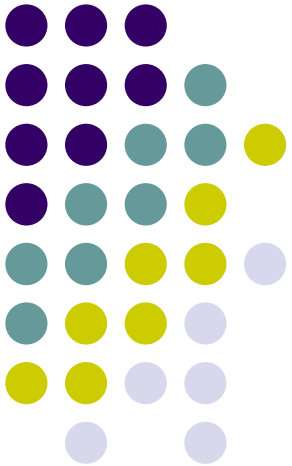
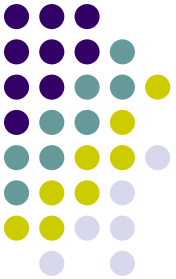
Chapter 4

- Carbon and the Molecular Diversity of Life

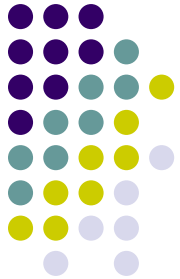


Organic Chemistry



- Organic Chemistry
  - The study of carbon-containing compounds
- Cells are composed of 70 – 95% water
  - Most of the rest is carbon-based compounds
- Organic compounds
  - Can arise only in living organisms
  - Example: CH_4
- Inorganic compounds
  - Found in the nonliving world
  - Example: NaCl

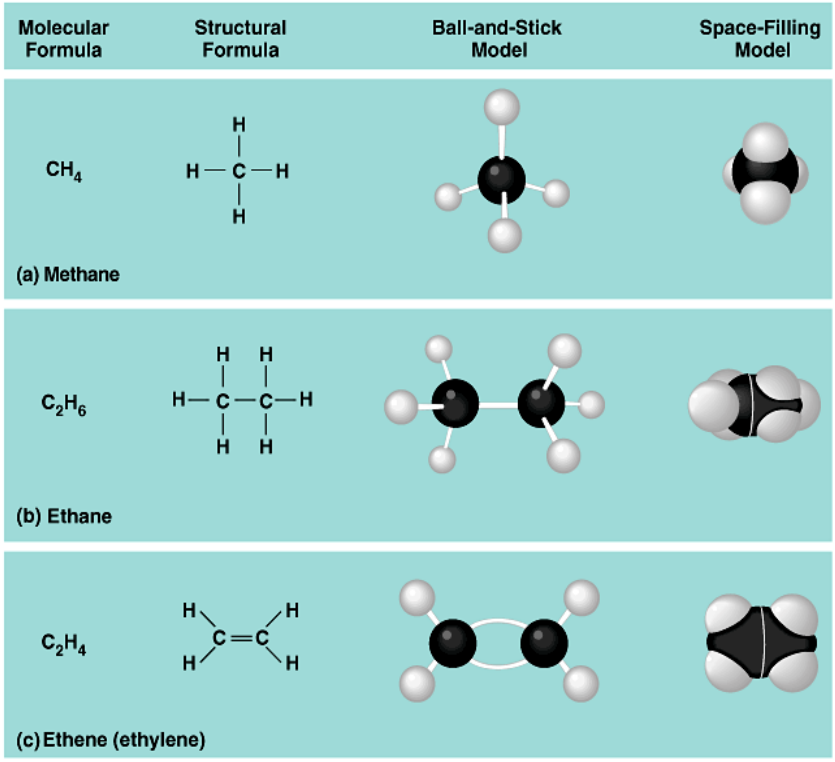
(Brief) History of Organic Chem



- Vitalism:
  - Belief in a life force outside the jurisdiction of physical and chemical laws
- Stanley Miller, 1953
  - Performed an experiment that demonstrated the spontaneous synthesis of organic compounds
- Mechanism:
  - The belief that all natural phenomena, including the processes of life, are governed by physical and chemical laws

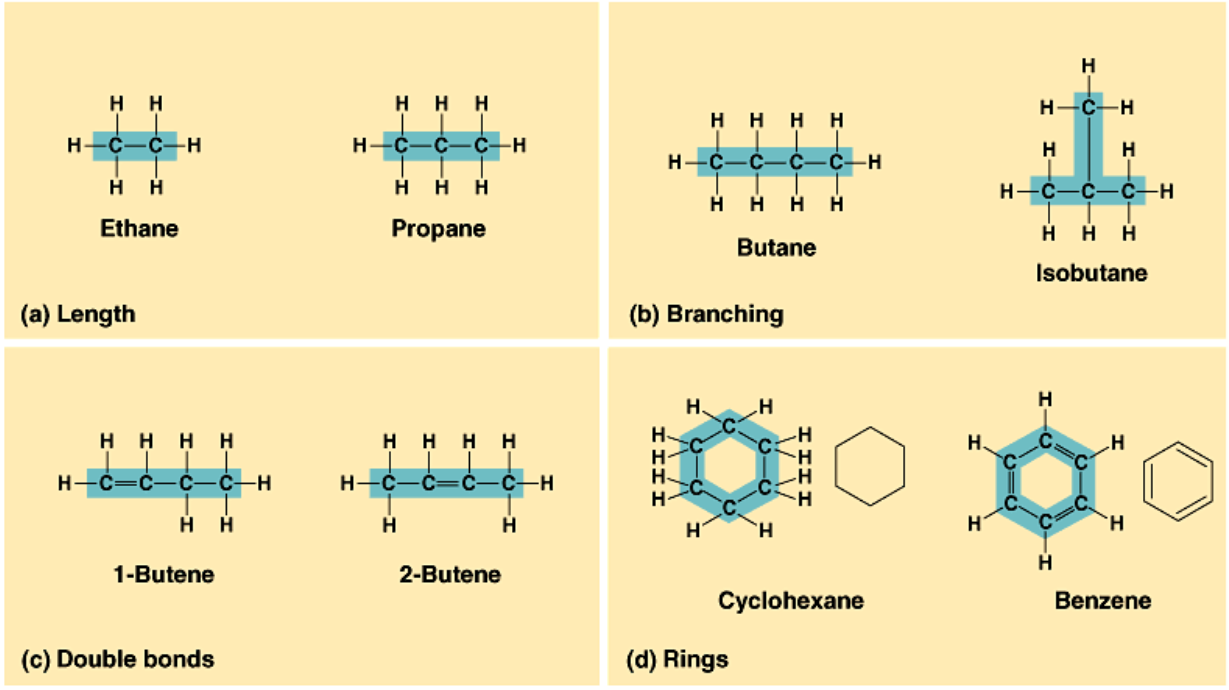
Carbon: The Molecule

- Carbon has 4 valence electrons
  - Therefore, it can form 4 covalent bonds



Carbon Skeleton Diversity

- Organic molecules are diverse in large part due to the variation in carbon skeletons

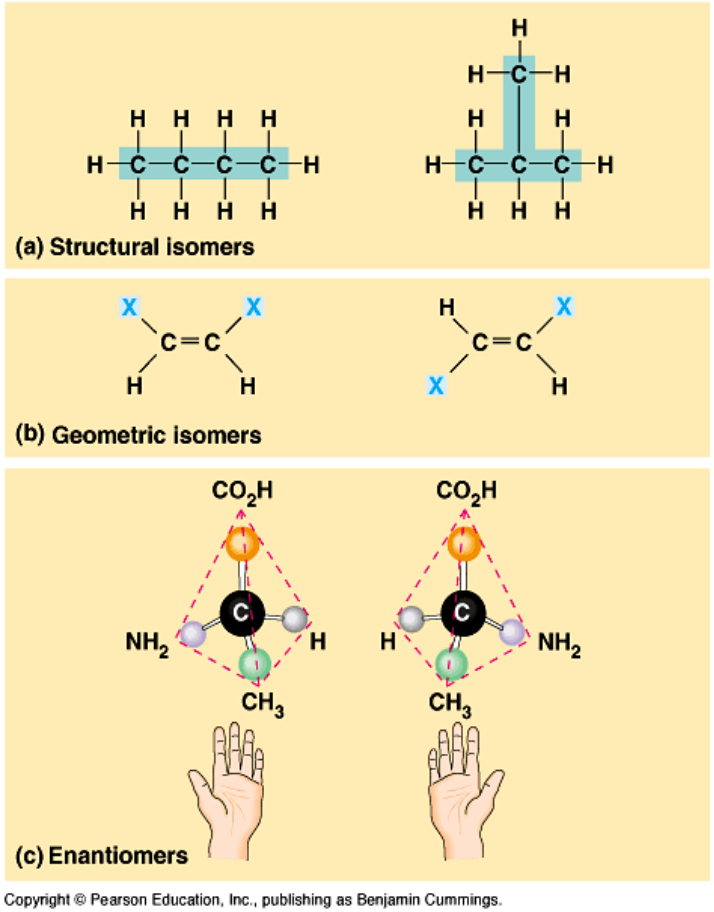


Isomers

- Isomers
  - Compounds that have the same molecular formula but different structures and therefore different properties
  - Structural Isomers
  - Geometric Isomers
  - Enantiomers

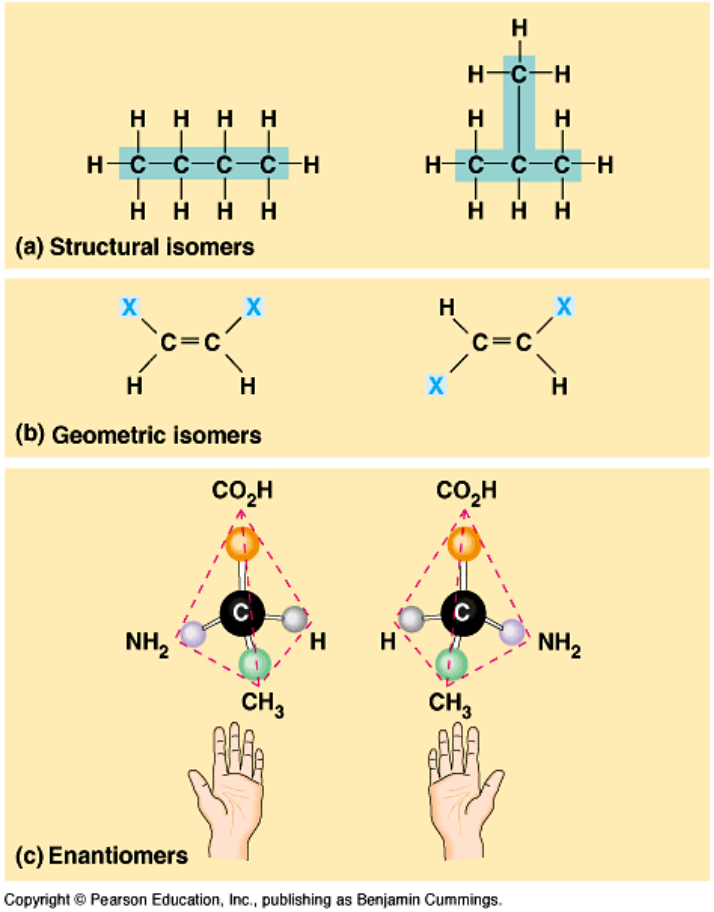
Structural Isomers

- Differ in covalent arrangements of their atoms



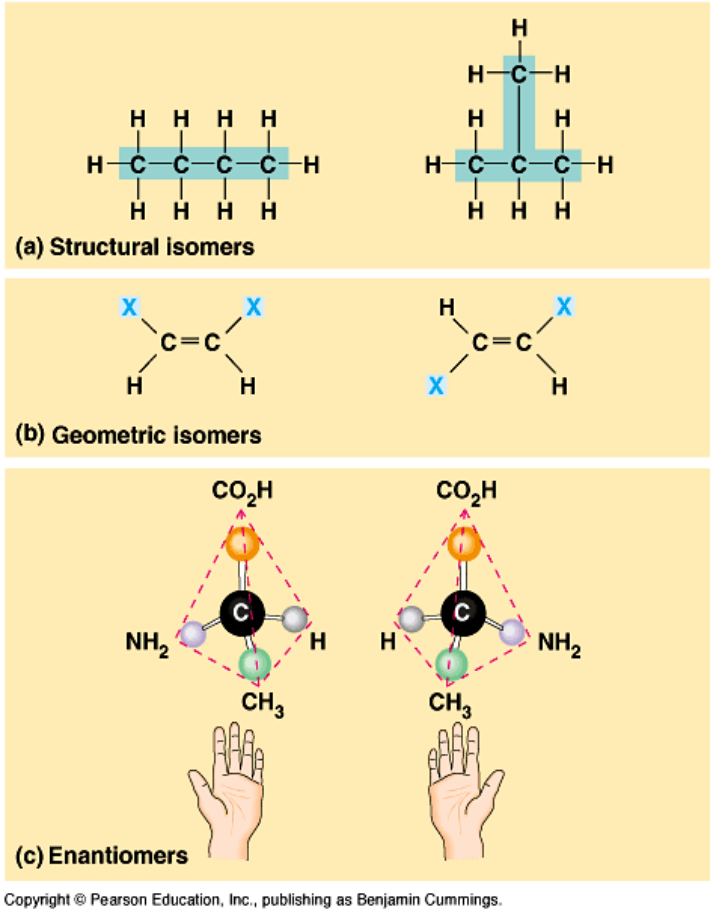
Geometric Isomers

- All of the covalent partnerships are the same, but the spatial arrangement is different
- Due to **double bonds**



Enantiomers

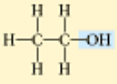
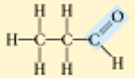
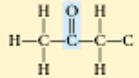
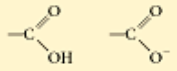
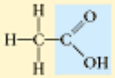
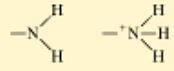
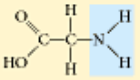
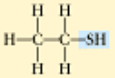
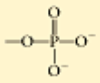
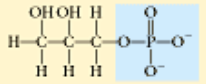
- Molecules that are mirror-images of each other
- Left- and right-handed
- Thalidomide:
  - Sedative vs. birth defects



Functional Groups

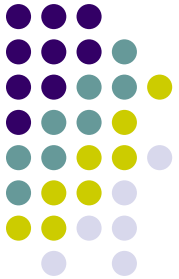
- Functional groups also make organic molecules diverse
- Each functional group has its own distinctive properties

Table 4.1 Functional Groups of Organic Compounds

Functional Group	Formula	Name of Compounds	Example
Hydroxyl	—OH	Alcohols	 Ethanol (the drug of alcoholic beverages)
Carbonyl		Aldehydes	 Propanal
		Ketones	 Acetone
Carboxyl	 (non-ionized) (ionized)	Carboxylic acids	 Acetic acid* (the acid of vinegar)
Amino	 (non-ionized) (ionized)	Amines	 Glycine* (an amino acid)
Sulfhydryl	—SH	Thiols	 Ethanethiol
Phosphate		Organic phosphates	 Glycerol phosphate

*The ionized forms of the carboxyl and amino groups prevail in cells. However, acetic acid and glycine are represented here in their non-ionized forms.

Functional Groups

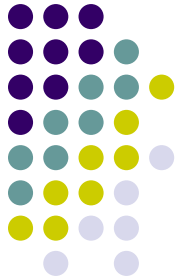


- Hydroxyl Group:
  - R–OH
  - Polar
- Carbonyl Group:
  - C=O
  - Aldehyde:
    - double bond is at the end of the molecule
  - Ketone:
    - double bond is in the middle of the molecule

Functional Groups

- Carboxyl Group
  - Acidic
  - R-C=O
    OH \
- Amino Group
  - Basic
  - $R–NH_2$

Functional Groups



- Sulfhydryl Group:
  - – SH
  - Helps stabilize the structure of some proteins
- Phosphate Group:
  - $H_2PO_4^-$
  - Plays an important role in the transfer of energy