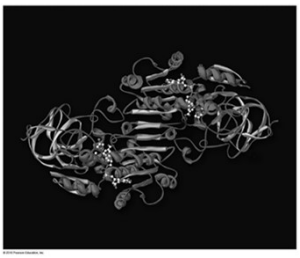


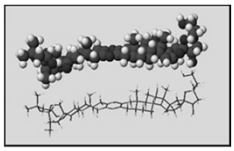
Chapter 3a
Carbon and the Molecular Diversity of Life

You Must Know

- The properties of carbon that make it so important.

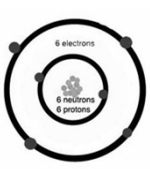
I. Importance of Carbon

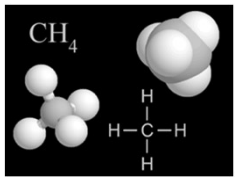
- **Organic chemistry**: branch of chemistry that specializes in study of carbon compounds
- **Organic compounds**: contain Carbon (& H)
- **Major elements of life**: CHNOPS
- Carbon can form large, complex, and diverse molecules



II. Diversity of Carbon

1. It has 4 valence electrons **(tetravalence)**

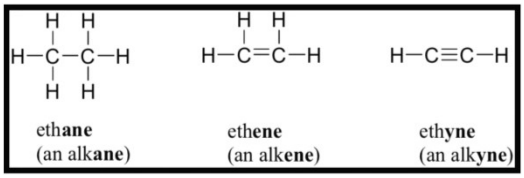




2. It can form up to 4 covalent bonds
   - Most frequent bonding partners: **H, O, N**

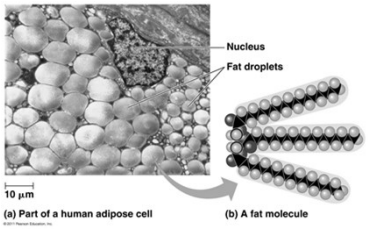
II. Diversity of Carbon

3. Bonds can be single, double, or triple covalent bonds.



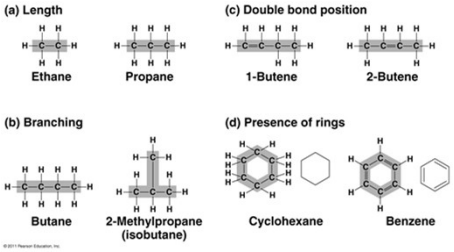
II. Diversity of Carbon

4. Carbon can form large molecules
   - 4 classes of **macromolecules**: carbohydrates, proteins, lipids, nucleic acids



II. Diversity of Carbon

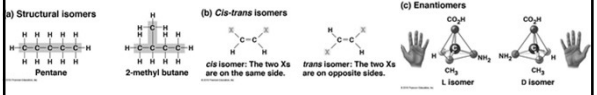
5. Molecules can be chains, ring-shaped, or branched



II. Diversity of Carbon

6. Forms **isomers**
   - Molecules have same molecular formula, but differ in atom arrangement
   - different structures → different properties/functions

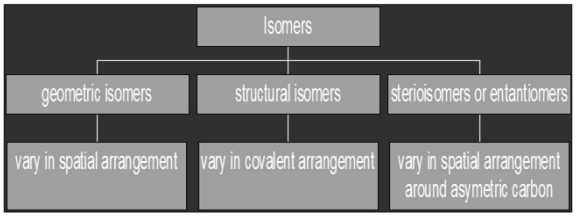
Structural Isomer	Cis-Trans Isomer	Enantiomers
Varies in covalent arrangement	Differ in spatial arrangement	Mirror images of molecules



Isomers

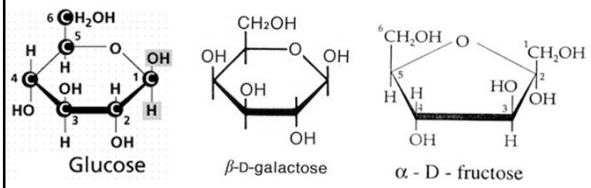
1. What is an isomer?

- Molecules that have the same molecular formula but different structures.



STRUCTURAL isomers

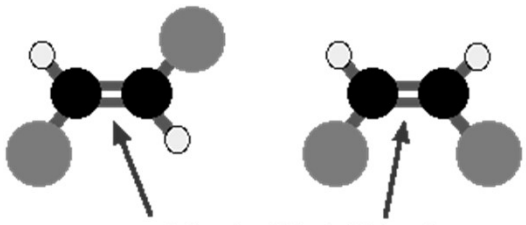
differing covalent bonding arrangement



$C_6H_{12}O_6$ $C_6H_{12}O_6$ $C_6H_{12}O_6$

http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookCHEM2.html
http://217.60.75.10/ltibiokemi/images/galactose.jpg
http://217.60.75.10/ltibiokemi/images/galactose.jpg

GEOMETRIC isomers - differ in arrangement around a DOUBLE BOND



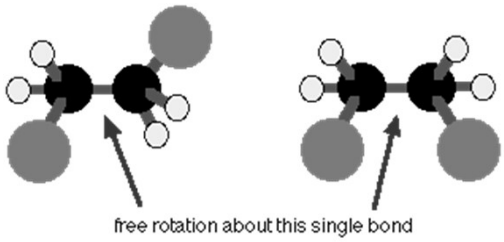
no rotation about this double bond

trans- form *cis- form*

http://www.chemguide.co.uk/basicorg/isomerism/geometric.html

Be Careful!

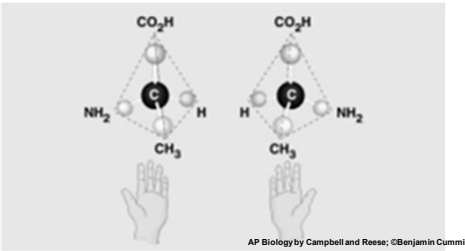
Single bonds can rotate!



free rotation about this single bond

. . . it's still the same stuff

ENANTIOMER isomers – differ in arrangement around a ASYMMETRIC carbon



. . . Mirror images

Drug manufacturing:

Thalidomide =

- "good" enantiomer → reduce morning sickness
- "bad" enantiomer → cause birth defects
- "good" converts to "bad" in patient's body
- Now used to treat cancers, leprosy, HIV

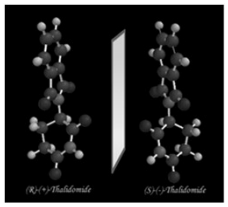


Fig. 4.8 The pharmacological importance of enantiomers

Drug	Condition	Effective Enantiomer	Ineffective Enantiomer
Ibuprofen	Pain; inflammation	*S*-Ibuprofen	*R*-Ibuprofen
Albuterol	Asthma	*R*-Albuterol	*S*-Albuterol

III. Functional Groups

- Behavior of organic molecules depends on functional groups
- Most common functional groups:

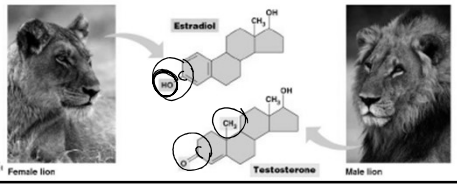
1. Hydroxyl
2. Carbonyl
3. Carboxyl
4. Amino
5. Sulfhydryl
6. Phosphate
7. Methyl

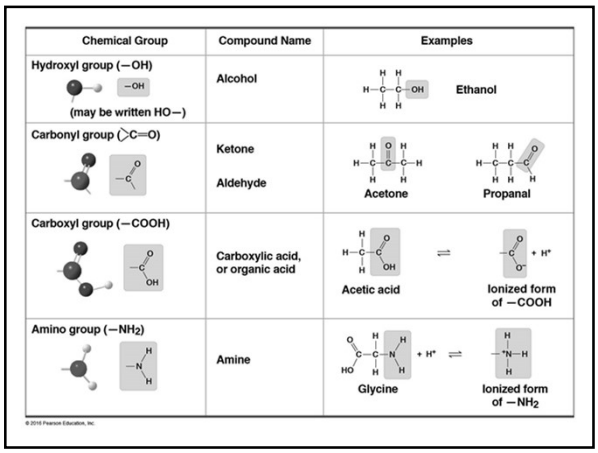
Functional Groups

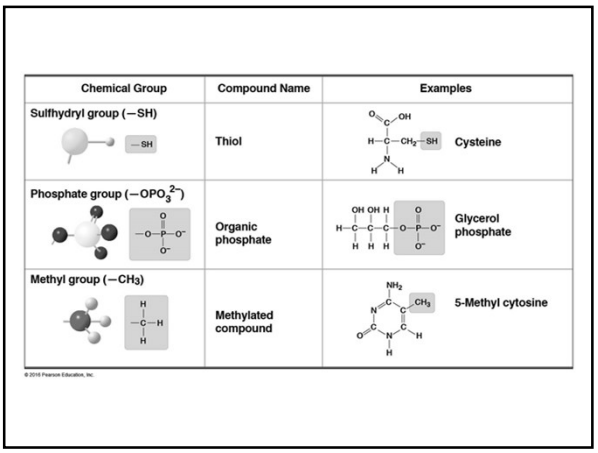
1. Are regions of organic molecules
2. Have specific chemical and physical properties
3. Behave consistently from one organic molecule to another
4. Effect the structure and function of organic molecules to which they belong.

Viva la difference!

- **Basic structure of male & female hormones is identical**
  - identical C skeleton
  - attachment of different functional groups
  - interact with different targets in the body

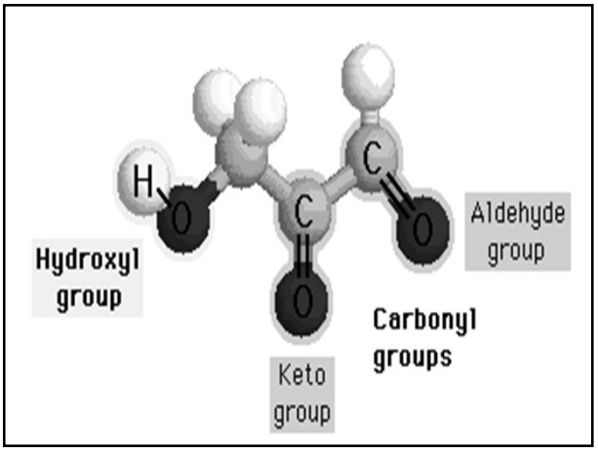


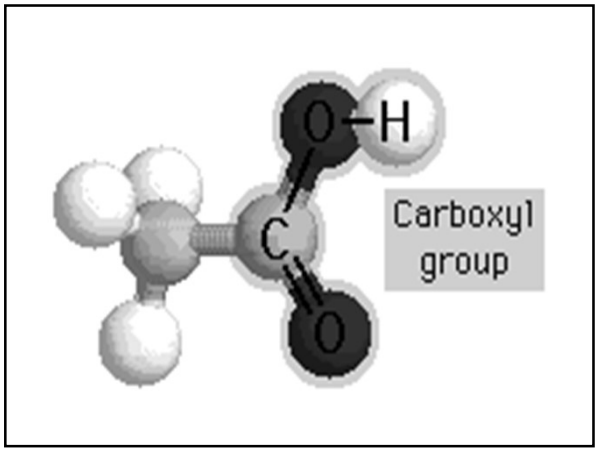


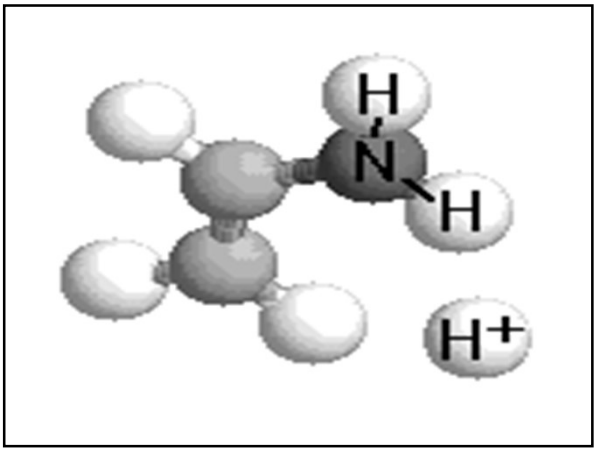


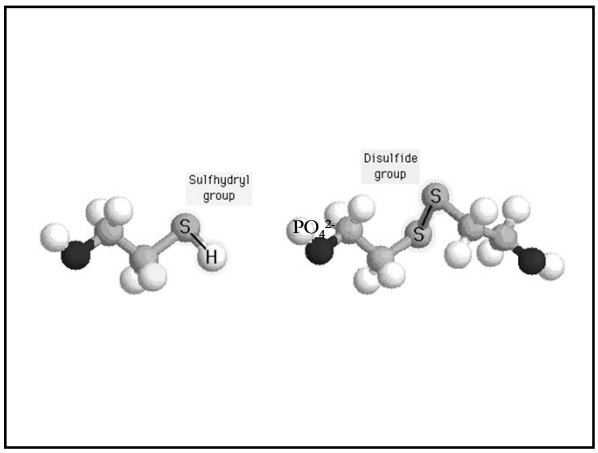
Functional Groups

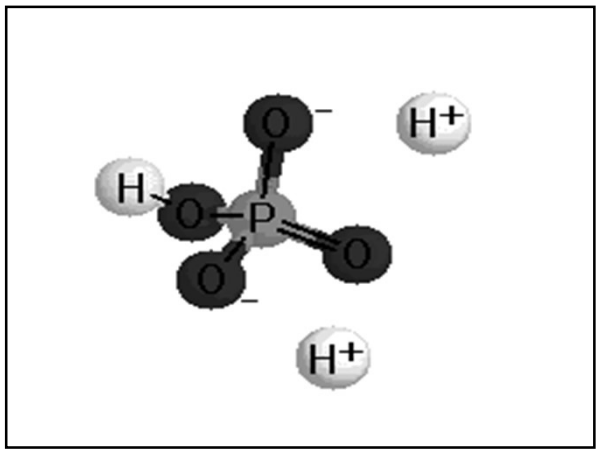
Functional Group	Molecular Formula	Names & Characteristics	Draw an Example
Hydroxyl	-OH	Alcohols; polar	Ethanol
Carbonyl	>CO	Ketones (inside skeleton) Aldehydes (at end); polar	Acetone Propanol
Carboxyl	-COOH	Carboxylic acids (organic acids) 2 functional groups	Acetic acid
Amino	$-NH_2$	Amines; basic	Glycine
Sulfhydryl	-SH	Thiols; form disulfide bridges to stabilize proteins	Ethanethiol
Phosphate	PO_4^{2-}	unstable; important for energy (ATP)	Glycerol phosphate
Methyl	$-CH_3$	Methylated compounds; addition to DNA affects expression of genes; testosterone & estradiol	5-methyl cytidine








Sulfhydryl group
Disulfide group
S
H
S
S
PO_4^{2-}


O⁻
H⁺
H
O
P
O
O⁻
H⁺