CHEM 103, Unit 1.1

Chemistry Bootcamp

Structural Chemistry—building up molecules from atoms, introducing solubility issues

(target example: active ingredient in chiles)

Colorado State University

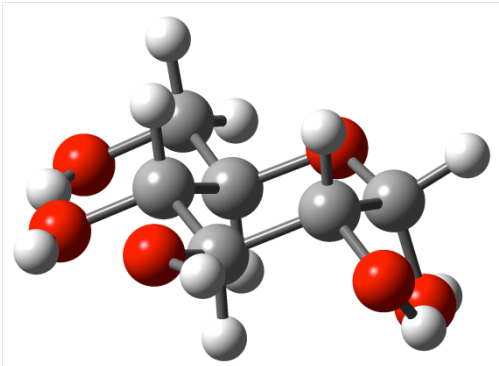
Structural Chemistry: Sweet, Fatty & Spicy

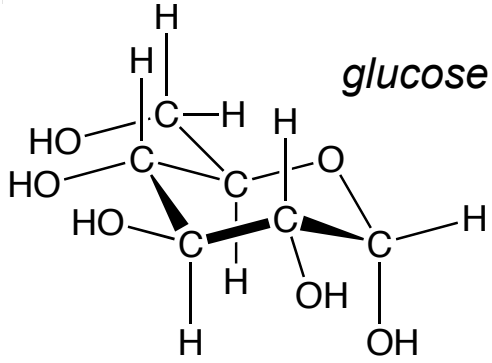
Molecular structure helps us understand:

How compounds react & are changed

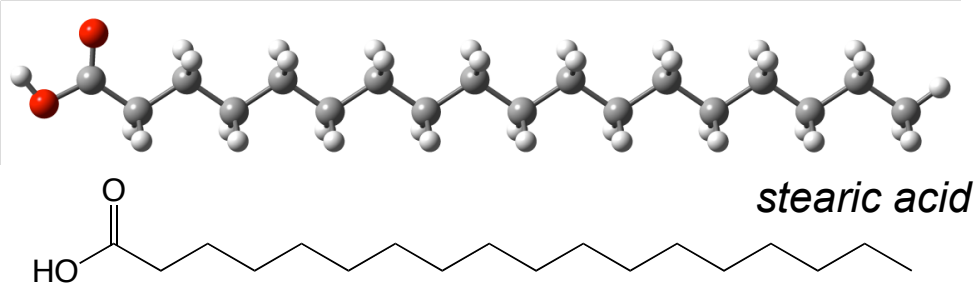
What will dissolve in (be soluble in) what

What biological molecules look like
& a bit about how they work

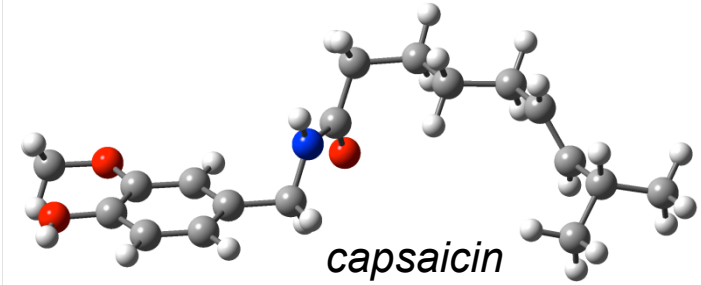




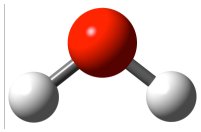
glucose



stearic acid



capsaicin



water

Structural Chemistry, Sweet & Spicy

Matter & Energy

Atoms (e^-, p^+, n) & Molecules

- Compounds (Molecules) built from atoms
- Described with Chemical formulas and structural diagrams
- Have 3-D structures (take up space)
- Carbon forms 4 bonds (connections) Nitrogen 3, and Oxygen 2
- 3-D shapes of atoms connected to make 3-D molecules
  - What does Sugar look like
  - Capsaicin (chiles)

Reactions

- Atoms neither created nor destroyed (balanced)
- For now one important reaction: condensation

Solutions

- Like dissolves like
- What do fats look like

Energy & Matter

Chemistry is the study of energy and matter
Matter can either be a mixture, an element, or a compound (molecule)

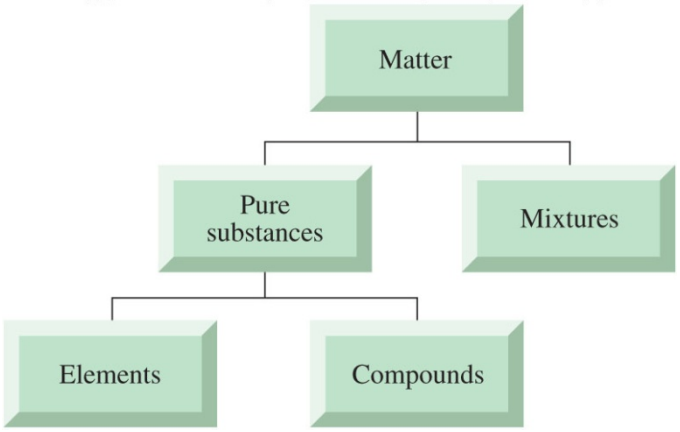


Table 1.6 Classification of Matter

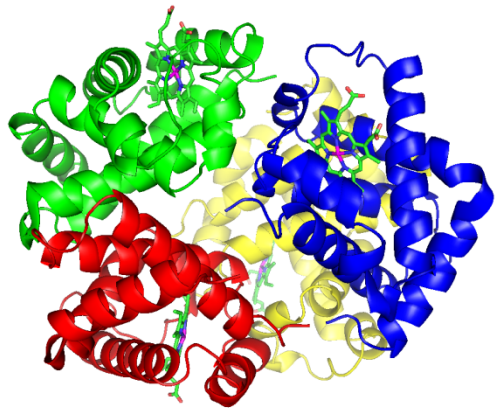
Substance	Observable Properties	Atomic Level
Element	Cannot be broken down into simpler substances	One type of atom
Compound	Fixed composition, but capable of being broken down into elements	Two or more different atoms in a fixed combination
Mixture	Variable composition of elements, compounds, or both	Variable assortment of atoms, molecules, or both

Matter does what it does because of manner in which it occupies space: its 3-D shape

Air is a mixture:

Composition of air:
78% N_2 element
21% O_2 element
0.9% Ar element
0.0385% CO_2 compound
a smidge of other stuff

Hemoglobin is a compound:



Section 1.1, 1.6

Atoms, Molecules, Names & Formulas

Atom: smallest stable unit of an element (e^-, p^+, n)

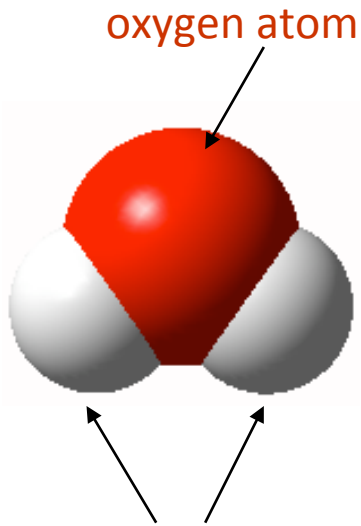
Molecule: smallest stable unit of a compound held together in specific spatial arrangements by chemical bonds (shared pairs of electrons).

Contain fixed #s of atoms of specific elements

Chemical formulas: symbolically represent the types & #s of elements in a molecule

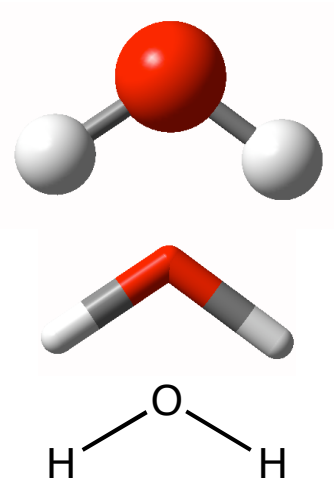
Water, H_2O

Space filling model

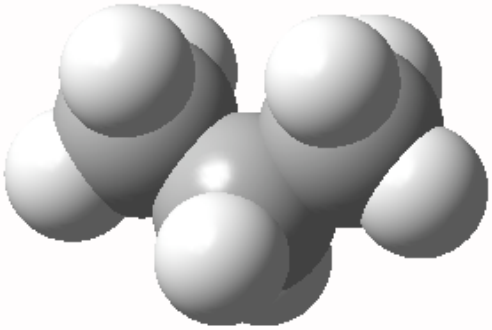


Two hydrogen atoms

Ball-and-stick model



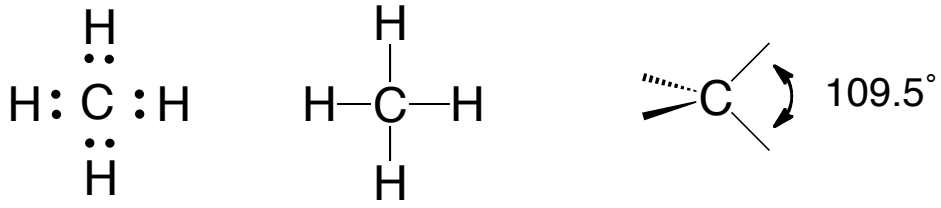
Other representations

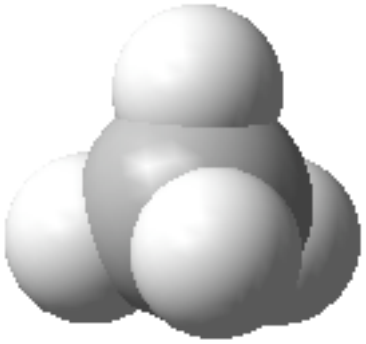


Propane, C_3H_8

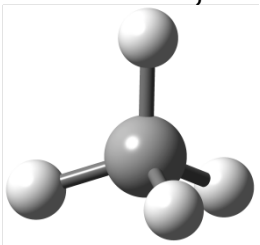
Determining Molecular Shapes

Carbon forms 4 bonds & has a tetrahedral structure, if bonded to four other atoms



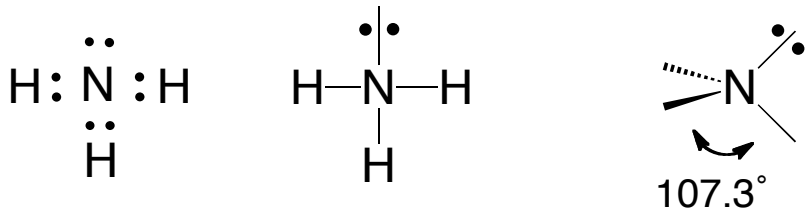


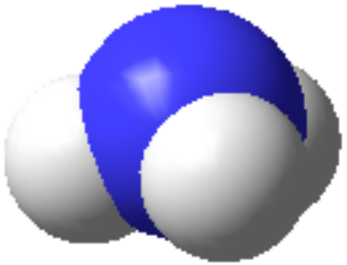
Methane, CH_4



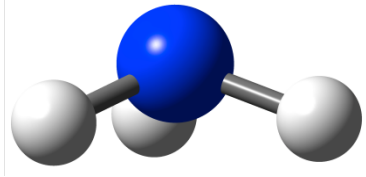
Electron pairs repell, tetrahedral arrangement is a far apart as the 4 pairs can be

Nitrogen forms 3 bonds and has a pyramidal structure

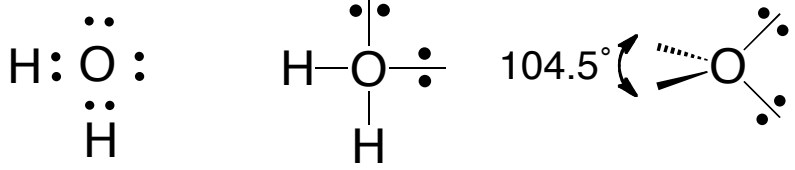


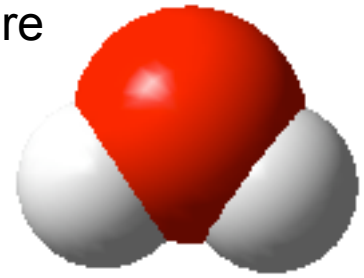


Ammonia, NH_3

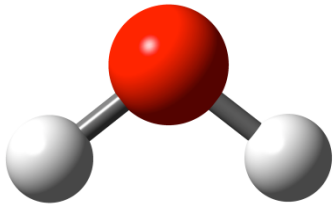


Oxygen forms two bonds and has a bent structure





Water, H_2O



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Periodic Table

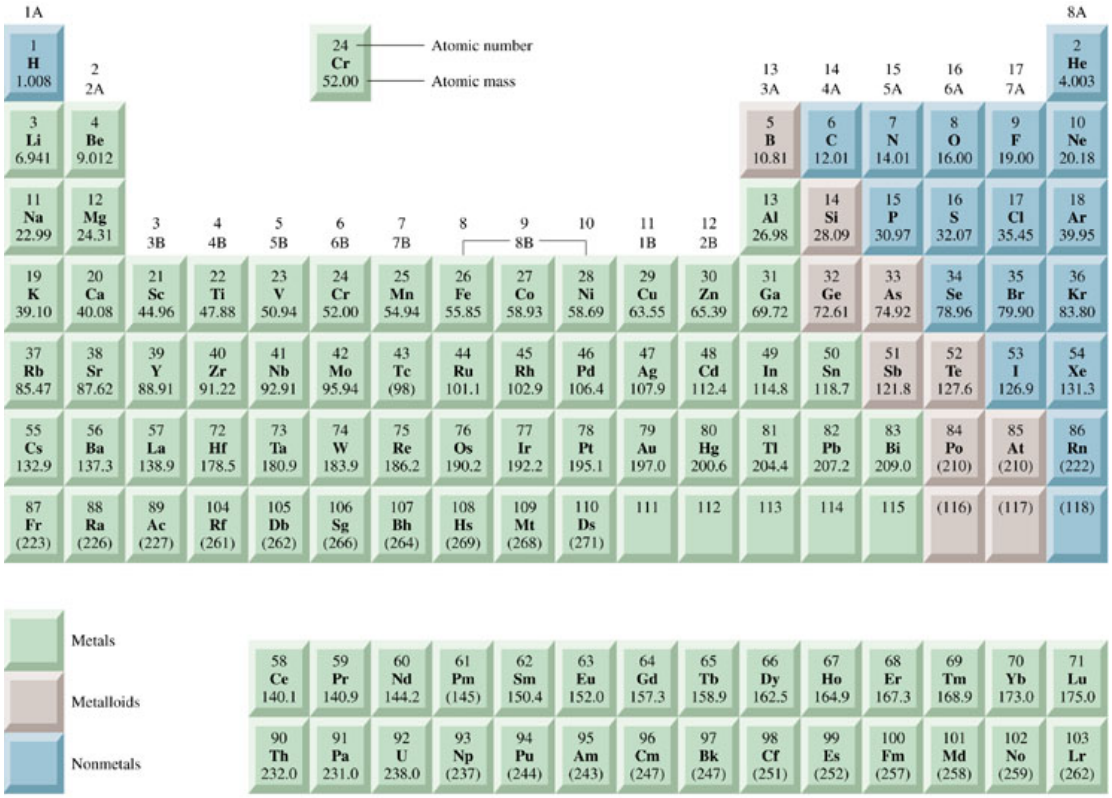
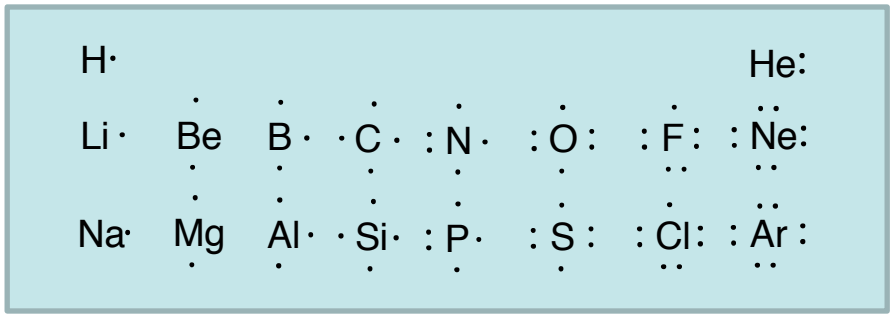


Table 2.2 Total and Outer Electrons for Atoms of the First 18 Elements

Group	1A	2A	3A	4A	5A	6A	7A	Noble Gases 8A
	1							2
	H							He
	1							2
	3	4	5	6	7	8	9	10
	Li	Be	B	C	N	O	F	Ne
	1	2	3	4	5	6	7	8
	11	12	13	14	15	16	17	18
	Na	Mg	Al	Si	P	S	Cl	Ar
	1	2	3	4	5	6	7	8

- Number *above* the atomic symbol is the atomic number, the total number of protons. It also gives the total number of electrons in a neutral atom.
- Number *below* the atomic symbol is the number of **outer** electrons in a neutral atom.



Section 1.6, 2.2

Structures of Molecules (Lewis Dot Structures)

Most atoms are reactive & react to form molecules with bonds between atoms—trying to achieve the same number of valence electrons as the noble gas of its period

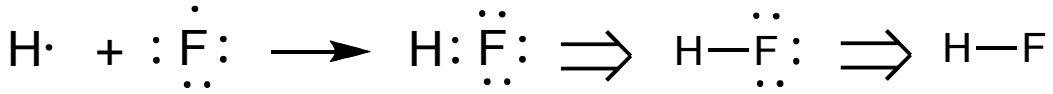
For our purposes, covalent bonds are pairs of shared electrons

Structures that show the outer electrons are called **Lewis (dot) structures**

Lewis structures of atoms help us build molecular structures

example 1: H• + •H → H:H → H-H

example 2: HF



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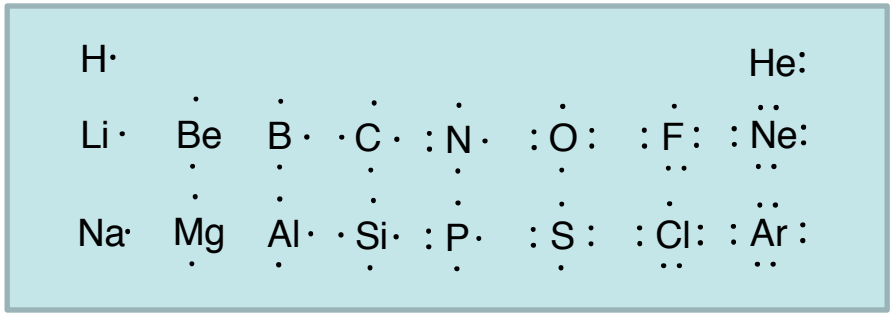
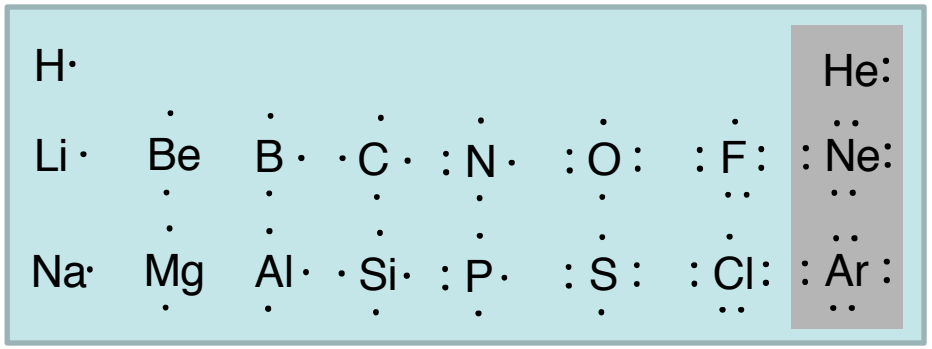


H looks like He and F looks like Ne

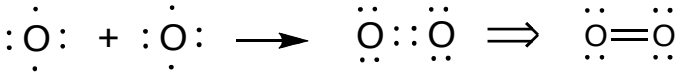
Line indicates a bond (pair of electrons)

Di- and Triatomic Molecules

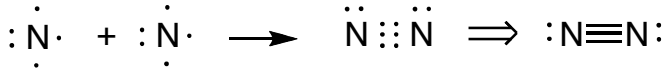
Atoms will share some or all of their valence electrons to achieve the same electronic configuration as the noble gas in its period. Covalent bonds are formed from pairs of shared electrons, and each atom gets to count the bonding electrons as its own…



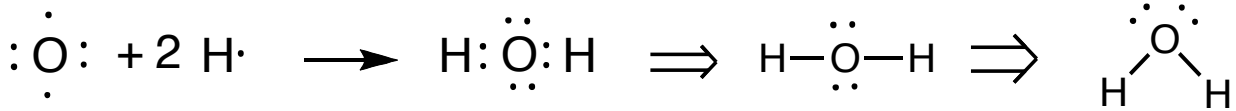
O_2

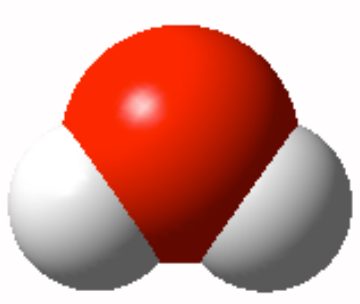


N_2



H_2O

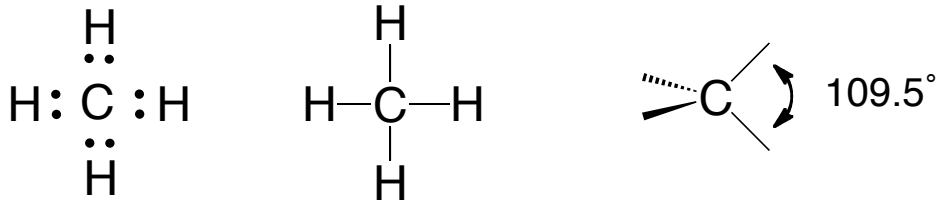


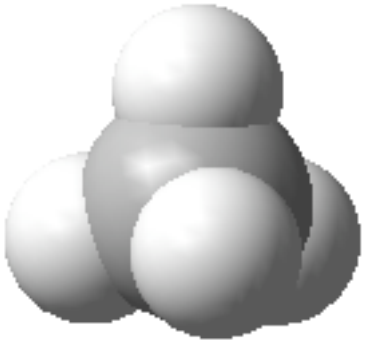


H looks like He and O looks like Ne

Determining Molecular Shapes

Carbon forms 4 bonds & has a tetrahedral structure, if bonded to four other atoms





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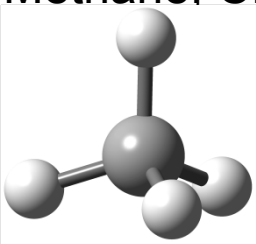

Electron pairs repell, tetrahedral arrangement is a far apart as the 4 pairs can be

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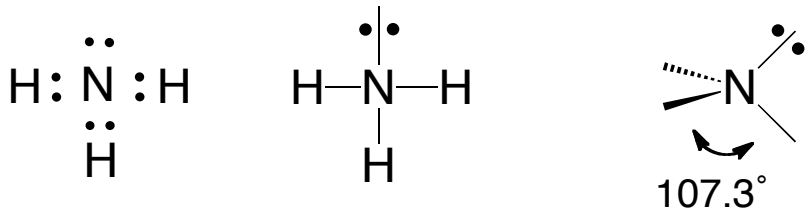

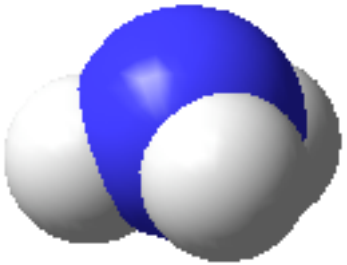

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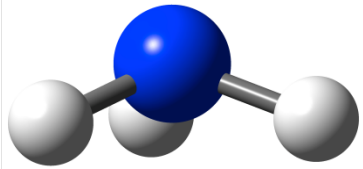
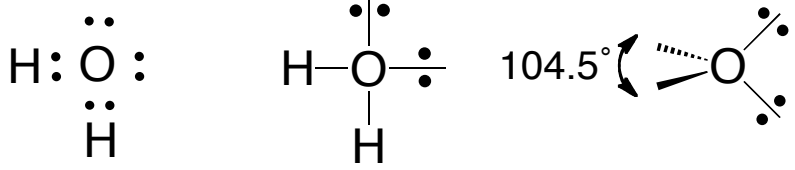
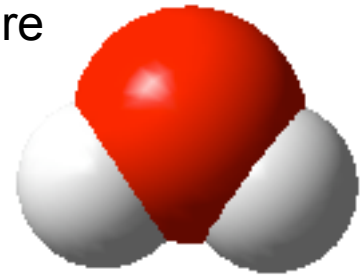
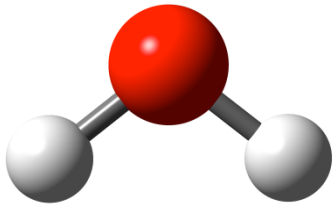


Oxygen forms two bonds and has a bent structure





Water, H_2O



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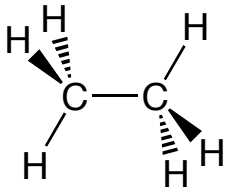
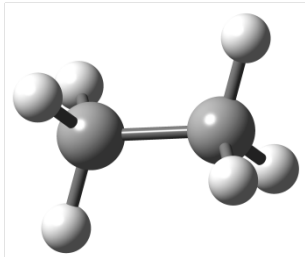
Combinations

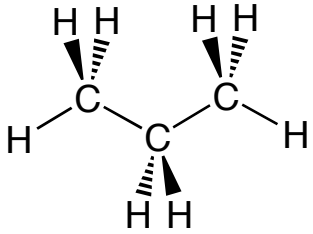
These tetrahedral, pyramidal, and bent units can be combined to make larger compounds

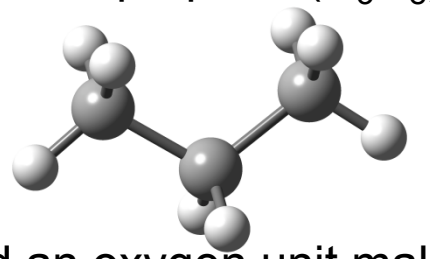
Two tetrahedral carbon units make ethane (C_2H_6)

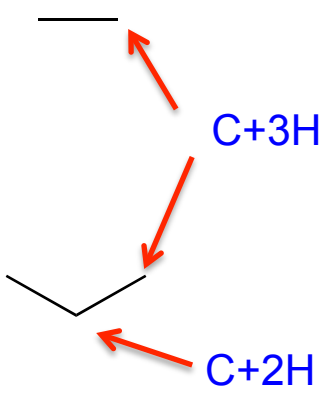




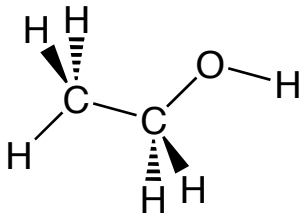
Three tetrahedral carbon units make propane (C_3H_8)

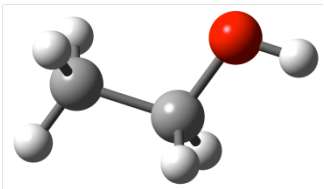


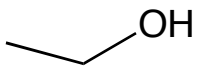




Two tetrahedral carbon units and an oxygen unit make ethanol (C_2H_6O)





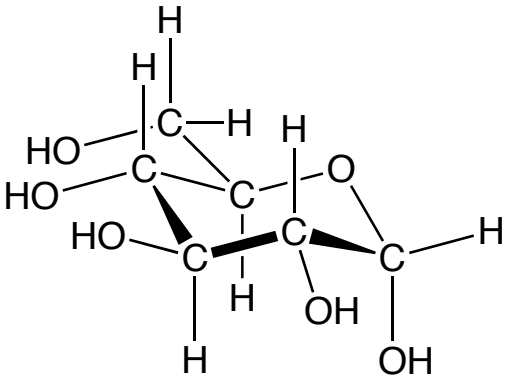


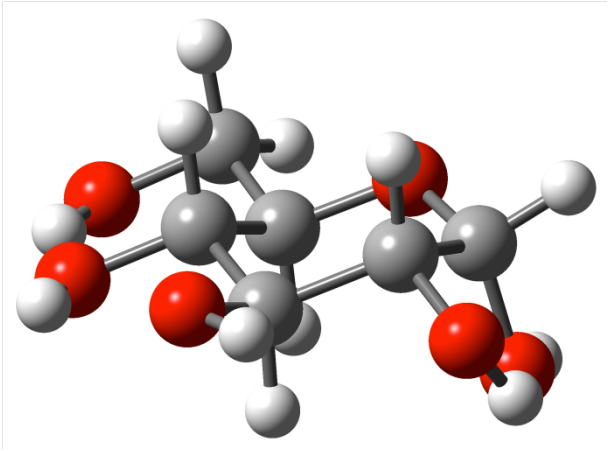
Alcohol or hydroxyl functional group. Functional groups help us recognize and understand physical and chemical propertiesl (solubility, reactivity, similarity)

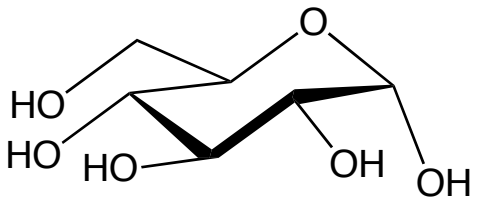
Section 10.2,10.3

Even Larger Combinations

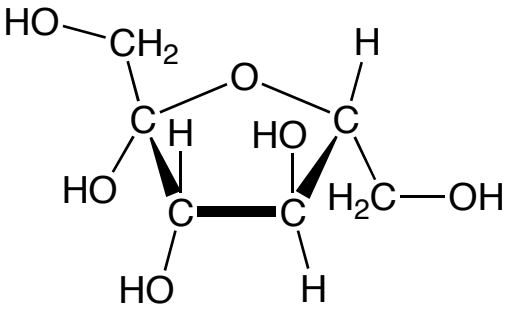
Six tetrahedral carbon units and six bent oxygen units can combine to form glucose (alcohol/hydroxyl functional group)

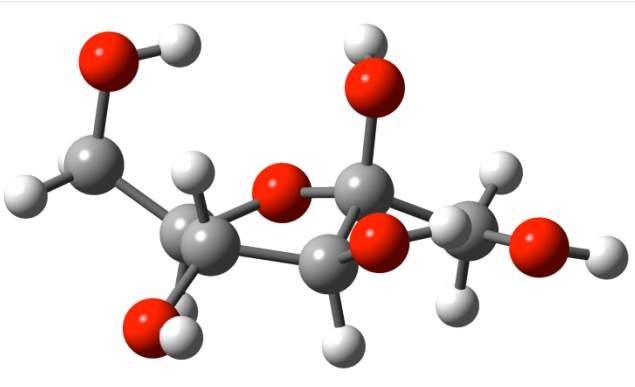


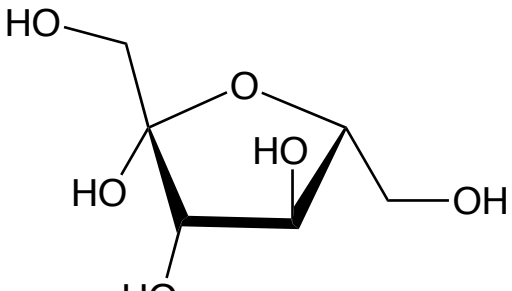




or fructose



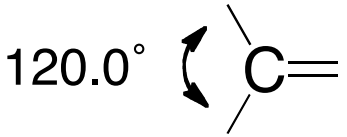


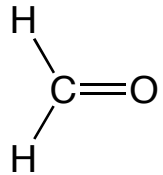


Section 10.2,10.3

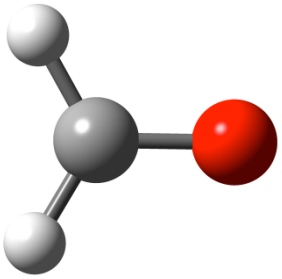
Double Bonds

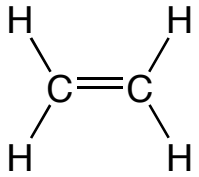
If bonded to three atoms (bonded twice to one), carbon is flat (trigonal planar) (still four bonds)



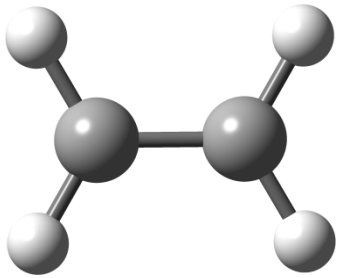


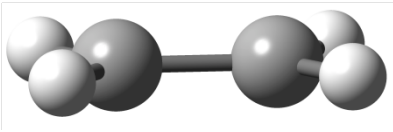
Formaldehyde, CH_2O

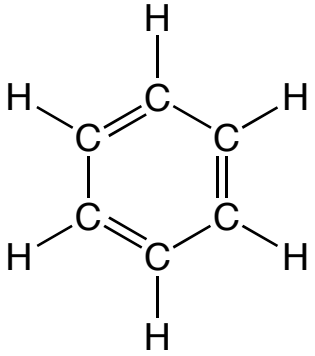




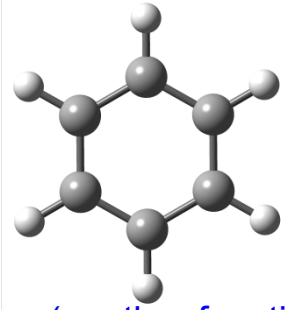
Ethylene, C_2H_4

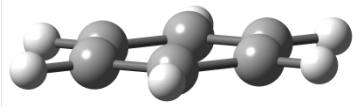


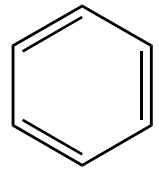




Benzene, C_6H_6





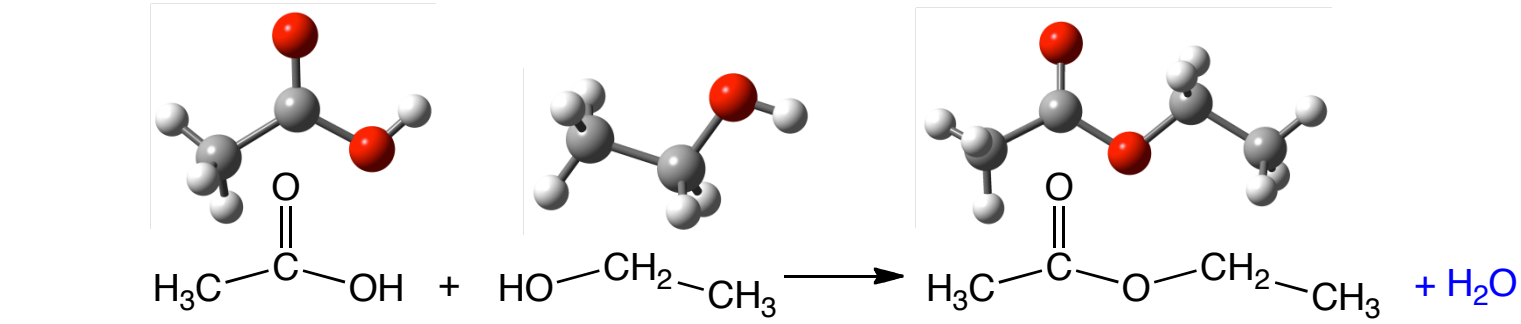


An example of an aromatic ring (another functional group)

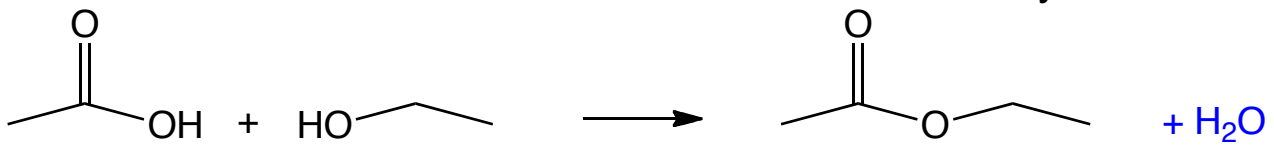
Section 10.2,10.3

Condensation Reaction

The one reaction we need to know to study the molecules of life is the condensation reaction (water (H_2O) is a product)



Acetic acid Ethanol Ethyl acetate



Carboxylic acid alcohol Ester (COOR)

$$C_2H_4O_2 + C_2H_6O \rightarrow C_4H_8O_2 + H_2O$$

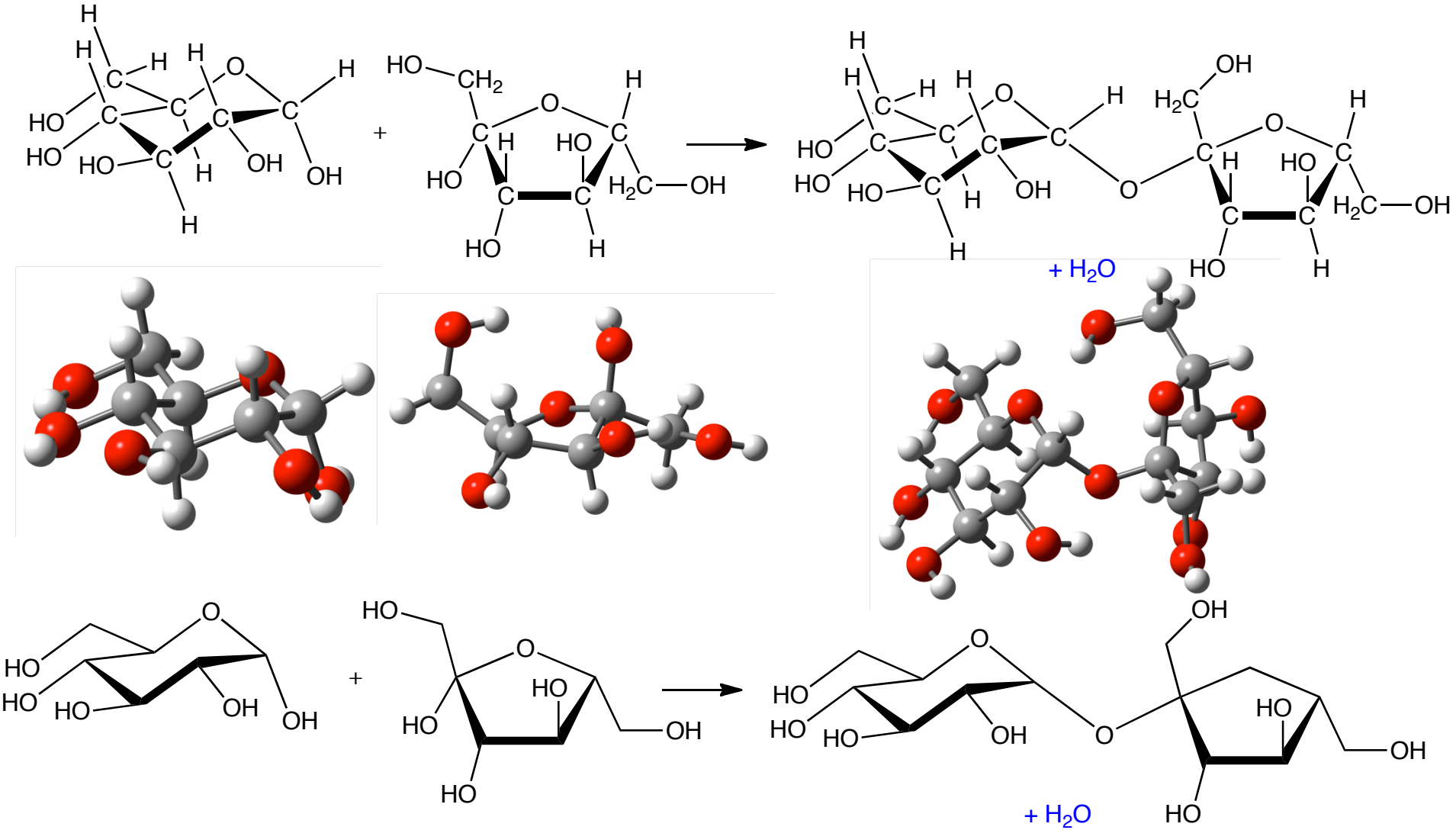
atoms of each element the same on reactant and product sides of the equation

Additional functional groups: carboxylic acid, ester

Section 10.2,10.3

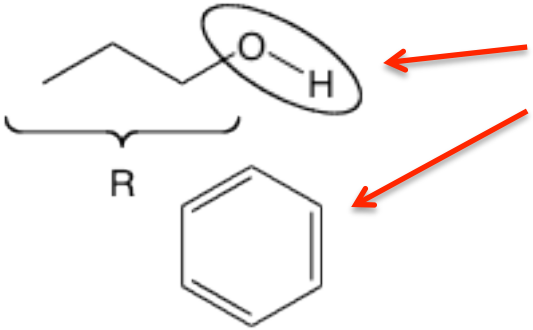
Sugar

Glucose and fructose can condense to form table sugar (sucrose)



Functional Group and Line Drawing Recap

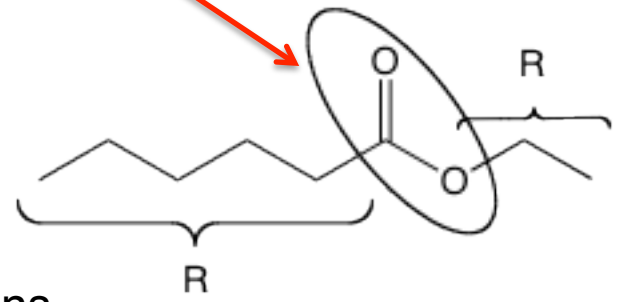
Functional groups we've seen so far (non HC parts of molecules)

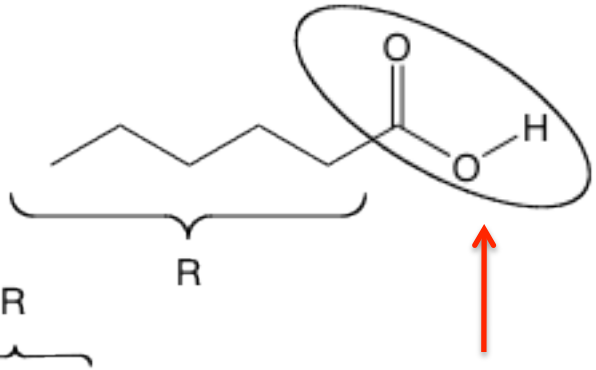


Alcohol/hydroxyl (OH)

Aromatic

Ester





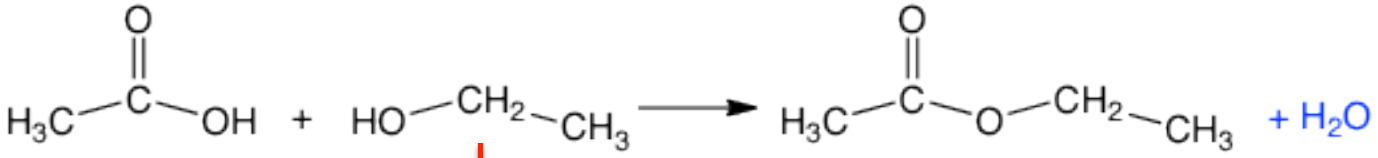
Carboxylic acid

R = hydrocarbon

Reactions

Atoms are neither created nor destroyed (balanced)

For now one important reaction: condensation



Line drawings: terminus of line means C+3H

Kink means C+2H