Introduction to Organic Chemistry

What is Organic Chemistry?

- Organic chemistry studies compounds containing carbon
  - Some carbon compounds are excluded because they act more like non-carbon containing compounds (carbon oxides, metal carbides, and carbonates)
- Organic compounds include drugs, fuels, toiletries, plastics, and fabrics.

Organic Chemistry - studies compounds containing carbon.

→ examples of organic compounds include drugs, fuels, toiletries, plastics, fabrics.

Why is Carbon So Special?

- Carbon can form a vast array of long chain and ring containing compounds because carbon has the unique ability to bond to itself.
- There is no theoretical limit to the number of organic compounds that can exist
- Aliphatic vs aromatic
- Carbon forms strong covalent bonds to hydrogen, nitrogen, oxygen, sulfur, and phosphorus in addition to others

Why is carbon So Special?

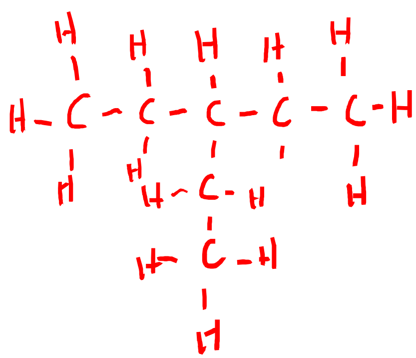
→ 4 valence electrons allow for a unique ability to bond to itself in chains and rings!

→ there is no theoretical limit to the number of organic compounds that exist.

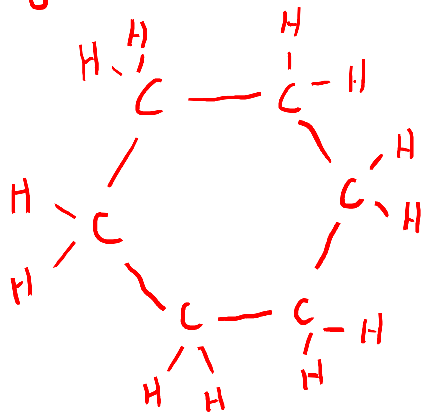
Classification of Carbon Compounds

aliphatic

Straight Chains

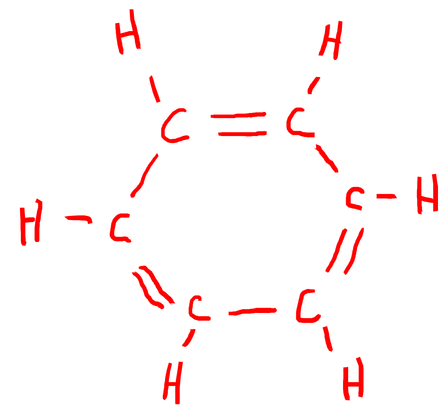


Cyclostructures



aromatic

Benzene



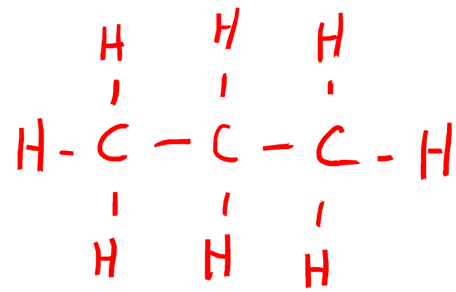
- six carbon ring with 3 double bonds

Carbon Bonding

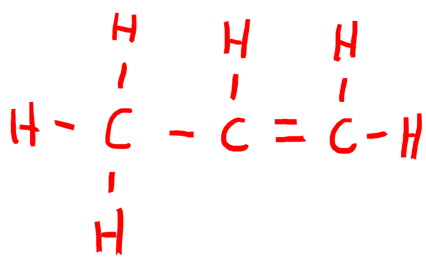
- ~~Most organic molecules have a hydrocarbon chain foundation, sometimes with "things" attached to it called substituent groups~~
- Two Categories of Hydrocarbon chains
- 1. Saturated
- 2. Unsaturated
  - *Caution: Some saturated carbon-containing molecules may have carbon double bonded to an OXYGEN…being saturated or unsaturated has to do with the bonds between carbon atoms*

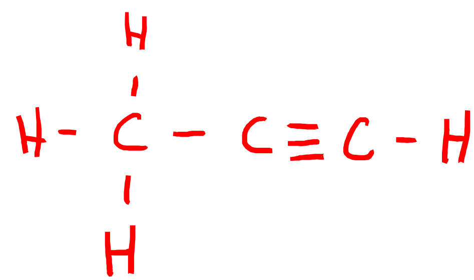
2 categories of hydrocarbons

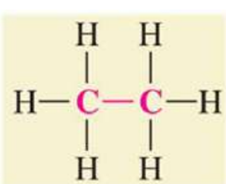
1) Saturated - carbon chains contain all single bonds.



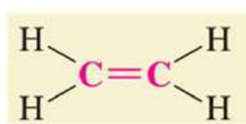
2) Unsaturated - Carbon chains contain at least one double or triple bond.





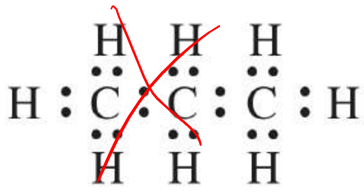


Ethane is a saturated hydrocarbon because it has all single bonds.

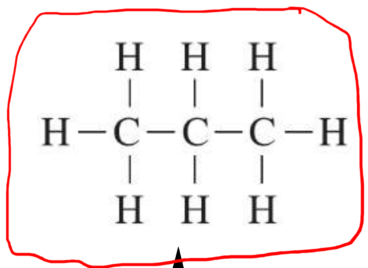


Ethene is an unsaturated hydrocarbon because it has a double bond.

Organic Formulas and Molecular Models



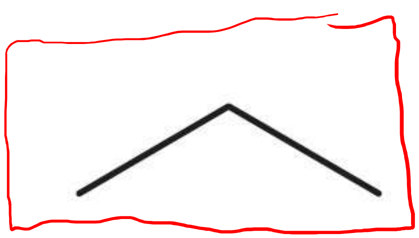
Lewis structure



Structural formula

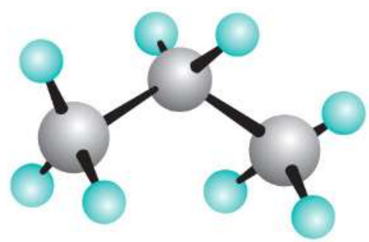
$CH_3CH_2CH_3$

Condensed structural formula



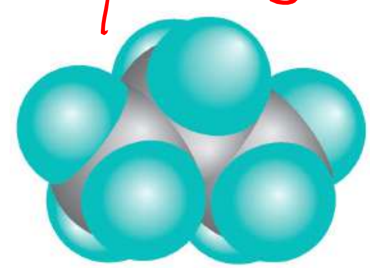
Line structure

Build



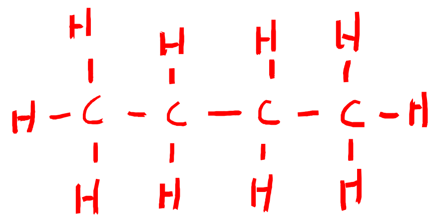
Ball-and-stick model

pictures



Space-fillng model

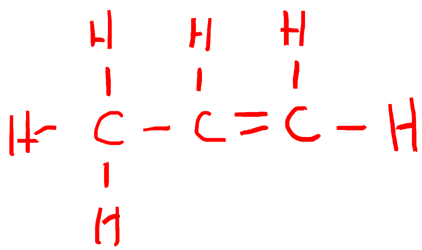
Structural Formula | Condensed | Line



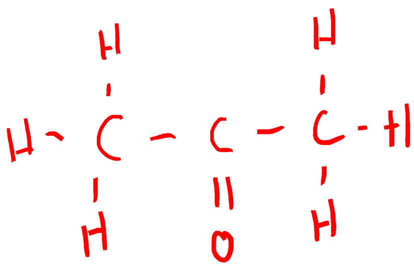
$CH_3CH_2CH_2CH_3$

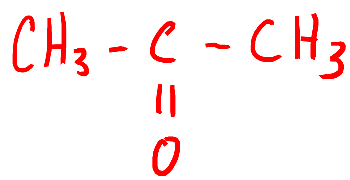
or

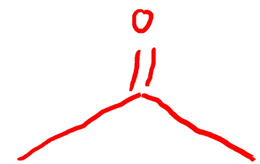
$CH_3-CH_2-CH_2-CH_3$

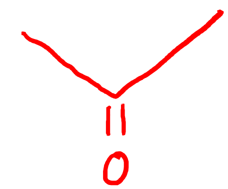


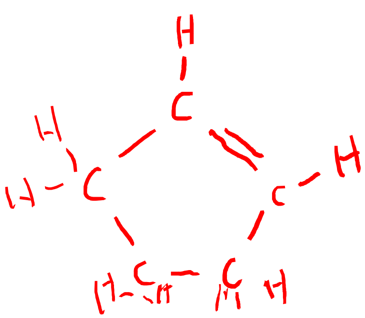
$CH_3-CH=CH_2$

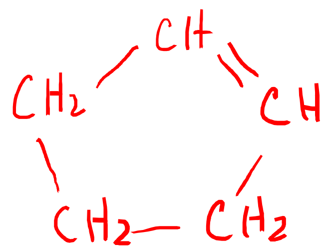


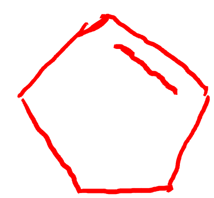






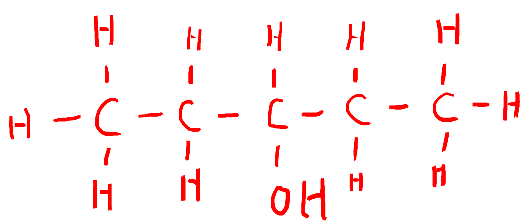


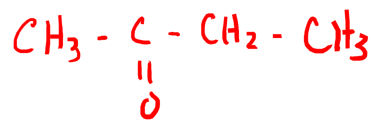


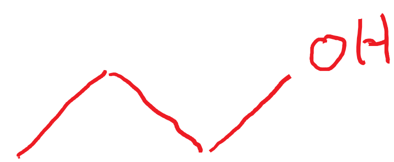


Practice with Drawing Organic Structures

Structural Formula	Condensed	Line



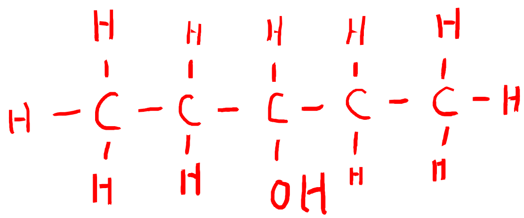


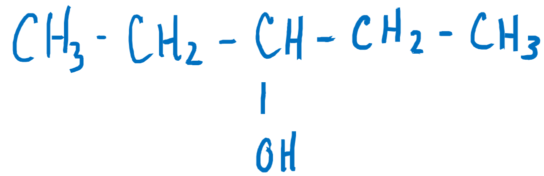


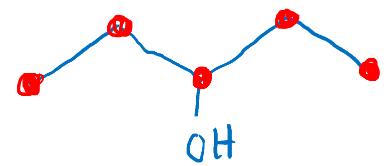
Practice with Drawing Organic Structures

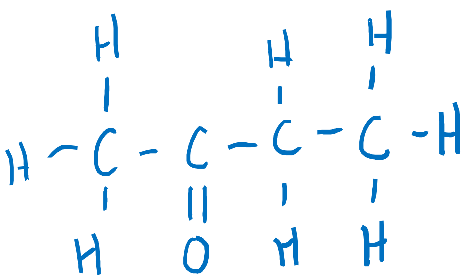
Structural Formula	Condensed	Line

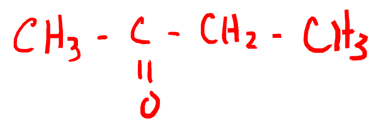
$CH_3CH_2CH(OH)CH_2CH_3$

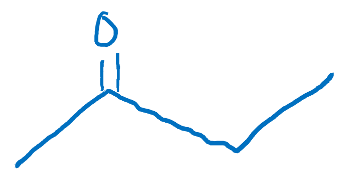


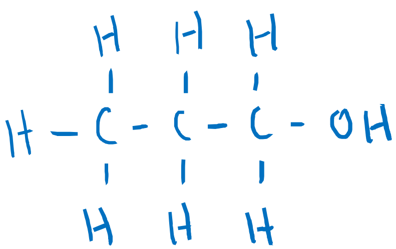




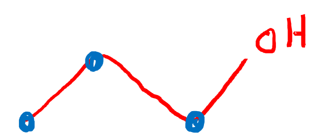








$CH_3-CH_2-CH_2-OH$

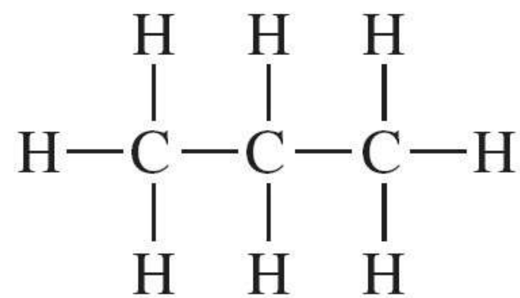


Organic Formulas and Molecular Models

Structural formulas or models are often used in organic chemistry to illustrate molecules.

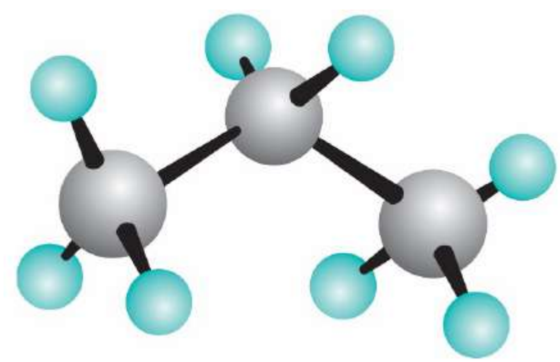
For example,

C_3H_8 is shown as



or in the case of a model.

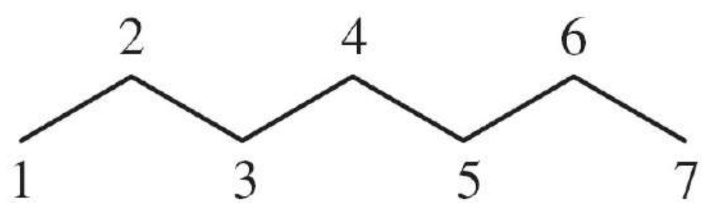
C_3H_8 is shown as



Organic Formulas and Molecular Models

This is an example of how to change a condensed structural formula into a line structure.

$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ *(condensed structural formula)*



(line structure)

The table on the next slide summarize formulas and models used in organic chemistry.

Classifying Organic Compounds

Functional groups are group of atoms *(or one atom)* that have specific behavioral characteristics in organic compounds.

Organic compounds are classified based on the functional groups that they contain.

Classifying Organic Compounds

The list of common functional groups found in organic compounds are shown here on Table 19.1.

Table 19.1 Classes of Organic Compounds

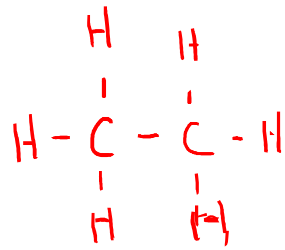
Class of compound	General formula*	IUPAC name**, ***	Molecular formula	Condensed structural formula	Structural formula
Alkane	RH	Eth*ane* (Ethane)	C_2H_6	CH_3CH_3	H—C—C—H
Alkene	R—CH=CH_2	Eth*ene* (Ethylene)	C_2H_4	$H_2C=CH_2$	$H_2C=CH_2$
Alkyne	R—C≡C—H	Eth*yne* (Acetylene)	C_2H_2	HC≡CH	H—C≡C—H
Alkyl halide	RX	Chloroethane (Ethyl chloride)	C_2H_5Cl	CH_3CH_2Cl	H—C—C—Cl
Alcohol	ROH	Ethan*ol* (Ethyl alcohol)	C_2H_6O	CH_3CH_2OH	H—C—C—OH
Ether	R—O—R	Methoxymethane (Dimethyl ether)	C_2H_6O	CH_3OCH_3	H—C—O—C—H
Aldehyde	R—C(H)=O	Ethan*al* (Acetaldehyde)	C_2H_4O	CH_3CHO	H—C—C(=O)—H
Ketone	R—C(=O)—R	Propan*one* (Dimethyl ketone)	C_3H_6O	CH_3COCH_3	H—C—C(=O)—C—H
Carboxylic acid	R—C(=O)—OH	Ethan*oic acid* (Acetic acid)	$C_2H_4O_2$	CH_3COOH	H—C—C(=O)—OH
Ester	R—C(=O)—OR	Methyl ethan*oate* (Methyl acetate)	$C_3H_6O_2$	CH_3COOCH_3	H—C—C(=O)—O—C—H
Amide	R—C(=O)—NH_2	Ethan*amide* (Acetamide)	C_2H_5ON	CH_3CONH_2	H—C—C(=O)—N(H)H
Amine	R—CH_2—NH_2	Aminoethane (Ethylamine)	C_2H_7N	$CH_3CH_2NH_2$	H—C—C—N—H

* The letter R is used to indicate any of the many possible alkyl groups. ** Class name ending in italic. *** Common name in parentheses.

Functional Groups

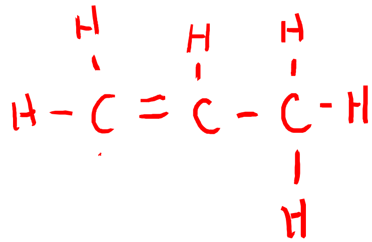
R - hydrocarbon chain

alkane



ethane CH_3CH_3

alkene

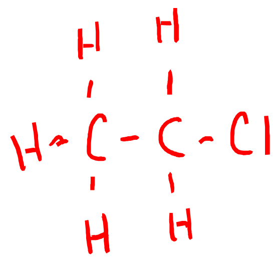


propene $CH_2=CHCH_3$

alkyne H–C≡C–H

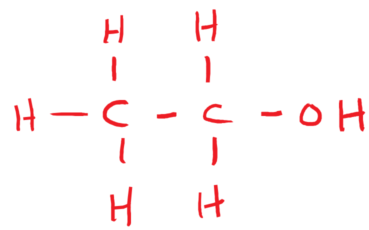
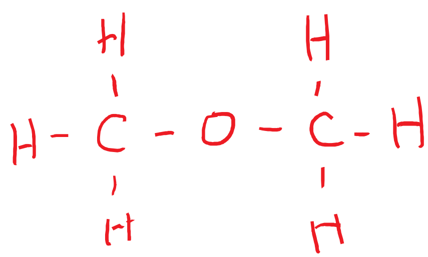
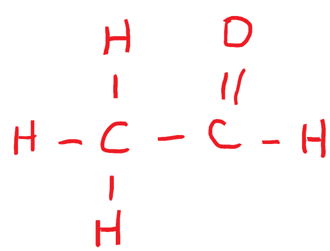
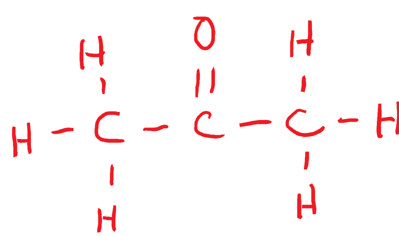
ethyne $CH\equiv CH$

alkyl halide R - Cl

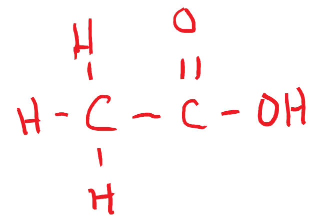


chloroethane CH_3CH_2Cl

halogens:
- Cl
- F
- Br
- I

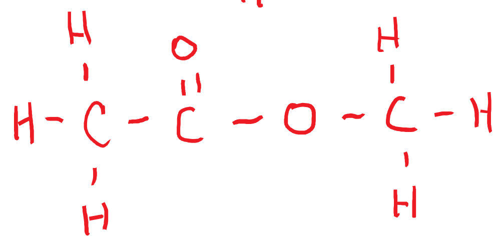
alcohol	R - OH		ethanol	CH_3CH_2OH
ether	R - O - R		dimethyl ether	CH_3-O-CH_3
aldehyde	$R-C(=O)-H$		ethanal	CH_3CHO
Ketone	$R-C(=O)-R$		propanone	$CH_3-C(=O)-CH_3$

carboxylic acid — R-C(=O)-OH



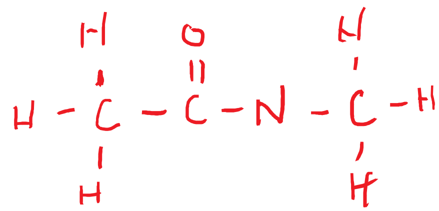
ethanoic acid — CH_3COOH

ester — R-C(=O)-O-R



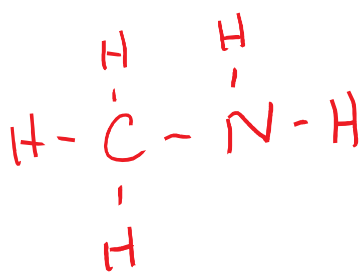
methyl-ethyl-ester — CH_3COOCH_3

amide — R-C(O)-N-R



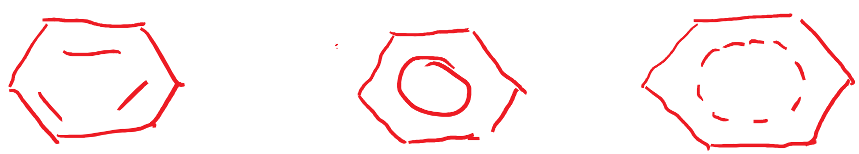
methyl ethyl amide — CH_3CONCH_3

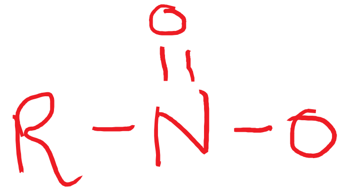
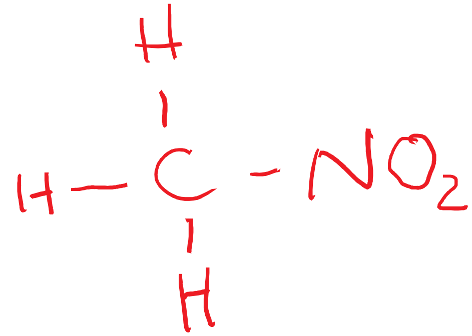
amine — $R-NH_2$



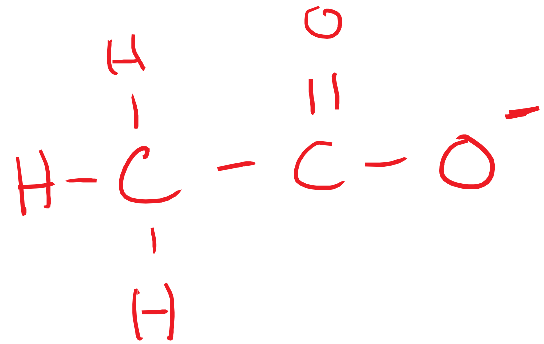
methyl amine — CH_3NH_2

Benzene (aromatic)



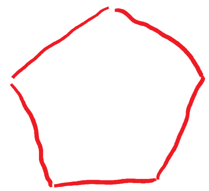
nitro $R-NO_2$ or  

cyanide $R-CN$ or $R\equiv CN$

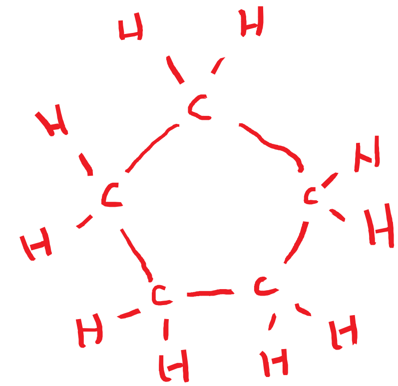
Carboxylate $R-COO^-$ 

→ Note: this is a carboxylic acid that has lost an electron. It is an ion and has a -1 charge.

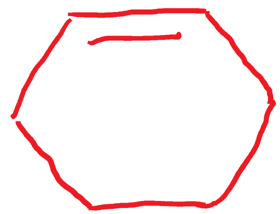
Cycloalkane



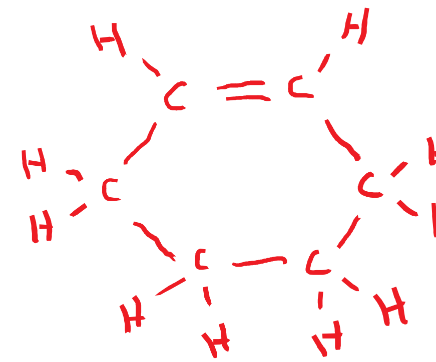
cyclopentane



Cycloalkene



cyclohexene



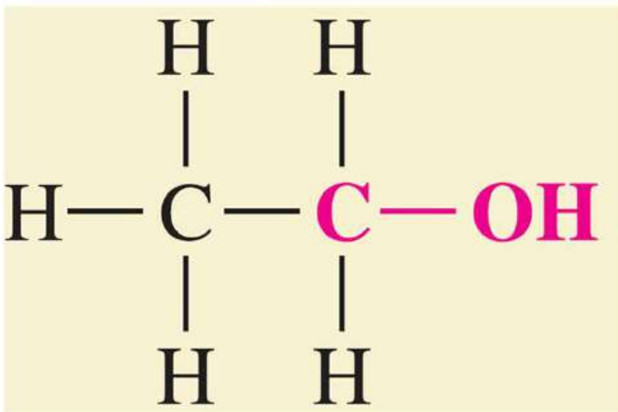
Classifying Organic Compounds

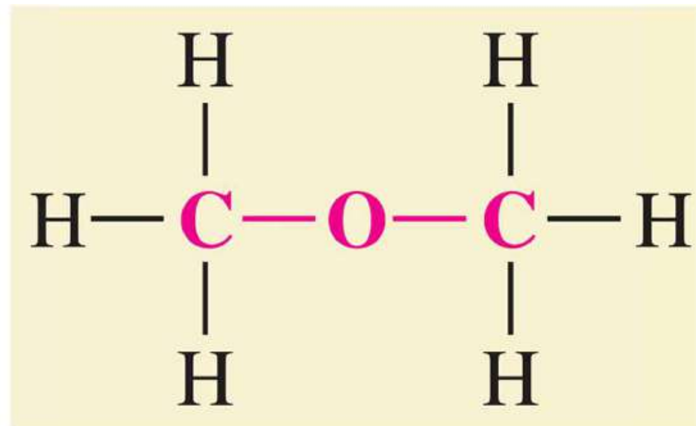
The list of important functional groups found in biological compounds is shown here on Table 19.2.

TABLE 19.2 | Important Functional Groups in Biochemistry

Biochemical class	Functional groups important to the biochemical		
Carbohydrates	$R{-}C(H){=}O$ aldehyde	$R{-}C({=}O){-}R$ ketone	ROH alcohol
Fatty acids	$R{-}C({=}O){-}OH$ carboxylic acid		
Proteins	$R{-}C({=}O){-}OH$ carboxylic acid		RCH_2NH_2 amine
Nucleic acids	ROH alcohol	[H_3PO_4 phosphoric acid]	

Classifying Organic Compounds





Ethanol contains the alcohol functional group and dimethyl ether contains the ether functional group. They have the same molecular formula but the boiling point (b.p.) of ethanol is 78°C while the b.p. of dimethyl ether is -23°C because of the structural differences between the molecules.