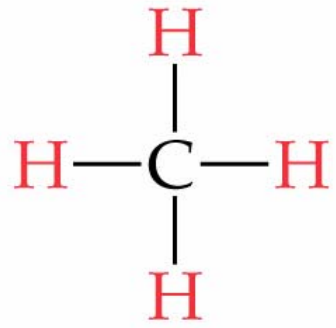
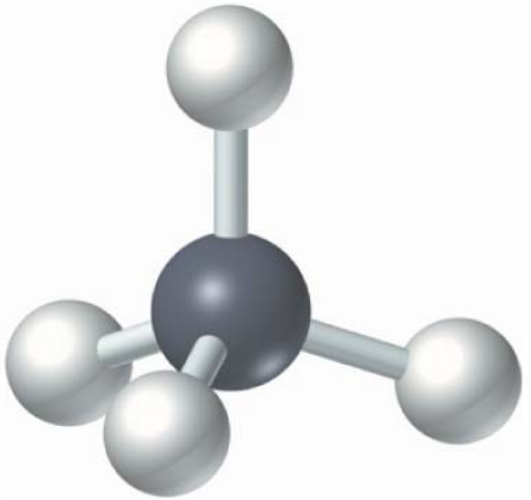
12.1 The Nature of Organic molecules

Organic chemistry: The chemistry of carbon compounds.

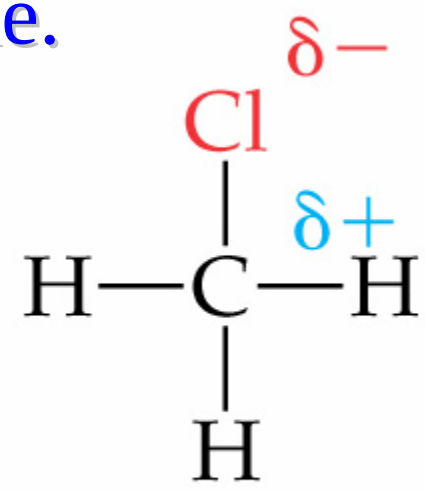
- Carbon is tetravalent; it always form four bonds.



Methane, CH_4



- Organic molecules have covalent bonds.
- Organic molecules contain polar covalent bonds when carbon bonds to an electronegative element on the right side of the periodic table.



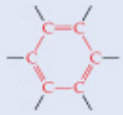
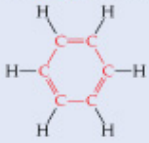
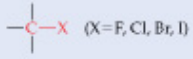
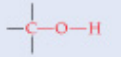
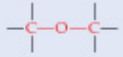
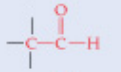
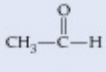
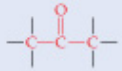
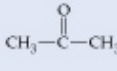
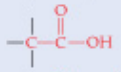
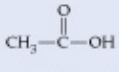
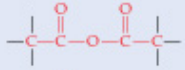
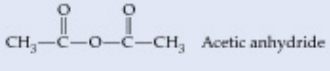
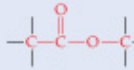
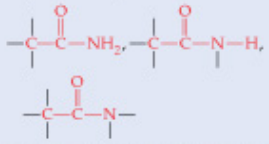
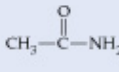
Chloromethane, CH_3Cl

12.2 families of Organic Molecules: Functional groups

More than 18 millions organic compounds, that are known today, are classified into just a few general families on the basis of chemistry that follows a simple pattern.

Functional group: A group of atoms within a large molecule that has a characteristic structure and chemical behavior. Functional groups allow us to group vast number of organic molecules in to few classes, Table 12.1.

TABLE 12.1 Some Important Families of Organic Molecules

Family Name	Functional Group Structure*	Simple Example	Name Ending
Alkane	Contains only C—H and C—C single bonds	CH_3CH_3 Ethane	*-ane*
Alkene		$H_2C{=}CH_2$ Ethylene	*-ene*
Alkyne		$H{-}C{\equiv}C{-}H$ Acetylene (Ethyne)	*-yne*
Aromatic		 Benzene	None
Alkyl halide	 (X=F, Cl, Br, I)	$CH_3{-}Cl$ Methyl chloride	None
Alcohol		$CH_3{-}OH$ Methyl alcohol (Methanol)	*-ol*
Ether		$CH_3{-}O{-}CH_3$ Dimethyl ether	None
Amine		$CH_3{-}NH_2$ Methylamine	*-amine*
Aldehyde		 Acetaldehyde (Ethanal)	*-al*
Ketone		 Acetone	*-one*
Carboxylic acid		 Acetic acid	*-ic acid*
Anhydride		 Acetic anhydride	None
Ester		 Methyl acetate	*-ate*
Amide		 Acetamide	*-amide*

* The bonds whose connections aren't specified are assumed to be attached to carbon or hydrogen atoms in the rest of the molecule.

- In Table 12.1, the first four families are hydrocarbons – organic compounds that contain only carbon and hydrogen.
  - *Alkanes* have only single bonds.
  - *Alkenes* contain a carbon-carbon double bond functional group.
  - *Alkynes* contain a carbon-carbon triple bond functional group.
  - *Aromatic* compounds contain a six-membered ring of carbon atoms with three alternating double bonds.

- In Table 12.1, the next four families have functional groups that contain only single bonds and have a carbon atom bonded to an electronegative atom.

  - *Alkyl halide*s have a carbon-halogen bond;

  - *Alcohol* have a carbon-oxygen bond;

  - *Ethers* have two carbons bonded to the same oxygen atom; and

  - *Amines* have a carbon-nitrogen bond.

- The remaining families have functional groups that contain a carbon-oxygen double bond; *aldehydes, ketones, carboxylic acids, anhydrides, esters, and amides.*

12.3 The Structure of Organic Molecules: Alkanes and Their Isomers

Alkanes: A hydrocarbon that has only single bonds.

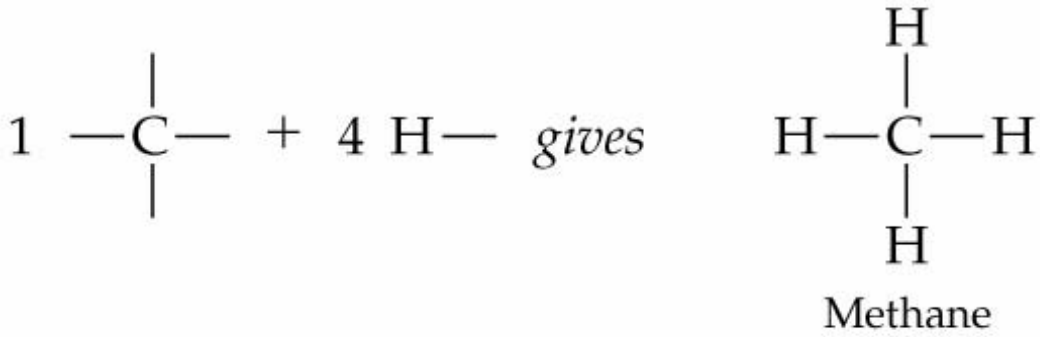
Straight chain alkanes: An alkane that has all its carbons connected in a row.

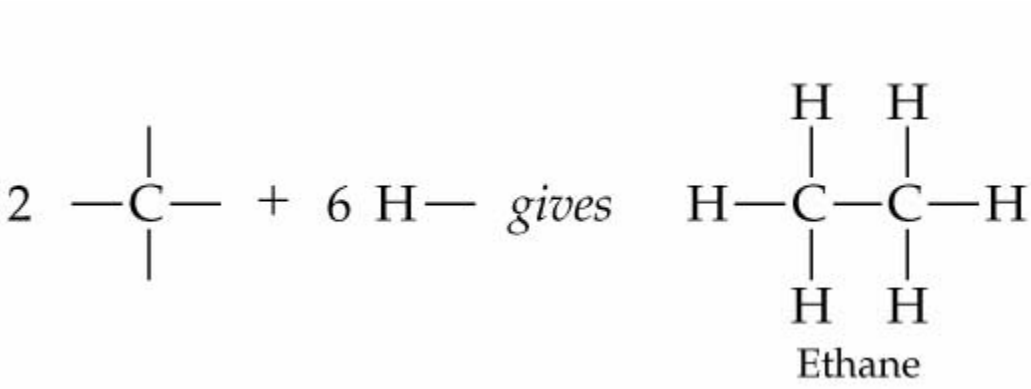
Branched chain alkanes: A alkane that has a branching connection of carbons.

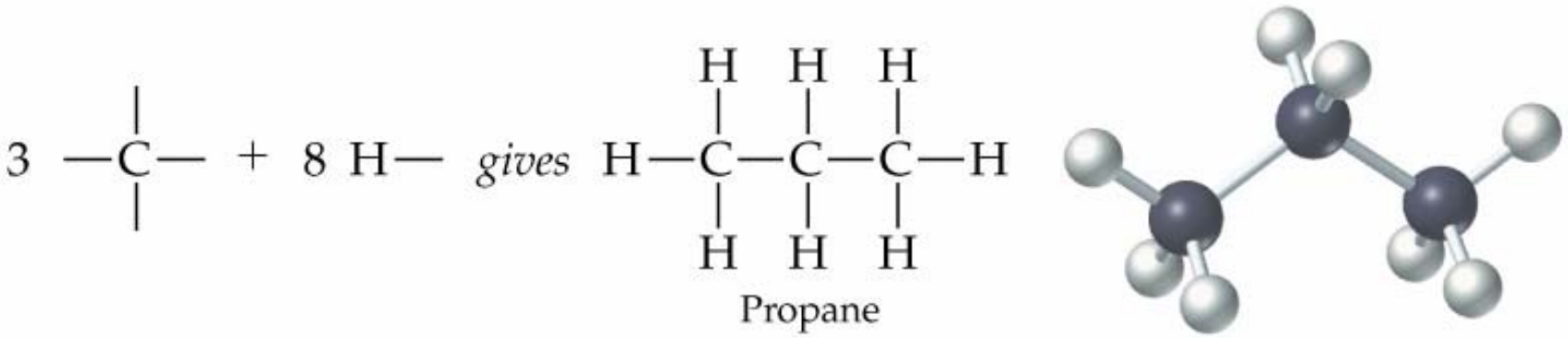
Isomers: Compounds with same molecular formula but different structures.

Constitutional isomers: Compounds with same molecular formula but different connections among their atoms.

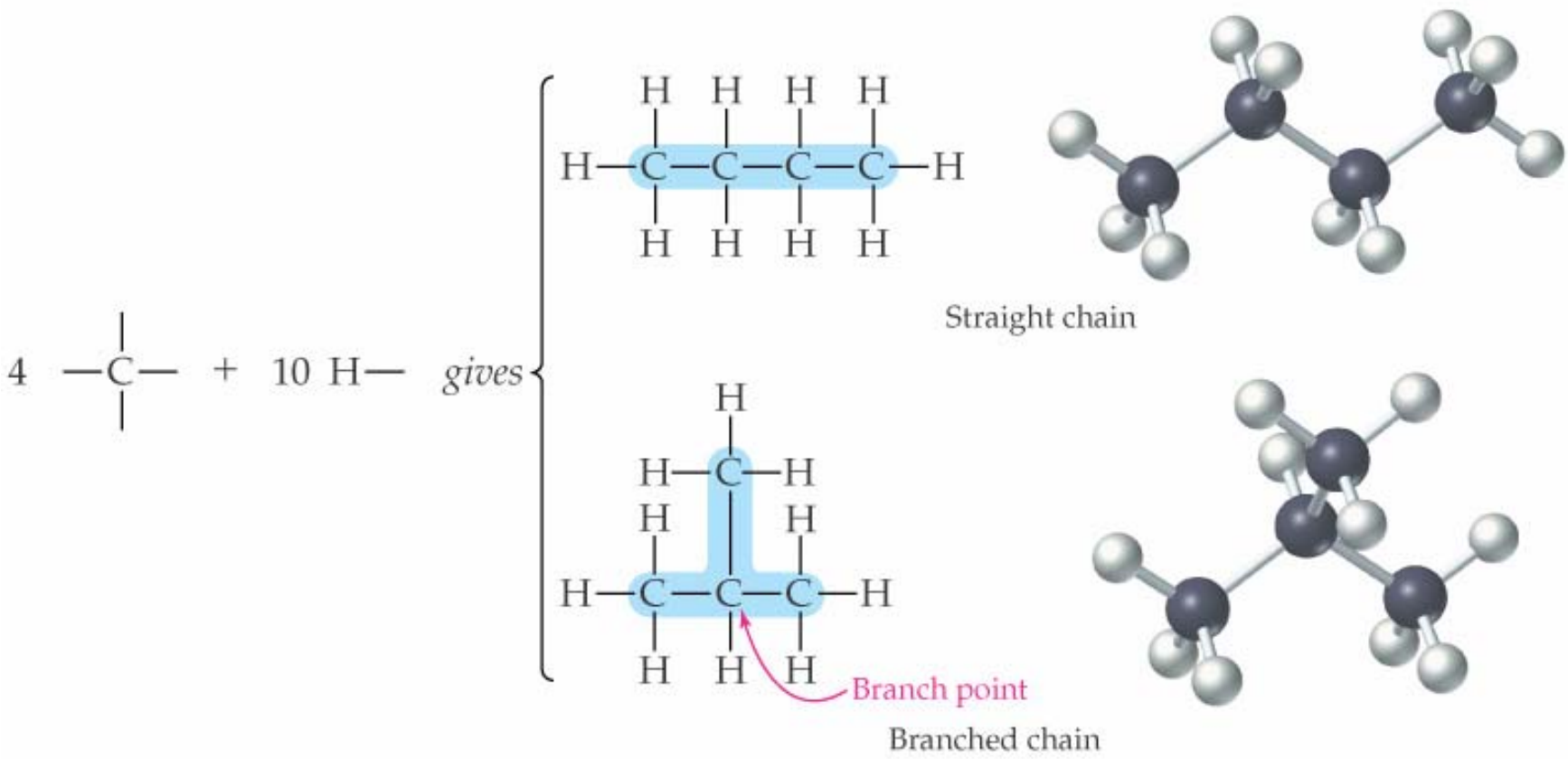
There is only one possible way that the carbons in methane (CH_4), ethane (C_2H_6), and propane (C_3H_8) can be arranged.





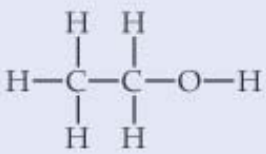
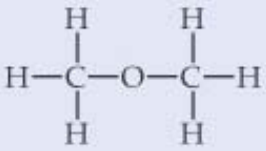


However, carbons in butane (C_4H_{10}) can be arranged in two ways; four carbons in a row (linear alkane) or a branching (branched alkane). These two structures are two constitutional isomers for butane. Number of possible structures increases with the number of carbons in the molecule.


4
+ 10 H—
gives
Straight chain
Branch point
Branched chain

Different constitutional isomers are completely different compounds. They have different structures, different physical properties such as melting point and boiling point, and may have different physiological properties.

TABLE 12.3 Some Properties of Ethyl Alcohol and Dimethyl Ether

Name and Molecular Formula	Structure	Boiling Point	Melting Point	Physiological Activity
Ethyl alcohol C_2H_6O	 	78.5°C	−117.3°C	Central-nervous-system depressant
Dimethyl ether C_2H_6O	 	−23°C	−138.5°C	Nontoxic; anesthetic at high concentration

12.4 Drawing Organic Structures

Condensed structure: A shorthand way of drawing structures in which carbon-carbon and carbon-hydrogen bonds are understood rather than shown.

12.5 The Shapes of Organic Molecules

- Molecules joined by a carbon-carbon single bonds are free to spin around the bond, giving rise to an infinite number of possible three dimensional geometries, or ***conformations***.

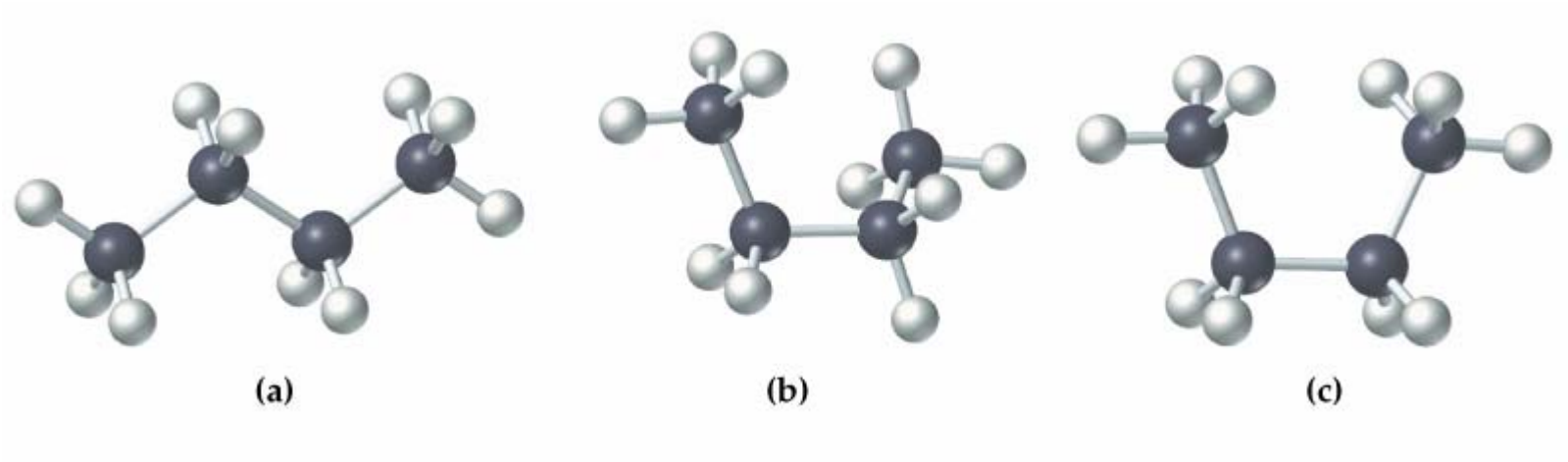


Fig 12.2 The structure of butane can be shown in several different ways.

- At any moment, however, most molecules are in the least crowded conformation.
- As long as any two structures show identical connections between atoms, they represent identical compound no matter how the structures are drawn.

Primary carbon atom: A carbon atom with one other carbon attached to it.

Secondary carbon atom: A carbon atom with two other carbons attached to it.

Tertiary carbon atom: A carbon atom with three other carbons attached to it.

Quaternary carbon atom: A carbon atom with four other carbons attached to it.

12.8 Reactions of Alkanes

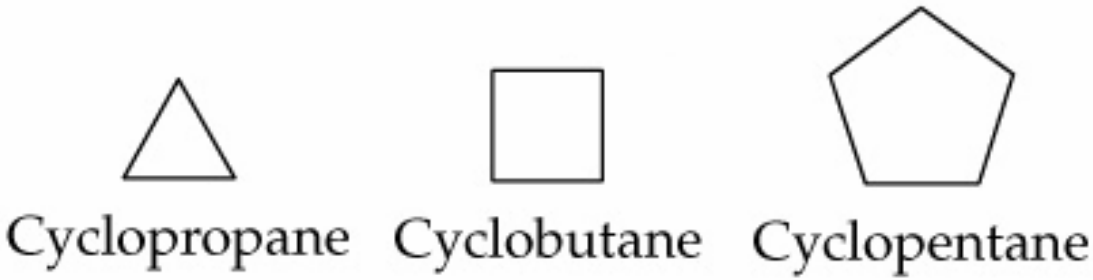
Alkanes don't react with acids, bases, or most other common laboratory reagents. Their only major reactions are with oxygen and with halogens.

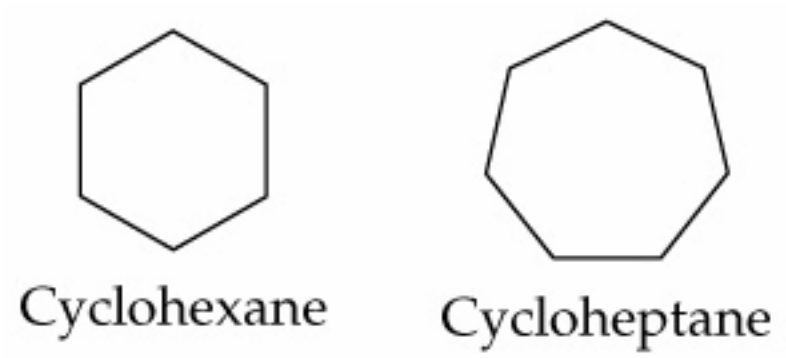
***Combustion*:** Reaction of alkanes with oxygen. Carbon dioxide and water are produced in this combustion reaction.

Halogenation reaction: Replacement of a hydrogen of alkanes by a chlorine or bromine. Initiation of halogenation reaction requires heat or light. Complete chlorination of methane produces carbon tetrachloride.

12.10 Drawing and Naming Cycloalkanes

Cycloalkanes are represented by polygons. A tyriangle represents cyclopropane, a square represents cyclobutane, a pentagon represents cyclopentane, and so on.





Line structure: A shorthand way of drawing structures in which atoms aren't shown; instead a carbon atom is understood to be at each intersection of lines and hydrogens are filled mentally.

Cycloalkanes are named by a straightforward extension of the rules for open-chain alkanes. In most cases, only two steps are needed: