

# Organic Chemistry

Hydrocarbons  
Functional Groups

# Organic Chemistry

- Organic compounds: containing only carbon, hydrogen and oxygen
- Hydrocarbons: limited to carbon and hydrogen atoms

# Examples of hydrocarbons

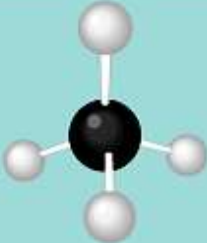

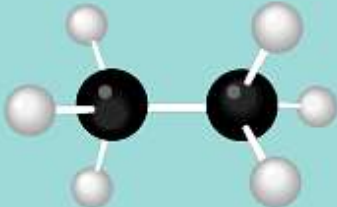

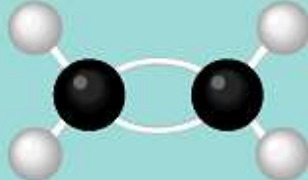

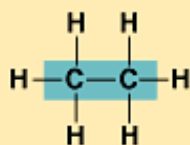
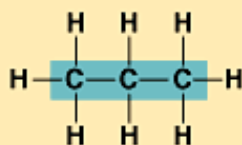
| Molecular Formula                                   | Structural Formula   | Ball-and-Stick Model   | Space-Filling Model   |
|---|--|--|---|
| $\text{CH}_4$<br><br>(a) Methane                    | $\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{H} \\   \\ \text{H} \end{array}$  |    |    |
| $\text{C}_2\text{H}_6$<br><br>(b) Ethane            | $\begin{array}{c} \text{H} & \text{H} \\   &   \\ \text{H}-\text{C}-\text{C}-\text{H} \\   &   \\ \text{H} & \text{H} \end{array}$         |   |    |
| $\text{C}_2\text{H}_4$<br><br>(c) Ethene (ethylene) | $\begin{array}{c} \text{H} & & \text{H} \\ & \diagdown & / \\ & \text{C}=\text{C} \\ & / & \diagdown \\ \text{H} & & \text{H} \end{array}$ |  |  |

Fig. 4.2, page 54

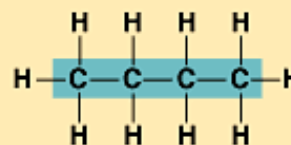
# Examples of hydrocarbons



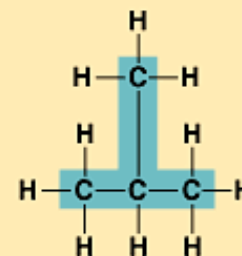
Ethane



Propane



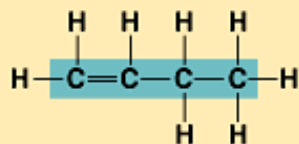
Butane



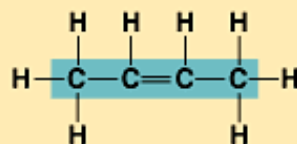
Isobutane

(a) Length

(b) Branching

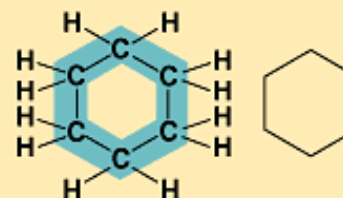


1-Butene

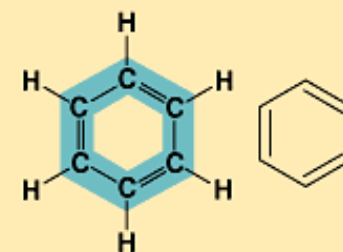


2-Butene

(c) Double bonds



Cyclohexane



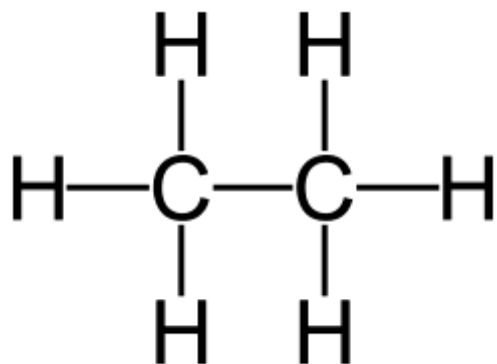
Benzene

(d) Rings

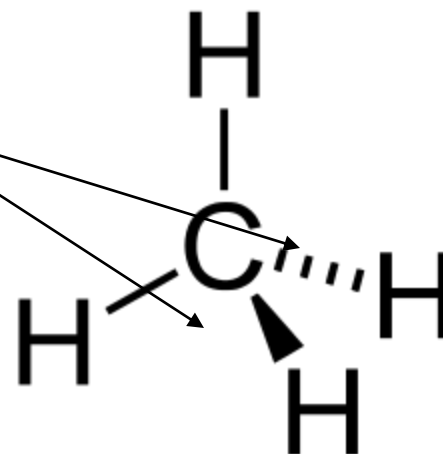
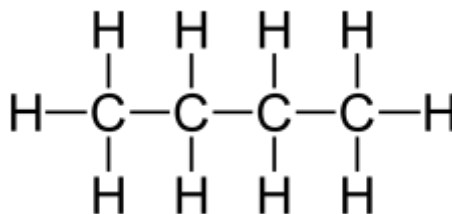
Fig. 4.4, page 55

# Alkanes

- Distinguishing Feature: Single Bonds
- General Formula:  $(C_nH_{2n+2})$
- Have only single bonds between carbon atoms

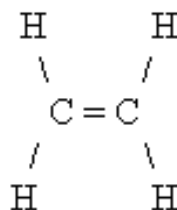


What do the lines represent?

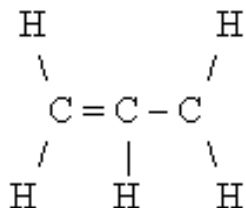


# Alkenes

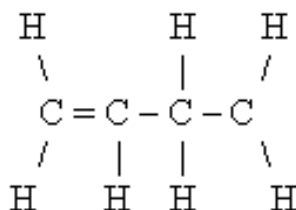
ETHENE:



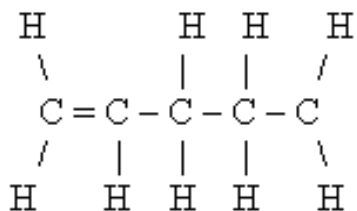
PROPENE:



BUTENE:



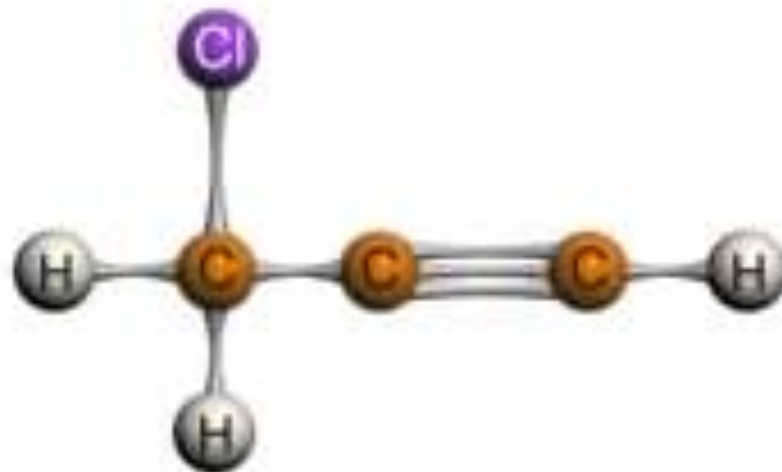
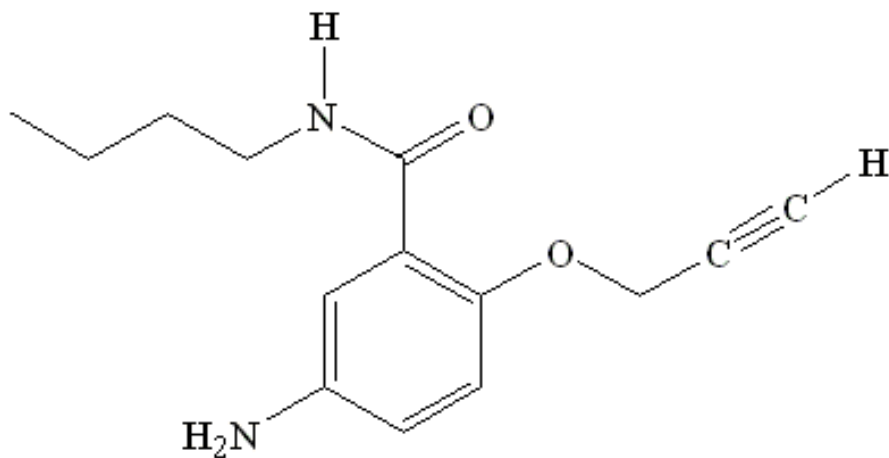
PENTENE:



- Distinguishing Feature: Double Bonds
- General Formula:  $(\text{C}_n\text{H}_{2n})$
- Have at least one double bond between carbon atoms

# Alkynes

- Distinguishing Feature: Triple Bonds
- General Formula:  $(C_nH_{2n-2})$ :
- Have at least one triple bond between carbon atoms.



# Prefix Naming System

Monkeys eat peeled bananas: (first four)

1. meth-

2. eth-

3. prop-

4. but-

5. pent-

6. hex-

7. hept-

8. oct-

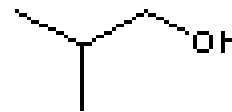
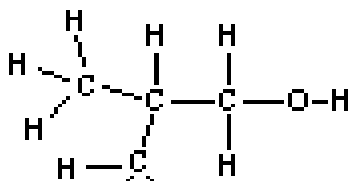
9. non-

10. dec-



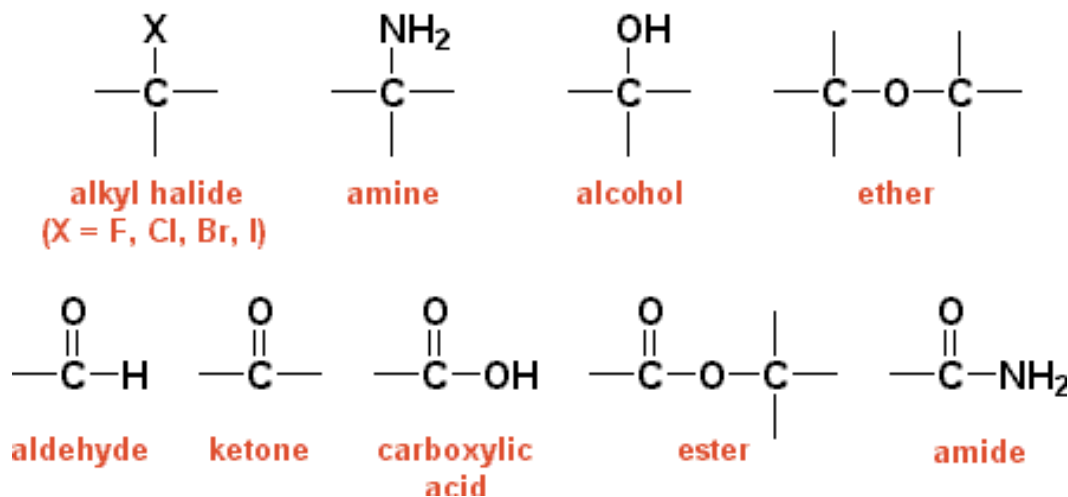
# Drawing Organic Compounds: Diagrams

- Complete structural diagram: shows all how all atoms in a structure are bonded
- Condensed structural diagram: simplifies the presentation of the structure by omitting the use of lines to represent bonds
- Line structure diagram: Carbon bonds are indicated with a line segment where the ends and points of the line segment represents a carbon. Hydrogens are not shown by assumed.



# Functional group

- A group of atoms that impart specific physical and chemical properties to an organic compound



# Applications of functional groups

- Knowing what functional groups a molecule contains allows for prediction of the properties of that molecule
  - Examples of physical properties: solubility, boiling point
  - Examples of chemical properties: reactivity

# Useful in industries

- Pharmaceutical industry
- Perfume and cosmetics (alcohol-OH)
- Biomedical engineering
- Materials science engineering (ceramics, polymers, metals)
- Aerospace industry (airplanes, spacecraft)

# Functional Group Classification

## At ends of molecules

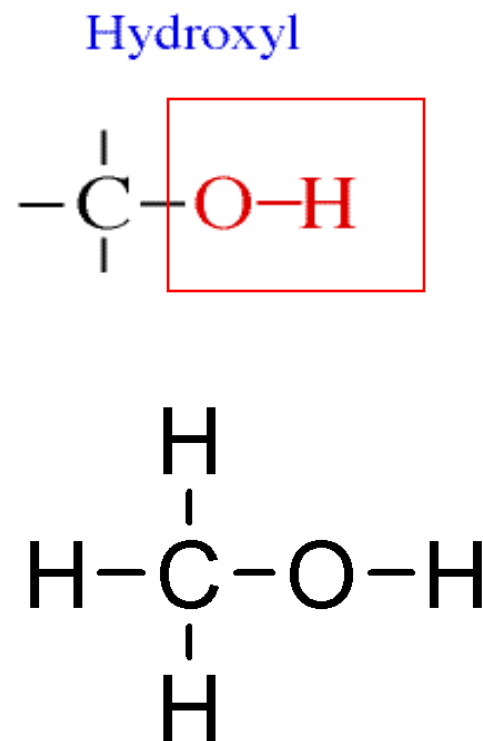
- Alcohol
- Aldehyde
- Carboxylic acid
- Amine
- Amide
- Phosphate
- Thiol

## In middle of molecule

- Ether
- Ketone
- Ester
- Amide
- Phosphate

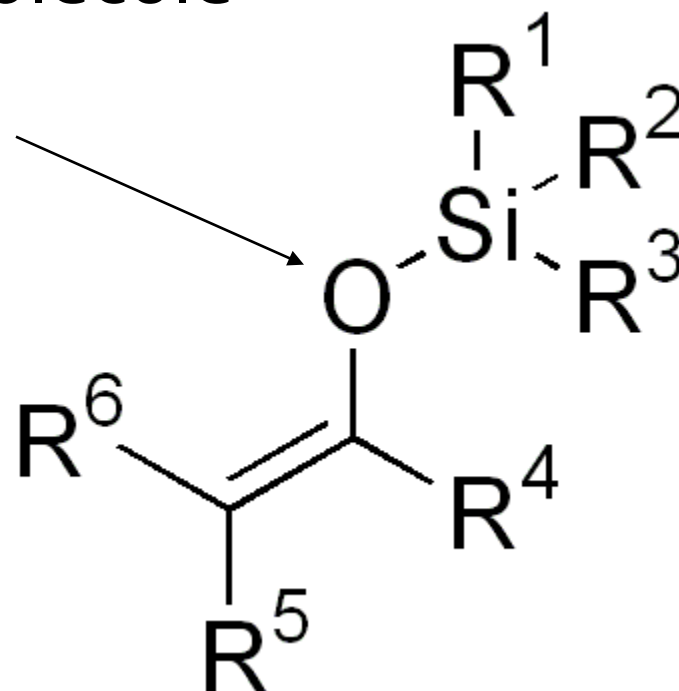
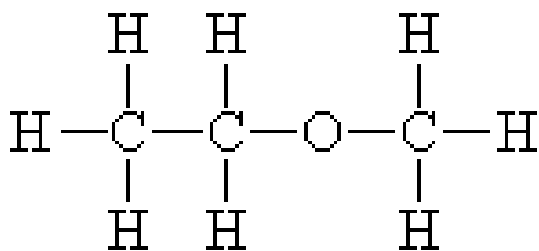
# Alcohol (hydroxyl)

- Ending in -ol
- Polar molecule
- Can be acidic depending on the surrounding atoms.
- Found at the end of a molecule
- Example:  
Methanol, ethanol



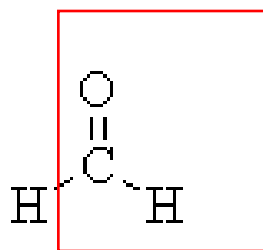
# Ether (alkoxy)

- Ends in ether
- Ethyl methyl ether
- Found in middle of molecule

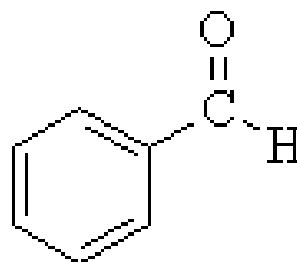


# Aldehyde (aldo, carbonyl)

- Ends in -al
- Double bond between carbon and oxygen atoms.
- Found at the end of the molecule.
- Example:



methanal

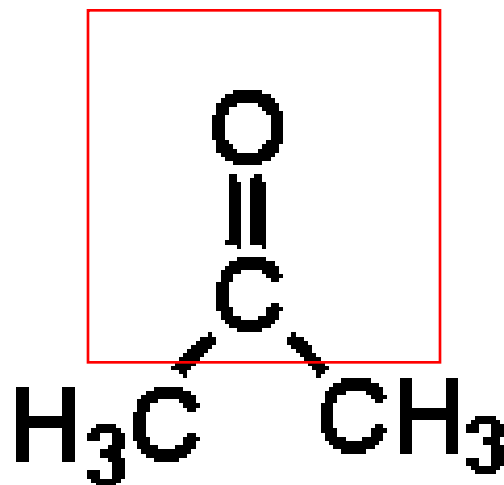


benzaldehyde



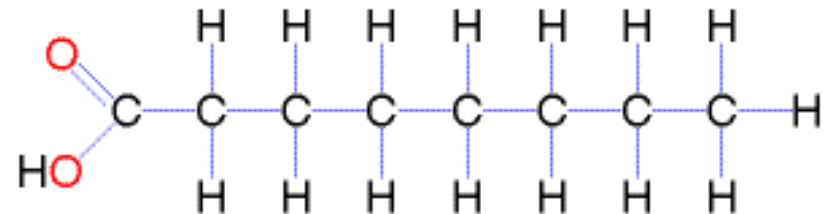
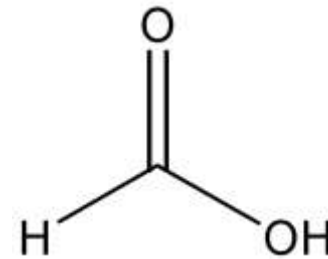
# Ketone (keto, carbonyl)

- End in -one
- Example Propanone
- Found in the middle of a molecule

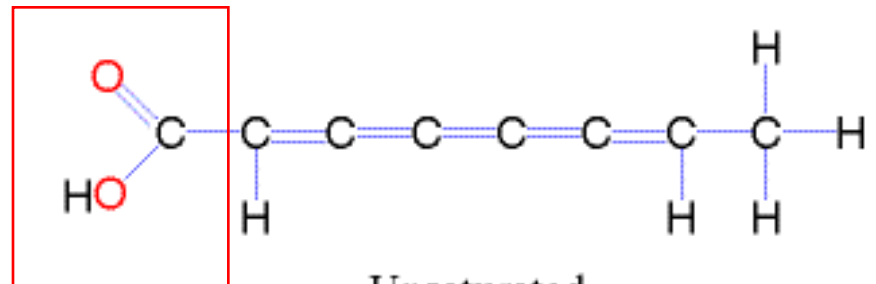


# Carboxylic acid (carboxyl)

- Ends in –oic acid
- Double bond between carbon and oxygen atoms.
- Found at the end of a molecule
- Example:  
Methanoic acid



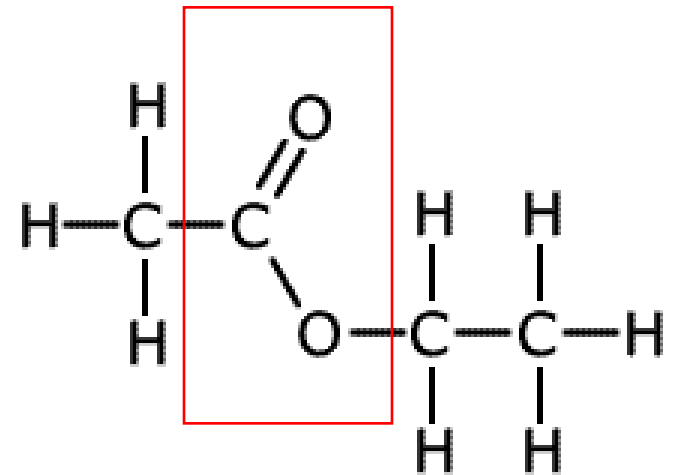
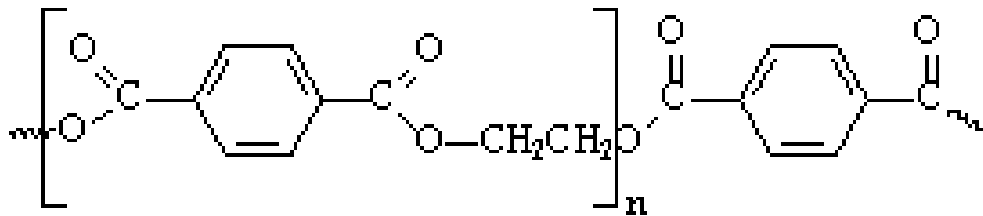
Saturated



Unsaturated

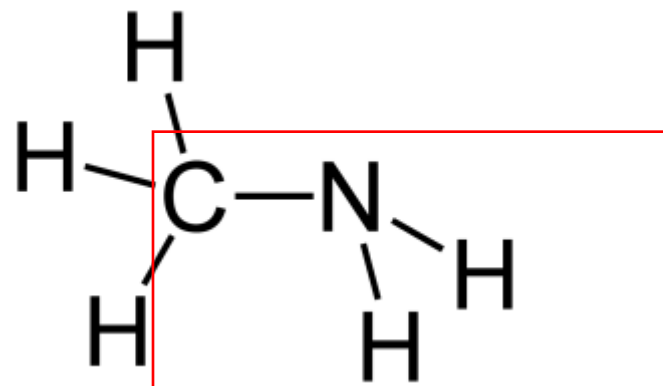
# Ester (acyl)

- Ends in oate
- Example: ethylethanoate, polyester
- Found in the middle of a molecule



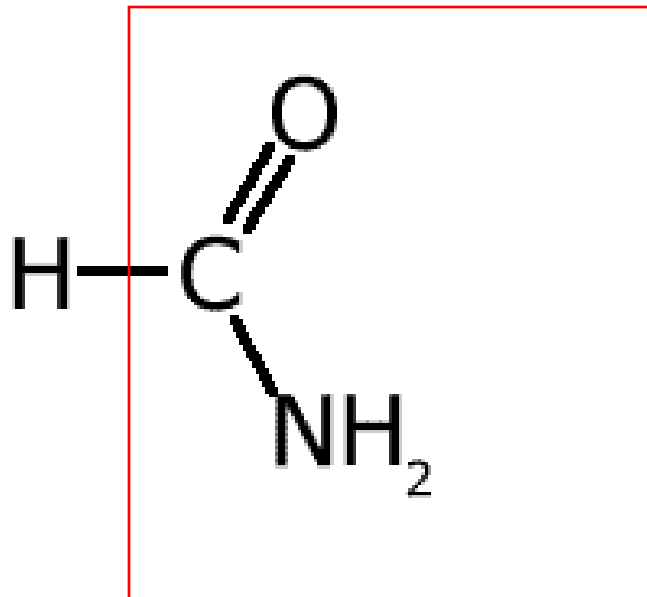
# Amines (amino)

- End in –amine
- Amines are a family of compounds containing nitrogen (N), all related to ammonia.
- Amines are different from ammonia in that at least one hydrogen (H) atom is replaced by a group of atoms containing carbon (C)
- Example: methyl amine



# \*Amide – slightly basic

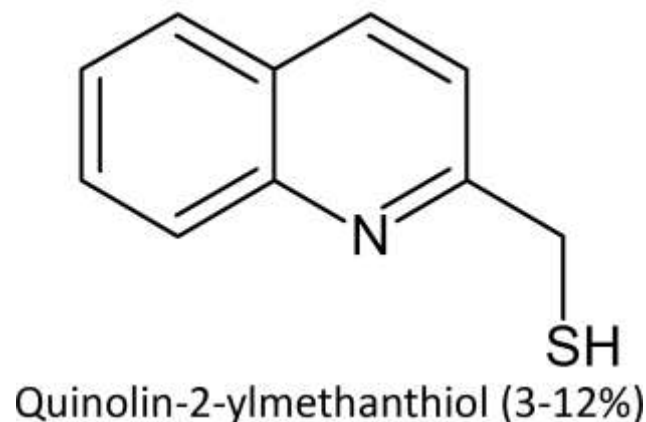
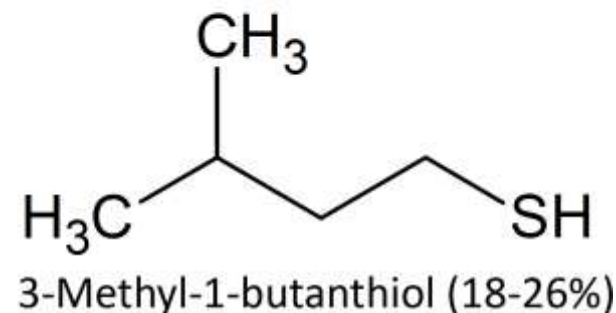
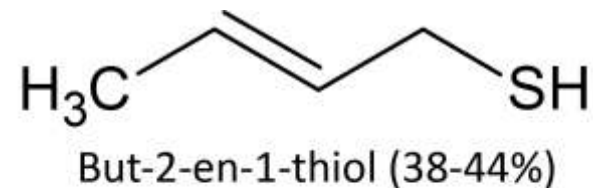
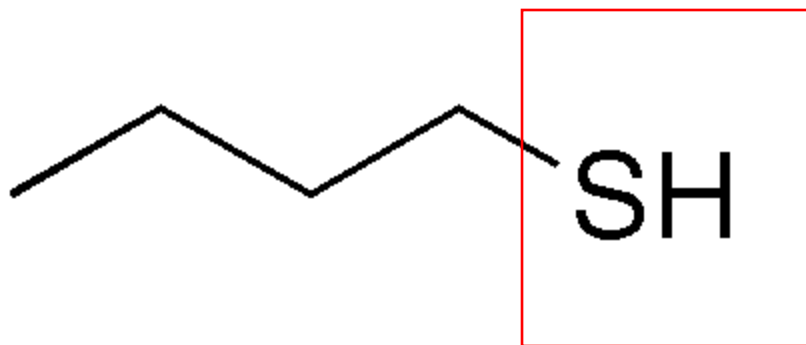
- Ends in –amide
- Example Methanamide



Can be found both midway through molecules or at ends of molecules

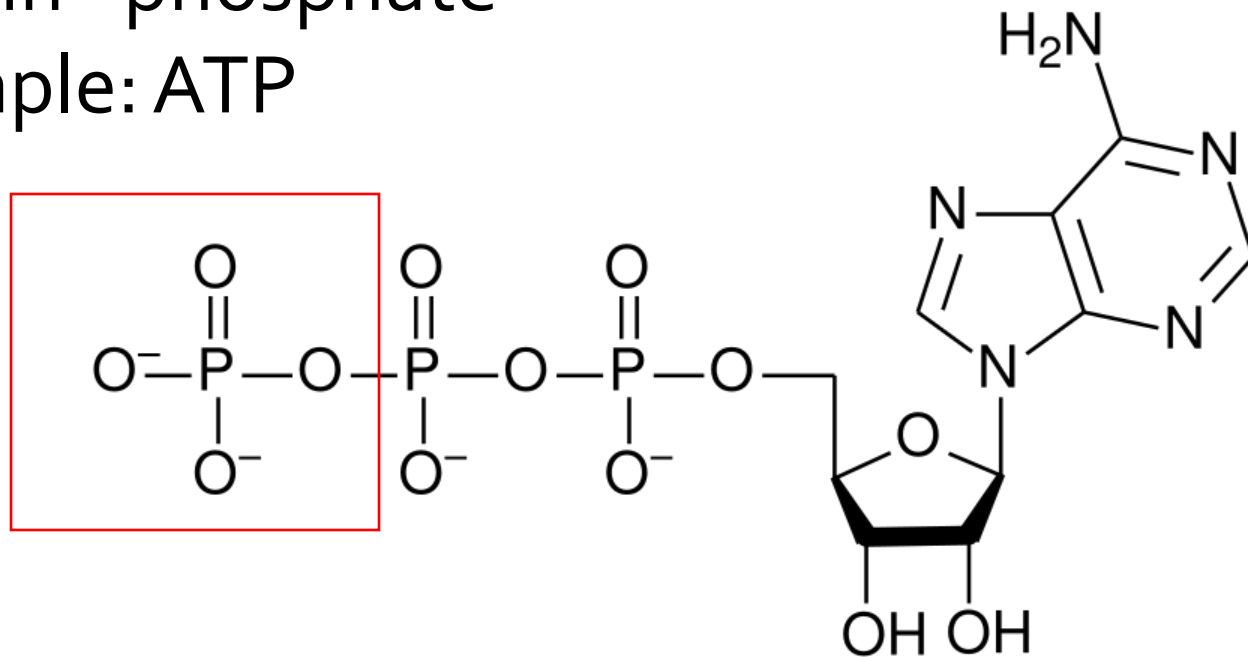
# Thiols (sulfhydryl)

- Ends in –thiol
- Example: Butathiol



# Phosphate- slightly acidic

- Ends in –phosphate
- Example: ATP



Can be found both midway through molecules or at ends of molecules

# Hydroxyl

**Table 4.1 Functional Groups of Organic Compounds**

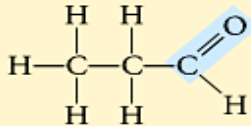
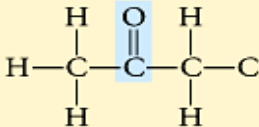
| Functional Group | Formula | Name of Compounds | Example  |
|------------------|---------|-------------------|--|
| Hydroxyl         | —OH     | Alcohols          | $\begin{array}{c} \text{H} \quad \text{H} \\   \quad   \\ \text{H}-\text{C}-\text{C}-\text{OH} \\   \quad   \\ \text{H} \quad \text{H} \end{array}$ <p>Ethanol<br/>(the drug of alcoholic beverages)</p> |

Note: There are some functional groups that are in this PowerPoint that are not listed in Table 4.1.

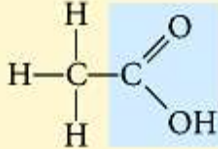


# Carbonyl

**Table 4.1 Functional Groups of Organic Compounds**

| Functional Group | Formula  | Name of Compounds | Example   |
|------------------|--|-------------------|---|
| Carbonyl         | $\begin{array}{c} \text{O} \\ \parallel \\ -\text{C} \\   \\ \text{H} \end{array}$ | Aldehydes         |  <p>Propanal</p> |
|                  | $\begin{array}{c} \text{O} \\ \parallel \\ -\text{C}- \end{array}$                 | Ketones           |  <p>Acetone</p>  |

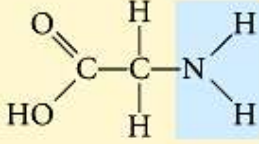
**Table 4.1 Functional Groups of Organic Compounds**

| Functional Group | Formula  | Name of Compounds | Example   |
|------------------|--|-------------------|---|
| Carboxyl         | <div> <math display="block">\begin{array}{c} \text{O} \\ \parallel \\ -\text{C} \\   \\ \text{OH} \end{array}</math> <p>(non-ionized)</p> </div> <div> <math display="block">\begin{array}{c} \text{O} \\ \parallel \\ -\text{C} \\   \\ \text{O}^- \end{array}</math> <p>(ionized)</p> </div> | Carboxylic acids  |  <p>Acetic acid*<br/>(the acid of vinegar)</p> |

\*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.

# Amino

**Table 4.1 Functional Groups of Organic Compounds**

| Functional Group   | Formula  | Name of Compounds | Example  |
|--|--|-------------------|--|
| Amino  | $\begin{array}{c} \text{H} \\ \diagup \\ \text{—N} \\ \diagdown \\ \text{H} \end{array}$<br>(non-ionized) $\begin{array}{c} \text{H} \\ \diagup \\ \text{—}^+\text{N} \\ \diagdown \\ \text{H} \end{array}$<br>(ionized) | Amines            | <br>Glycine*<br>(an amino acid) |
| <p>*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.</p> |  |                   |  |

# Sulfhydryl & Phosphate

**Table 4.1 Functional Groups of Organic Compounds**

| Functional Group | Formula      | Name of Compounds | Example   |
|------------------|--------------|-------------------|---|
| Sulfhydryl       | $\text{—SH}$ | Thiols            | $  \begin{array}{c}  \text{H} \quad \text{H} \\    \quad   \\  \text{H—C—C—SH} \\    \quad   \\  \text{H} \quad \text{H}  \end{array}  $ <p>Ethanethiol</p> |

**Table 4.1 Functional Groups of Organic Compounds**

| Functional Group | Formula   | Name of Compounds  | Example   |
|------------------|---|--------------------|---|
| Phosphate        | $  \begin{array}{c}  \text{O} \\     \\  \text{—O—P—O}^- \\    \\  \text{O}^-  \end{array}  $ | Organic phosphates | $  \begin{array}{c}  \text{OH OH H} \\    \quad   \quad   \\  \text{H—C—C—C—O—P—O}^- \\    \quad   \quad   \quad    \quad   \\  \text{H} \quad \text{H} \quad \text{H} \quad \text{O}^-  \end{array}  $ <p>Glycerol phosphate</p> |

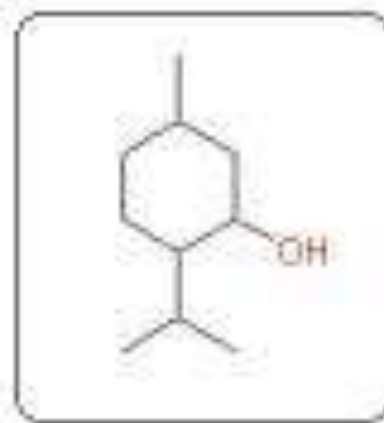
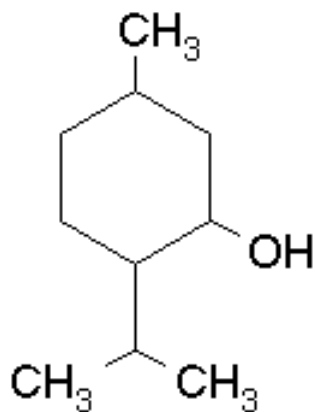
# Practice

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Identify the types of molecules in the next few slides...

# Menthol

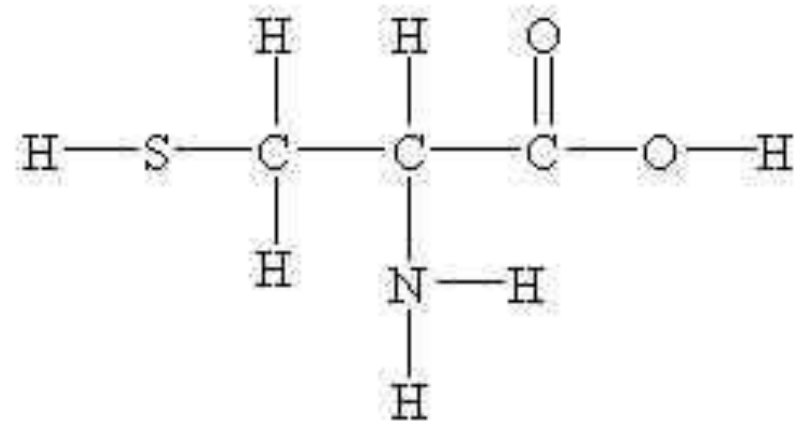
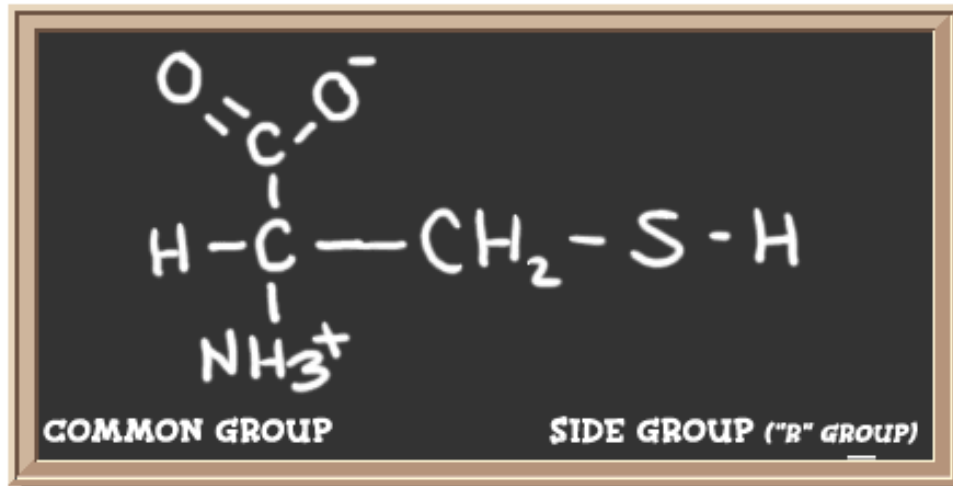
- Naturally found in mint oils
- Is an anesthetic
- Is used in products like cough medicine and breath freshener



Alcohol  
(Hydroxyl  
group)

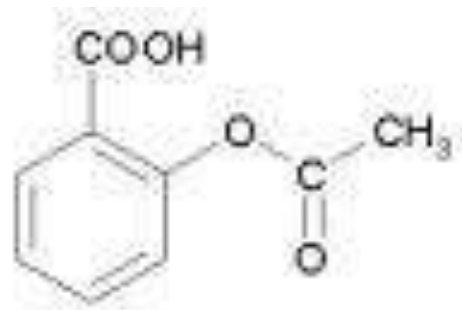
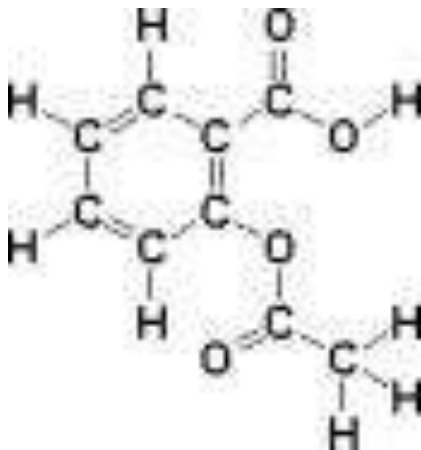
# Cysteine

- Is an amino acid



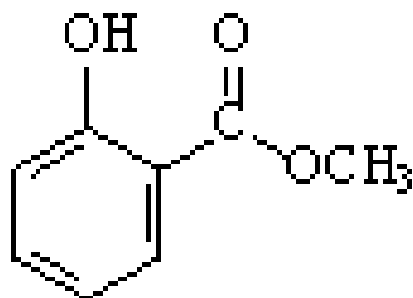
# Acetylsalicyclic acid (ASA)

- Closely related to a chemical naturally found in willow bark
- Is a painkiller
- Is the active ingredient in Aspirin

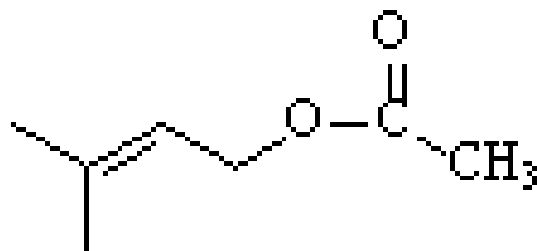


A carboxylic acid  
and an ester

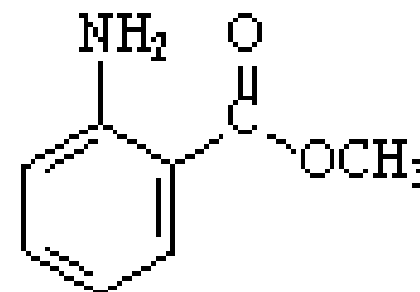
# Fragrance & Flavour Compounds



Methyl Salicylate  
(wintergreen)



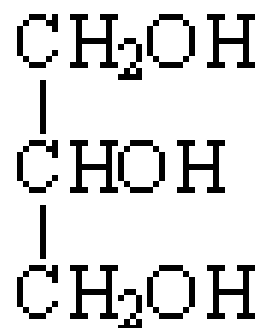
Isopentyl Acetate  
("juicy fruit")



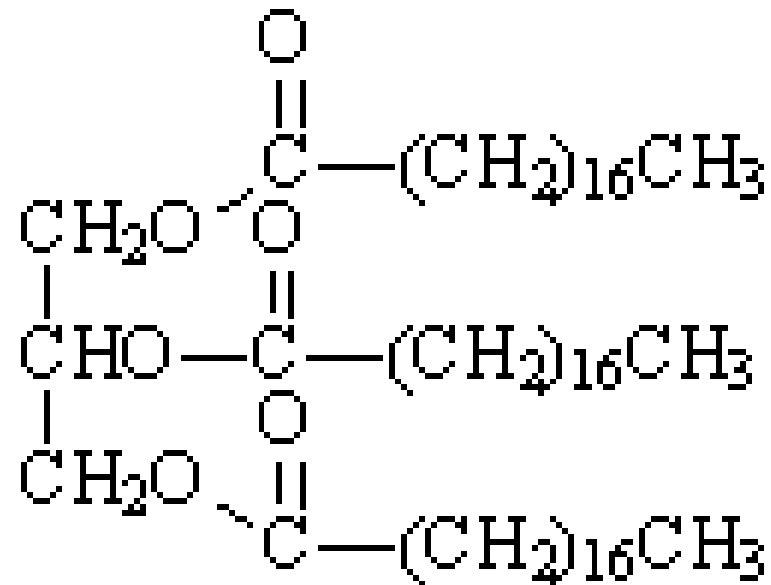
Methyl Anthranilate  
(grape flavor)



# Fats



Glycerol

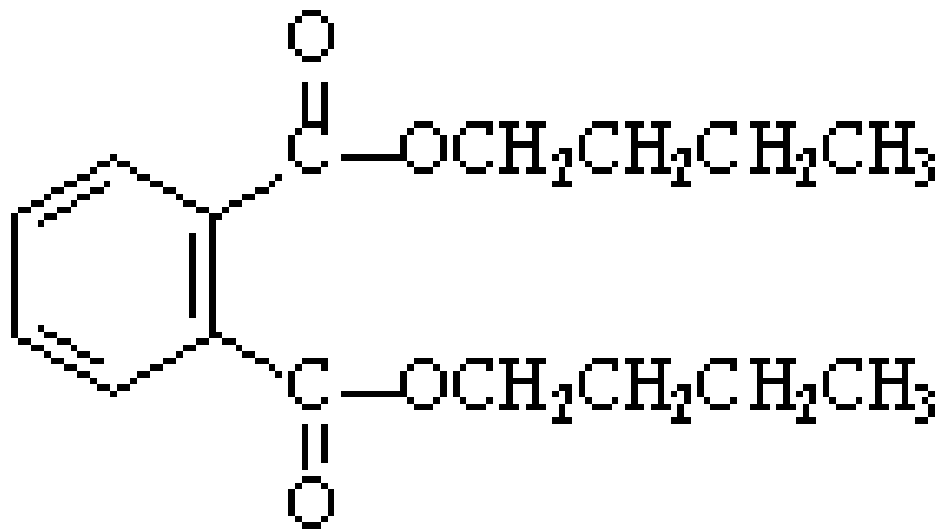


A fat (if solid)

An oil (if liquid)

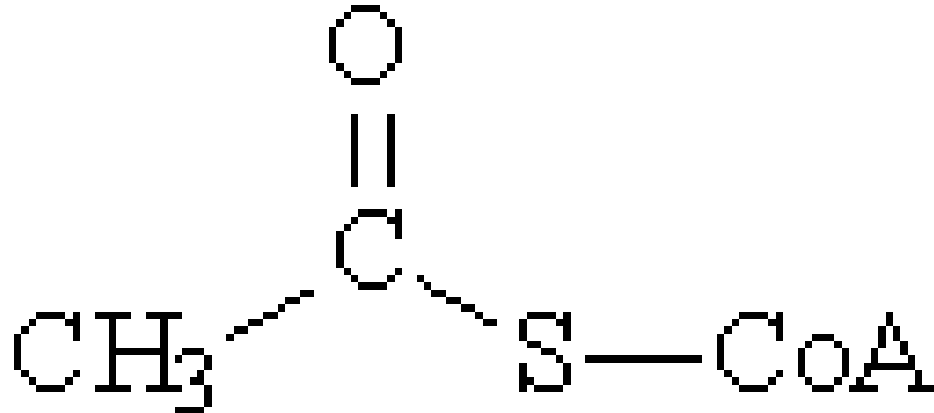
# n-Butyl Phthalate

- Many plastics are brittle
- To make them more pliable n-butyl phthalate is added



# Acetyl Coenzyme A

- Acetylating agent
- Two carbon building block



# Polyester

- A synthetic polymer
- Used in clothes, carpets, videotape film, toys (as filler)

