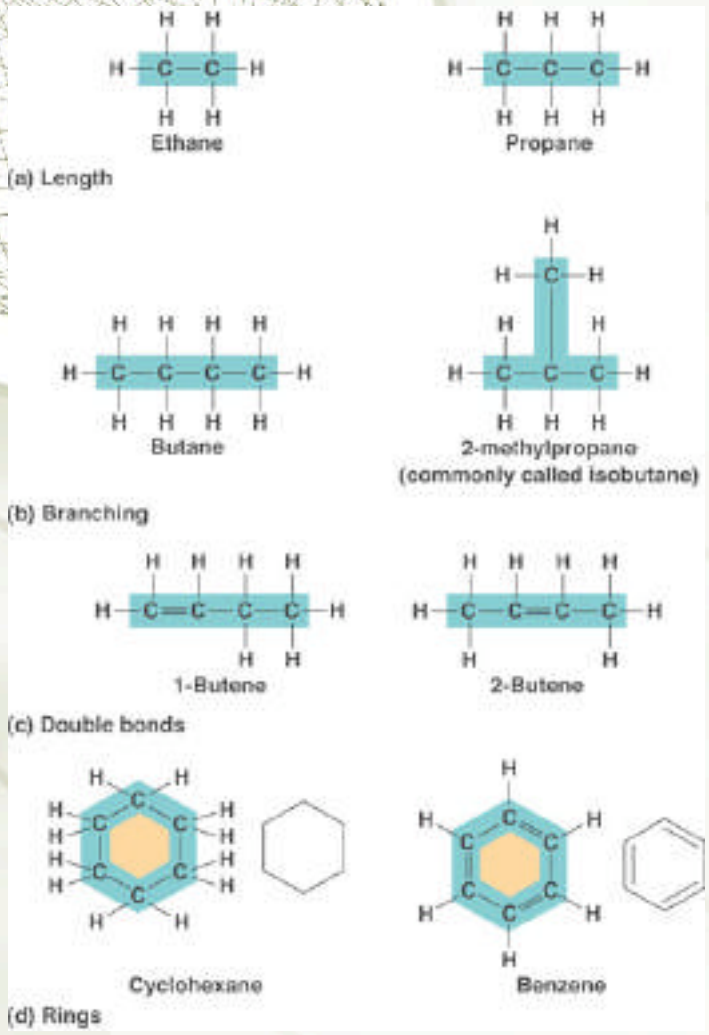


- **Polar covalent bonds let water form weak hydrogen bonds with other water molecules.**
- **Can also interact with other non water molecules that have a charge (<u>the basis of solubility</u>)**
- **Water becomes a "network" of connected molecules.**
- **"Pull" at one molecule, you "pull" at all of them!**

Which leads to the unusual emergent properties of water…

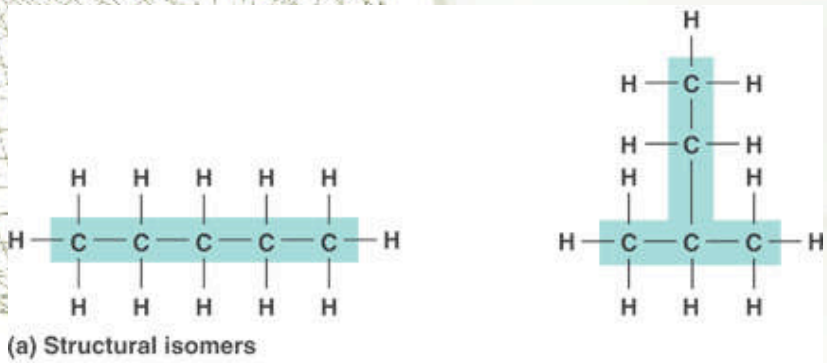
- Cohesion.
- Moderation of temperature.
- Density of solid phase (ice).
- Solvent properties.

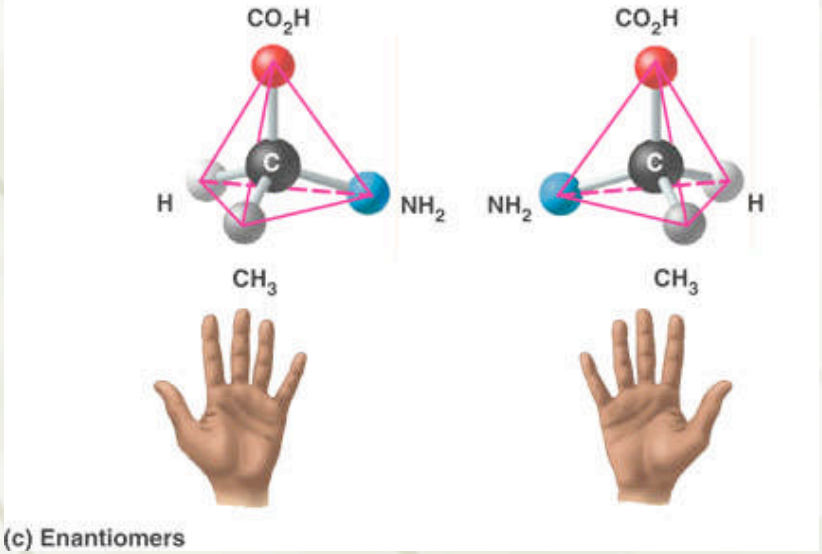
Organic molecules are the basis of life!



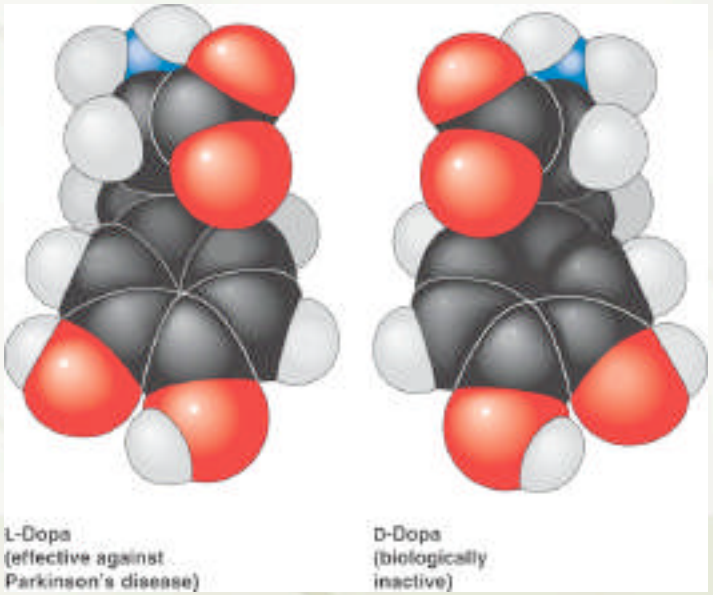
- **"Organic" means more than one carbon atom in a molecule!**
- **Notice how the carbon "skeletons" shown have different shapes, bonds, etc.**
- **Each carbon atom can only have a total of FOUR bonds attached to it (a valence of 4).**
- **Think about putting Legos or Tinkertoys together---that is how most biological molecules are made.**
- **Components in the skeletons control shape, and therefore function!**

Differences among organic "shapes" are subtle!





- **Isomers have the same components, but different shapes.**
- **Structural isomers.**
- **Geometric isomers.**
- **Enantiomers…a complex concept (think about mirror images).**



Functional groups added to organic molecules can alter functionality, too.

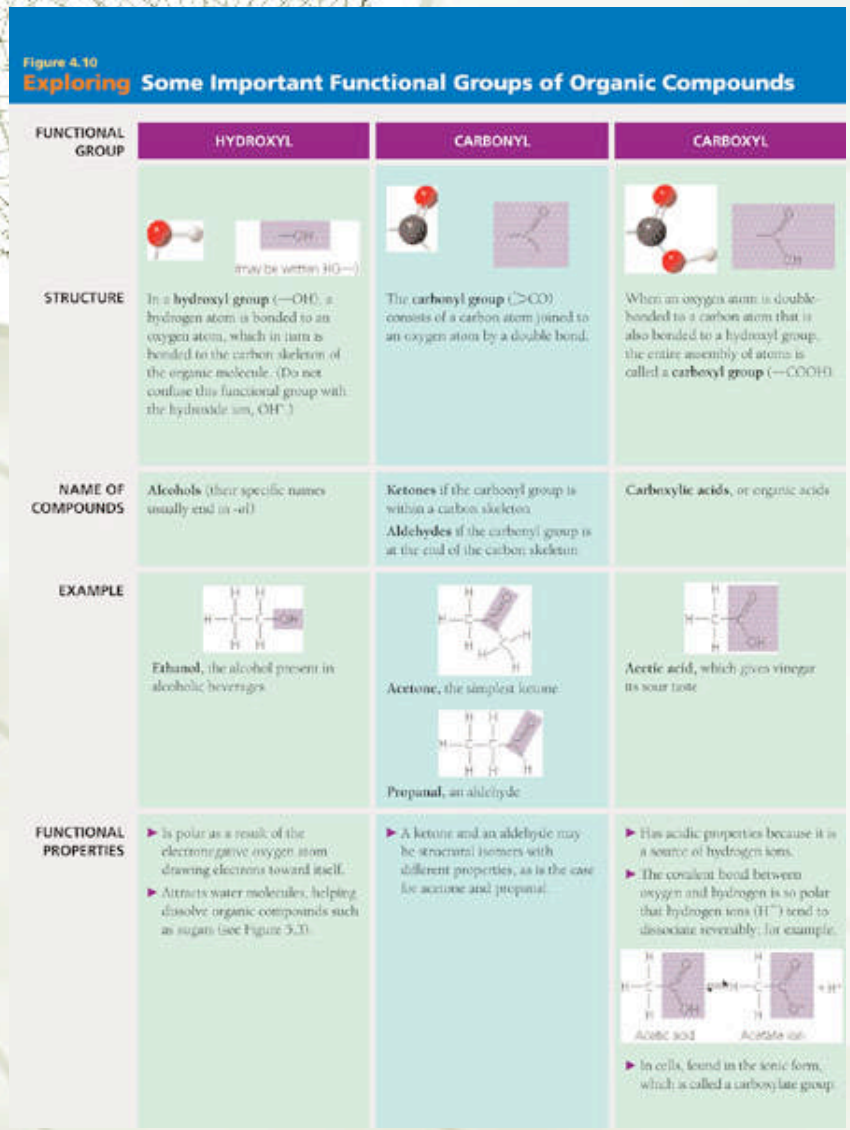


Figure 4.10
Exploring Some Important Functional Groups of Organic Compounds

FUNCTIONAL GROUP	HYDROXYL	CARBONYL	CARBOXYL
STRUCTURE	In a **hydroxyl group** (—OH), a hydrogen atom is bonded to an oxygen atom, which in turn is bonded to the carbon skeleton of the organic molecule. (Do not confuse this functional group with the hydroxide ion, OH^-.)	The **carbonyl group** (>CO) consists of a carbon atom joined to an oxygen atom by a double bond.	When an oxygen atom is double-bonded to a carbon atom that is also bonded to a hydroxyl group, the entire assembly of atoms is called a **carboxyl group** (—COOH).
NAME OF COMPOUNDS	**Alcohols** (their specific names usually end in *-ol*)	**Ketones** if the carbonyl group is within a carbon skeleton **Aldehydes** if the carbonyl group is at the end of the carbon skeleton	**Carboxylic acids**, or organic acids
EXAMPLE	**Ethanol**, the alcohol present in alcoholic beverages	**Acetone**, the simplest ketone **Propanal**, an aldehyde	**Acetic acid**, which gives vinegar its sour taste
FUNCTIONAL PROPERTIES	▸ Is polar as a result of the electronegative oxygen atom drawing electrons toward itself. ▸ Attracts water molecules, helping dissolve organic compounds such as sugars (see Figure 3.3).	▸ A ketone and an aldehyde may be structural isomers with different properties, as is the case for acetone and propanal.	▸ Has acidic properties because it is a source of hydrogen ions. ▸ The covalent bond between oxygen and hydrogen is so polar that hydrogen ions (H^+) tend to dissociate reversibly; for example, Acetic acid ⇌ Acetate ion + H^+ ▸ In cells, found in the ionic form, which is called a carboxylate group.

- Figure 4.10 in your book lists different functional groups, gives examples, and gives functional properties.
- Example: carboxyl groups have acidic properties, and can allow hydrogen bonding, as well as some ionic bonds.
- Please review this figure on your own, and think about the effects on a molecule of adding or taking away a given functional group.

Summing things up…

- Let's stop here (it is Friday!)
- Next time, we will move on to specific biological molecules.
- Please think about atoms, elements, bonds (strong versus weak), molecular shape (again), functional groups, and the truly remarkable properties of water.
- Have a great weekend!