

# **Inorganic chemistry**

**Atoms** : defined as the smallest representative sample of an element. Only 106 different kinds of atoms are known to exist. Each element has a symbol and a name. the symbol is made up of one or two letters taken from the name of the element. The 106 elements can be listed in a number of ways. One way is to list them alphabetically. Another and more useful way is to arrange the elements in the **periodic table**.

**Periodic Table:** Arrange the elements depending of chemical and physical properties. The periodic table consist of a number of columns called **groups**. The horizontal rows are called **periods**. The elements in each group have similar chemical and physical properties. For example, the elements in the far right of periodic table, called the noble gases.

The element in group **IA** are called the alkali metals. Those in group **IIA** are called the alkaline earth metals the transition metals are the elements located in groups **IIIB** to **IIB**. The halogens are the elements in group **VIIA**. All the members of a groups have similar physical and chemical properties.

The elements are divided into three classes depended on their physical properties. Element that show a metallic luster when polished, capable of being drawn out into wire, can be hammered into sheets, and are good conductors of heat and electricity are classed as **metals**. elements that do not have these properties are classed as **nonmetals**. A class between these two is called the **metalloids elements**.

Only 90 of the 106 elements are found in nature. The others are prepared in the laboratory by instruments and techniques.

There are three particles that arranged in an atom, are **electrons**, **protons**, and **neutrons**. Each of these particles are characteristic properties. The discovery of these particles was a major step toward determining the structure of atoms. But how are these particles arranged in an atom?

### Three important subatomic particles

Name	Charge	Mass(amu)	Symbol
Electron	-1	1/1837	$\bar{e}$
Proton	+1	1.007	$H^+$ , $P^+$ , $P$
Neutron	0	1.004	n

**Periodic Table of the Elements**

The periodic table shows elements from Hydrogen (1) to Oganesson (118). It includes the Lanthanide Series (57-71) and Actinide Series (89-103). A legend at the bottom identifies element categories by color: Alkali Metal (purple), Alkaline Earth (blue), Transition Metal (green), Basic Metal (orange), Semimetal (yellow), Nonmetal (light blue), Halogen (dark blue), Noble Gas (pink), Lanthanide (light green), and Actinide (red).

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**Atomic numbers:** all the atoms of an element have the same atomic number. The atomic number of an element is equal to the number of protons and in same time equal number of electrons in its nucleus. The importance of this statement became clear with the discovery of isotopes.

**Mass number:** the mass number of an atom is the sum of the number of protons and neutrons in its nucleus. For example; the mass number of hydrogen is 1, while in deuterium is 2.

**Isotopes:** Atoms whose nuclei have the same number of protons but different numbers of neutrons. For example; hydrogen atoms called **deuterium** atoms have nuclei that contain one proton and one neutron. The nuclei of hydrogen atoms called **tritium** atoms, when have one proton and two neutrons. Hydrogen is not the only element that has isotopes. Many other elements have two or more isotopes.

**Atomic weight:** The mass of an element is a weighted average of masses of all its isotopes. For example;

$$\text{Average atomic mass of C} = (0.9889)(12.00) + (0.0111)(13.00) \\ = 12.01$$

**Ions:** there are two types of ions:

**Positive ions;** called cations, are formed when atoms lose electron. Such  $\text{Na}^+$ .

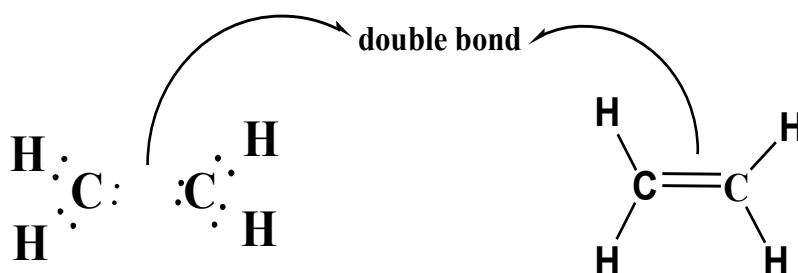
**Negative ions;** called anions, are formed when atoms gain electrons. Such  $\text{Cl}^-$ .

The charge on an ion is determined by the number of electrons it must gain or lose to achieve the electron arrangement of the nearest noble gas.

**Chemical bonds:** Molecules are made up of atoms joined together. This join is called chemical bonds.

**a. ionic bonds;** formed by a strong attraction between negative and positive ions. Anion and cations are formed in many chemical reactions by the transfer of one or more electrons from one element to another. For example;  $\text{NaCl}$ .

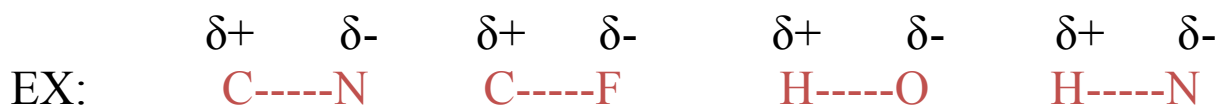
**b. Covalent bonds;** formed by sharing electrons to achieve a noble gas electron arrangement for each atom. Meaning a pair of electrons shared between two atoms. For example:  $\text{H}_2$ ,  $\text{Cl}_2$ ,  $\text{O}_2$  and  $\text{CH}_2=\text{CH}_2$ .



**c. polar covalent bonds:** The ability to attract electrons differs from atom to atom. Formed between two atoms of different elements depends on the difference in their electronegativity. For example; in HCl (hydrogen chloride), the hydrogen and chlorine atoms share a pair of electrons. Because chlorine is more electronegative than hydrogen, the electron pair is drawn toward chlorine, giving it a partial negative charge and leaving a partial positive charge on the hydrogen.



In a polar covalent bond, the more electronegative atom acquires a partial negative charge, and its less electronegative partner acquires a partial positive charge.



Atoms of the elements H, C, N, O, S and halogens form polar covalent bonds with atoms of other elements.

**Chemical reaction:** the chemical reaction occur around us, the burning of fuel, the rusting of iron, and the growth of plants and animals are all examples of chemical reactions. We represent these and other chemical reactions on paper by *chemical equations*. A chemical equation is a concise way of giving information about a chemical reaction. The compounds that react in a chemical reaction are represented by their chemical formulas in the chemical equation.



# AQUEOUS SOLUTIONS AND COLLOIDS

Solutions and colloids are essential to life. The solutions in living systems are aqueous, they are made with water. Therefore we must learn types of solutions and concentration of it, and used to explain their biologically important properties.

**Solution:** Homogenous mixture of molecules, atoms or ions of two or more different substance.

In the solution there are two substance which called components. One found in excess called the **Solvent**, and other is called **solute**. For example; solution of sugar in water, water is the solvent and sugar is the solute. The three states of matter can combine in nine different ways to form solution containing two components:

Table ( ) Type of solutions

solvent	solute	Examples
liquid	liquid	Alcoholic beverages
Solid	liquid	An amalgam (mercury in silver)
Gas	liquid	-
Gas	solid	-
liquid	solid	Salt water
Solid	solid	metal alloys (brass or tin)
Gas	Gas	Air
liquid	Gas	carbonated beverages
Solid	Gas	hydrogen gas in palladium metal

-there is usually a limit to the amount of solute that can be dissolved in a solvent at particular temperature when this limit is reached, no more solute will dissolve in the solvent. When this happens we say that the solvent is saturated with solute, and called saturated solution.

**Solubility:** The amount of solute that dissolved in a given quantity of solvent to form the saturated solution. The solubility of a solute in a particular solvent depends on a number of factors:

- 1-kind of solvent
- 2-kind of solute
- 3-The temperature of the solvent
- 4-The pressure above the solvent.

The results of our experiences in the world have led to the very general rule that (like dissolves like). By this we mean that a polar solvent such as water is a good solvent for ionic compounds such as sodium chloride. Gasoline, a mixture of nonpolar organic compounds,

is a good solvent for other nonpolar organic compounds such as oils. The polar and nonpolar substances will not solutions such gasoline and water.

**solubilities of several compounds in water**

Compound	Solubility at 20°C (g/100ml)	Solubility at 100°C (g/100ml)
NaCl	36.2	39.1
NH <sub>4</sub> Br	97.1	146.0
KBr	59.4	102.0
NH <sub>3</sub>	47.5	6.9
KNO <sub>3</sub>	37.8	247.0
O <sub>2</sub>	0.00434	0.00080
Li <sub>2</sub> CO <sub>3</sub>	1.33	0.725
Ca SO <sub>4</sub>	0.21	0.16

\*Sometimes there is no limit to the amount of one substance that dissolve in another. This is particularly true for solution of a liquid in liquid.

**1. Completely miscible:** pair of liquids that are infinitely soluble in each other.

**2. Partially miscible:** other liquids are only slightly soluble in each other.

**3. Immiscible:** liquids that are insoluble in each other, ex. Gasoline immiscible water.

\*Temperature of the solvent affect the solubility of the solute, in general solutes are more soluble in hot than cold solvents. Solubilities of several solids increasing greatly with increasing temperature, others increase only slightly. Other actually decrease. Above Table.

Gases are other compounds whose solubility in water decrease with increasing temperature. A familiar example is boiling water. The bubbles that form when water is heated are air escaping from solution because dissolved air is less soluble in water at higher temperatures.

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## Concentration of solutions

We describe the relative amounts of solute and solvent in a solution by means of units of concentration. There are several such units, and we will examine the most commonly used ones.

### A- Weight/ Weight percent:

One way to specify the concentration of a solute in a solution is as a *percent by weight*. The concentration of the solute is given by the following equation (8-1):

$$\text{percent by weight solute} = \frac{\text{weight of solute in g}}{\text{weight of solute in g} + \text{weight of solvent in g}} \times 100$$

The following example shows how to express the concentration of a solute in the unit.

**Example :** What is the percent by weight of sugar in a solution made by dissolving 10 gm of sugar in 90 gm of water?

**Step 1.** Relate the quantities in equation 8-1 to those given in the problem:

Ans:

Weight of solute = 10 gm

Weight of of solute and solvent = 10+90=100gm

Then:

$$10\text{gm} / 100\text{gm} \times 100 = 10\%$$

Q/ Determine the percent by weight of the solute in each of the following solutions?

(a) 1.5 gm of sodume chloride in 100gm water

(b) 3.5 gm of glucose in 250 gm of water

## **B- Volume/ Volume percent**

A convenient way of expressing the concentration of a liquid solute dissolved in a liquid is as a percent by volume. This unit of concentration is similar to percent by weight except that volumes in milliliters are used instead of weight in gram. The equation is as following:

$$\text{percent by volume solute} = \frac{\text{volume of solute in ml}}{\text{total volume of solution in ml}} \times 100$$

We can express the concentration of solute in this unit, as shown in the following example.

Example: what is the percent by volume of ethyl alcohol in a solution made by diluting 10 ml of ethyl alcohol to 100 ml with water?

**Ans:**

Volume of solute = 10 ml

Total volume of solution = 100 ml

Then:

Percent by volume ethyl alcohol =  $10 / 100 \times 100 = 10\%$

**Q1/** Determine the percent by volume of the solute in each of the following solutions:

- (a) 5 ml of rubbing alcohol diluted to 150 ml with water
- (b) 15 ml of ethyl alcohol diluted to 500ml with water

### **C- Weight/Volume percent:**

This widely used method of expressing concentration is a combination of weight and volume. This weight is usually that of the solid solute and the volume is that of the total solution. This unit is defined as follows.

$$\text{percent by weight/volume solute} = \frac{\text{weight of solute in gm}}{\text{total volume of solution in ml}} \times 100$$

To use of this unit is shown in the following example:

Example: what is the percent by weight /volume of sodium chloride in a solution made by diluted 1.5 gm of sodium chloride to 100 ml with water?

Ans:

Weight of solute = 1.5 gm

Total volume of solution = 100 ml

Place thr quantities into above equation:

$$\begin{aligned} \text{percent by weight /volume NaCl} &= \frac{1.5 \text{ gm}}{100 \text{ ml}} \times 100 \\ &= 1.5\% \end{aligned}$$

Low concentrations of solute are often expressed in milligrams (mg) per 100 ml. this weight / volume percent unit is defined as following:

$$\text{milligrams per 100 ml} = \text{mg} / 100 \text{ ml} = \frac{\text{weight of solute in mg}}{100 \text{ ml of solution}}$$

This unit is often used to express the concentrations of solute in blood and urea, as shown in the following:

Example: 1 ml sample of blood plasma is found to contain 3.3 mg of sodium ions. Express this concentration in mg/100ml .

Ans: solute = 3.3 mg , solution = 1 ml of blood plasma

To find out the number of mg in 100 ml of blood plasma, we set up the following proportion :

$$\frac{3.3 \text{ mg}}{1 \text{ ml}} \times \frac{x}{100 \text{ ml}}$$

By rearrange and solve for x

$$x = \frac{3.3 \text{ mg} \times 100 \text{ ml}}{1 \text{ ml}} = 330 \text{ mg}$$

There are 330 mg of sodium ions in 100 ml of blood plasma .

Therefore we say 330 mg per 100 ml

This value is within the normal concentration range of sodium ions in blood plasma ( 320 – 350/ 100 ml)

This percent mg / 100 ml sometimes called mg percent.

Q/ determine the concentration of solute in each of the following solutions in mg / 100 ml.

- (a) 32 mg of sugar diluted to 10 ml with water
- (b) 5 ml of solution that contains 1 gm of sodium ion

### **D- Molar Concentration (Molarity)**

We can used the moles to measure of quantities of matters. We can extend this concept to solutions by expressing the amount of solute present in 1 L of solution in terms of moles.

Molar concentration, or molarity, which defined as the number of moles of solute per liter of solution, is designated by the capital letter M.

This definition is given in the form of an equation, as following:

$$M = \frac{\text{number of moles of solute}}{\text{number of liters of solution}}$$



**Example :** Determine the molar concentration of a solution that contains 25 gm of glucose,  $C_6H_{12}O_6$  in 500 ml of solution.

**Ans:**

Convert 25 gm of glucose into moles

Molecular weight of glucose = 180 gm/ mol

$$\text{Number of moles} = \frac{25 \text{ gm}}{180 \text{ gm}} = 0.139 \text{ mol}$$

$$\text{Volume in L} = \frac{500 \text{ ml}}{1000 \text{ ml}} = 0.5 \text{ L}$$

Then: by using equation of molarity we can measure the concentration in molarity:

$$M = \frac{\text{number of moles}}{\text{volume in L}} = \frac{0.139 \text{ mol}}{0.5 \text{ L}} = 0.278 \text{ M}$$

Q1/ How many grams of glucose are needed to make 2 L of 2 M solution?

Q2/ How many grams are needed to make 500 ml of 0.15 M sucrose ( $C_{12}H_{22}O_{11}$ ) solution.

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## E= Part Per Million and Part Per Billion:

These units of concentration are widely used to report very small amounts of solute in a solution. The concentration of pollutants in water and air are usually reported in these units.

\* **one part per million:** abbreviated **ppm**, contains 1 part of solute per 1 million ( $10^6$ ) parts of solution. By parts we mean any unit of measure such as grams, liters, or anything else we choose.

For example, the concentration of solid pollutants in solid food is given in ppm expressed as mg of pollutant (the solute) in 1 million mg of solid food (the solution). Because 1 million mg is equivalent to 1 kg. ppm is usually defined as follows:

$$\text{ppm} = \frac{\text{weight of solute, in mg}}{\text{weight of solution, in kg}} \quad \text{or} \quad \frac{\text{mg of solute}}{\text{L of solution}} \quad \text{or} \quad \frac{\mu\text{L}}{\text{L}}$$

The express the concentration of small quantities of solid solute in water, the unit ppm is usually define as mg of solute per liter of solution. This change from weight to volume of solvent can be made because 1 million mg (1 kg) of water occupies approximately 1 L. this definition of ppm is also frequently used even through the solution may weight somewhat more or less than 1 kg.

Air pollution is measured in ppm on the basis of measurements of volume rather than weight. Thus, 1 ppm means that there is 1  $\mu\text{L}$  of pollutant (the solute) per 1 million ( $10^6$ )  $\mu\text{L}$  (1L) of air (the solution).

**One part per billion:** The sensitivity of analytical methods has improved so much that parts per billion, abbreviated **ppb**, has become a common unit of concentration. Its use and definition are similar to those of ppm. Thus, **1 ppb contains 1 part of solute per 1 billion ( $10^9$ ) part of solution.** Again, the part refer to weight or volume, depending on whether the solution is a gas, liquid, or solid.

$$\text{ppb} = \frac{\text{weight of solut in } \mu\text{g}}{\text{weight of solution in kg}} \quad \text{or} \quad \frac{\mu\text{g of solute}}{\text{L of solution}} \quad \text{or} \quad \frac{\mu\text{L}}{10^3\text{L}}$$

The units ppm and ppb are extremely small. For example, 1 ppm is equivalent to 1 cent in 10,000 dollars, and 1 ppb is equivalent to 1 cent in 10 million dollars. These unit are convenient means to express very small concentrations without using exponential notation. The use of these units is shown in the following :

**Example:** The maximum Food and Drug Administration (FDA) tolerance of mercury in fish is 0.5 ppm. A 10 gm sample of fish is found to contain 72 µg of mercury. Does the amount of mercury in the fish exceed the FDA maximum tolerance?

Ans:

ppm = 1 part of measure unit per 1 million parts  
then:

$$\text{ppm} = \frac{\text{weight of mercury in } \mu\text{g}}{\text{weight of fish sample in gm}}$$

$$= \frac{72 \mu\text{g}}{10 \text{ gm}} = 7.2 \text{ ppm}$$

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# First -dentistry-SECOND SEMISTER

Lecture ( 1 )

2020-2021

Dr. Mahmoud

## ORGANIC CHEMISTRY

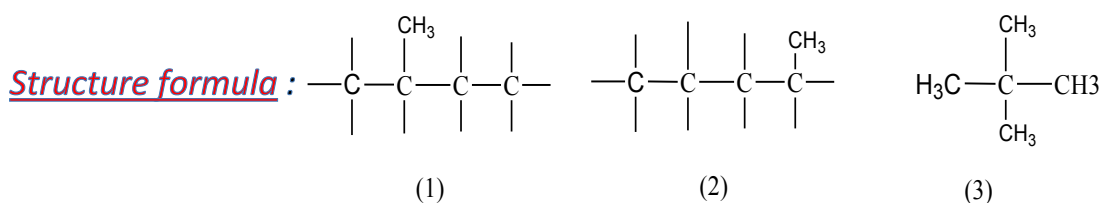
**Organic Chemistry** : The chemistry of carbon and its chemical compounds. Carbon atoms have four polar covalent bonds with atoms of other elements or other carbon atoms.

Carbon atoms can form thousands of long chains , or rings of all size, the chains and rings can having branches and crosslinks to the carbon atoms of these chains and rings there are attached with other atoms. Chiefly hydrogen, but also fluorine, chlorine, bromide, iodine, oxygen, nitrogen, sulfur, phosphors and many others.

Organic chemistry is a field of immense of the food importance to technology it's the chemistry of dyes and drugs, paper, ink, paints and plastic, gasoline and rubber tires, it's the chemistry we eat and the clothing we wear.

Organic chemistry is fundamental to biology and medicine. A side from water, living organisms are made up chiefly of organic compounds, the molecules of molecular biology, are organic molecules ultimately biological processes are a matter of organic chemistry.

• **Structural formulas**: organic compounds tell us how the atoms arrangement in a different forms in the molecule. The chemical formula loses some of its usefulness because we fiend that one chemical formula dose not always represent just one compound. For example three different organic compounds all have the same chemical formula,  $C_5H_{12}$  . These three compounds are isomers .



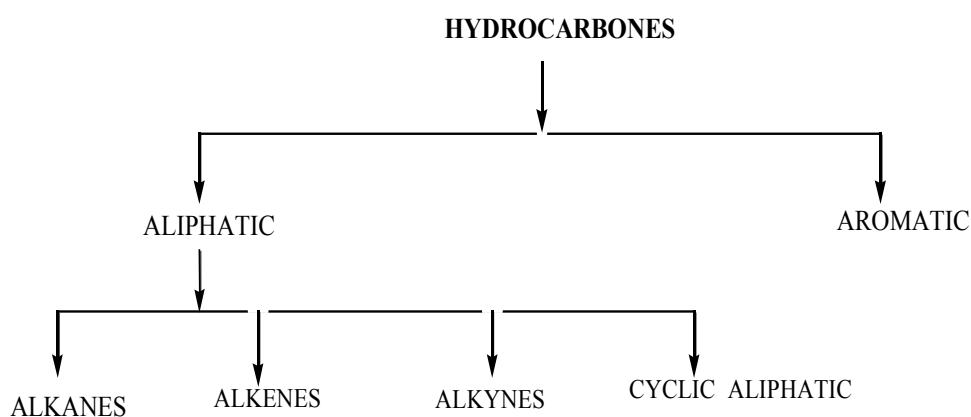
Chemical formula :       $C_5H_{12}$                        $C_5H_{12}$                        $C_5H_{12}$

• *Chemical formulas provide us with information about the number and kinds of atoms in a molecule .*

• Structural isomers: *compounds, that have the same chemical formulas but differ in their structural formulas . the structural isomers dose not find in the methane, ethane and propane, its start from butane, pentane.....et.*

Hydrocarbons : *Organic compounds contain carbon and hydrogen atoms.*

*The petroleum ( complex mixture of hydrocarbons ) and natural gas formed as the result of a geological process that started millions of years ago for organic material, From plants and animals were buried with sediments from oceans and rivers. With the passing time, the sediments were slowly subjected to great pressures and bacterial action, which formed gas and petroleum deposits. Hydrocarbons classified as :*

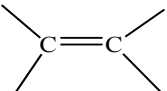
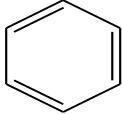
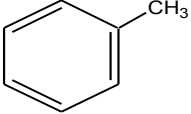


1. *Alkanes : that contain only single bonds between carbons atoms .*
2. *Alkenes : that contain one or more carbon - carbon double bonds .*
3. *Alkynes : that contain one or more carbon - carbon triple bonds .*
4. *Cyclic aliphatic : that forms deferent cyclic such tricyclic, tetracyclic, pentacyclic, hexacyclic, .... and more.*
5. *Aromatic hydrocarbons : that contain six electrons (3  $\pi$  bonds ) in a six member ring and may be contain single and double bonds.*

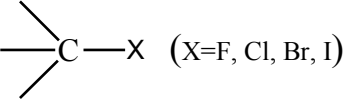
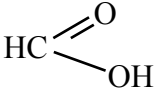
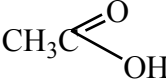
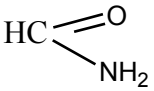
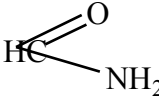
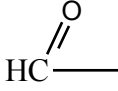
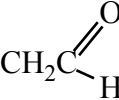
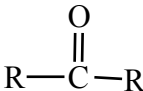
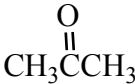
**Function groups** : The specific atoms or groups that formed bond with carbon atom such as CL, OH, SH, NH<sub>2</sub> or .....et .These groups at which reactions occur are called function groups.

Function groups can be organized chemical reaction in to classes . this is the way that we organize the study of organic chemistry.

*Table of function groups*

function groups	class of compounds	Example
	Alkene	2HC=CH <sub>2</sub>
HC≡CH	Alkyne	HC≡CH
	Aromatic	



functional groups	class of comp.	Example
	Halide	CH <sub>3</sub> Cl
R—OH	Alcohol	CH <sub>3</sub> OH
R—O—R	Ether	CH <sub>3</sub> O CH <sub>3</sub>
R—NH <sub>2</sub>	Amine	CH <sub>3</sub> NH <sub>2</sub>
	Carboxylic acid	
	Amide	
	Aldehyde	
	Ketone	

### International Unit of Pure and Applied Chemistry (IUPAC)

- Alkanes:** can be naming alkanes according to the number of carbon atom in compound

**C1** naming methane

**C2** = ethane

**C3** = propane

**C4** = butane

..... et

Other naming by adding the ending ...ane to the Greek name for the number of carbon atoms in the compound, like pentane = penta = 5 .

- Branched chain alkanes are named by using the following rules:

- 1- Determine the longest continuous chain of carbon atoms in the molecule .
- 2- Carbons or function groups that have replaced ... one
- 3- If the substituent is a hydrocarbon group, this group is named by changing the ...ane to ...yl for example:

-CH<sub>3</sub>                      Methyl

CH<sub>3</sub>-CH<sub>2</sub>-CH<sub>2</sub>-            Propyl

CH<sub>3</sub>-CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>-        n- butyl



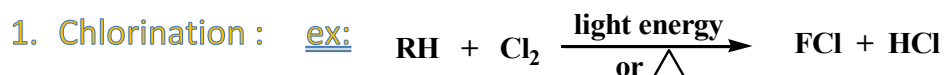
### Physical properties:

For all alkanes general the boiling point and melting point increase as the number of carbon atoms increase. Fewer than five Carbon atoms are gases, where as those containing five to ten Carbon atoms are liquids . alkanes containing 11 or more carbon atoms viscose liquids, and alkanes containing 20 or more carbon atoms are wax like solids.

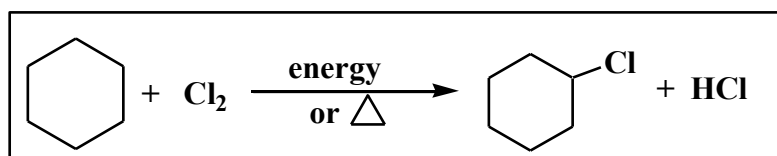
Alkanes contain only single covalent bond, C-C or C-H because the electronegativity of carbon and hydrogen are nearly the same.

Alkanes have lower boiling points than most other organic compounds of comparable molecular weight.

### CHEMICAL REACTIONS OF ALKANES :



The symbol RH represent the alkane where R is an alkyl or cyclo-alkyl group. Chlorination of an alkane is a substitution reaction :



2. Oxidation : oxidizing reagents are (  $K_2Cr_2O_7$  ,  $KMnO_4$  ) :



### PREPARATION OF ALKANE :

Each of the smaller alkanes, from methane through n-pentane and isopentane can be obtained in form by fractional distillation of petroleum and natural gas:

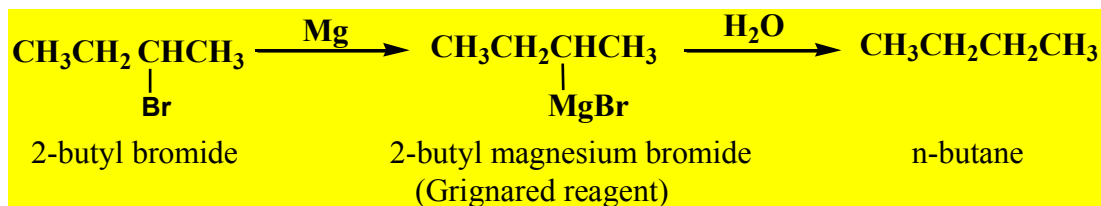
1- Hydrogenation of alkenes:



2- Reduction of alkyl halides :

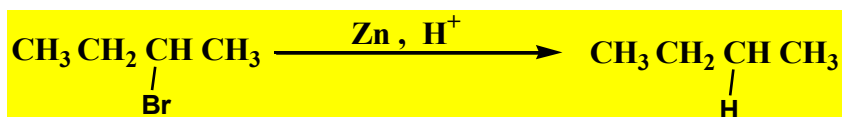
a. Hydrolysis of Grignard reagent:

Ex:



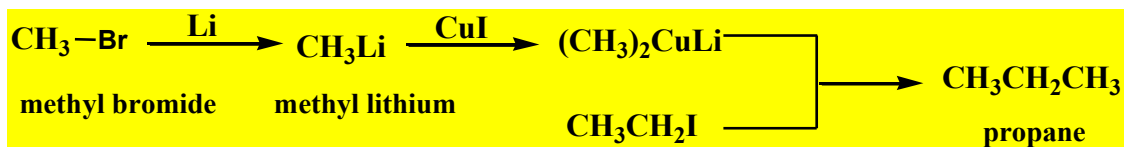
b. Reduction metal and acid:

Ex:



3. Coupling of alkyl halides with organometallic compounds:

Ex:



## PREPARATION OF ALKENES :

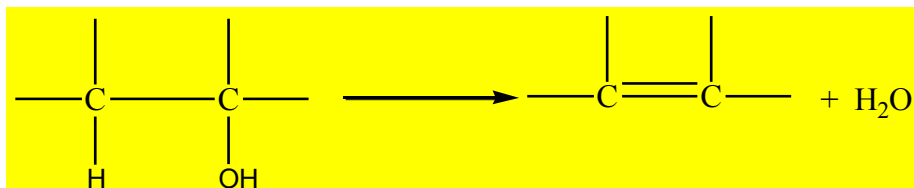
### 1. Dehydrohalogenation of alkyl halides :

Ex:

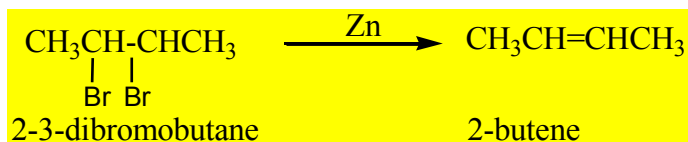


### 2. Dehydration of alcohols:

EX:



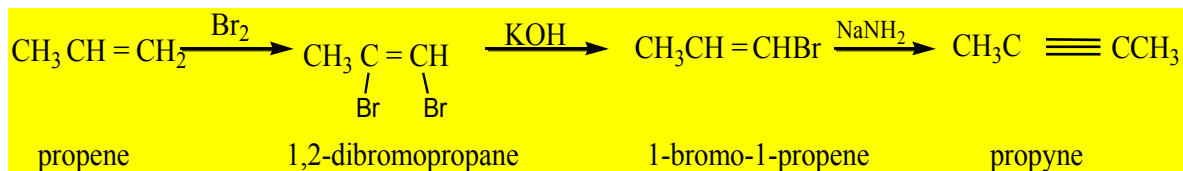
### 3. De halogenation:



## PREPARATION OF ALKYNES:

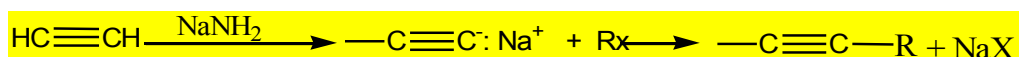
### 1. Dehydrohalogenation of alkyl dihalides:

Ex:



### 2. Reaction of sodium acetylides with primary alkyl halides:

Ex:

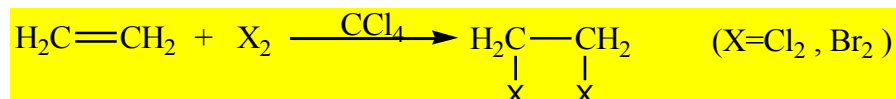


## REACTIONS OF ALKENES:

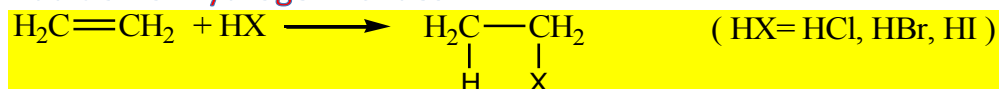
### 1. Hydrogenation:



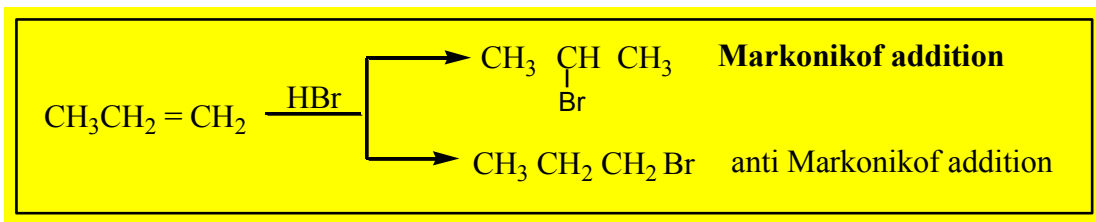
### 2. Halogenation:



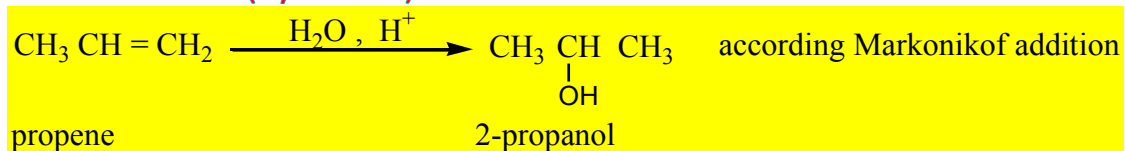
### 3. Addition of hydrogen halides:



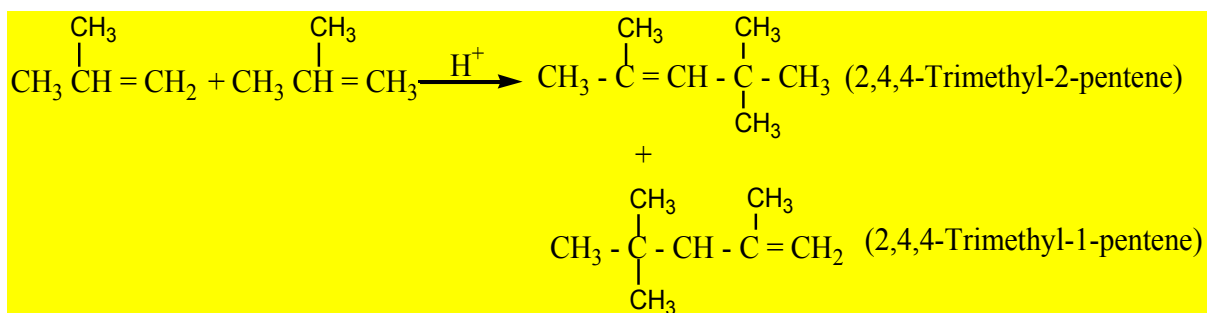
this addition depend of Markonikof addition:



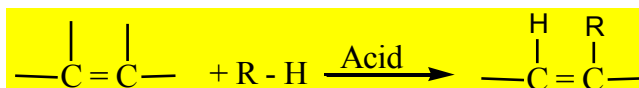
4. Addition of water (hydration):



5. Dimerization: since the alkenes produced contain exactly twice the number of carbon and hydrogen atoms as the original isobutylene, they are known as dimers ( di=tow, mer=part) of isobutylene, and the reaction is called dimerization. Other alkenes undergo analogous dimerization.



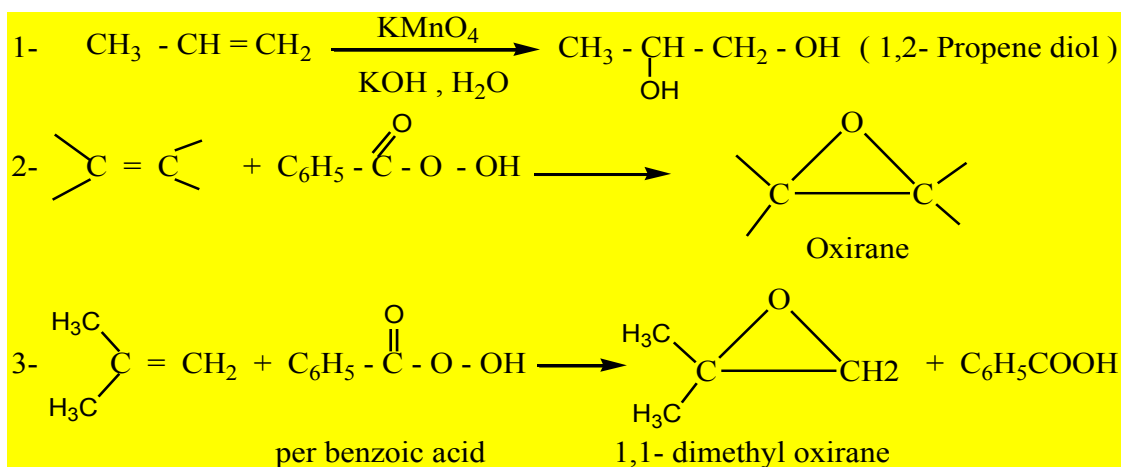
6. Alkylation:



7. Oxidation: oxidation reagents are:

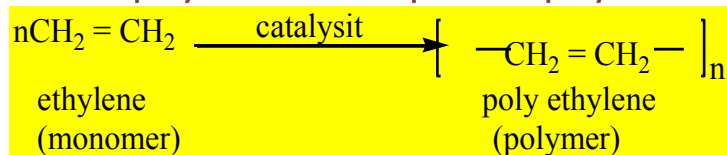
- a-  $\text{KMnO}_4$
- b.  $\text{O}_3$  (pzone)
- c. Per acids ( $\text{RCO}_3\text{H}$ )

Ex:



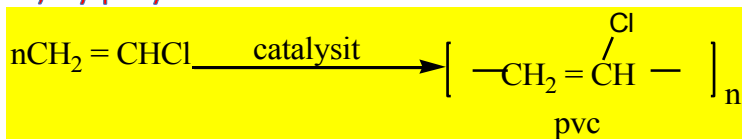
Markonikof role: the hydrogen of acid (HX) is add to the carbon of the double bond containing the greatest number of hydrogens.

8. Polymerization: with a catalyst, an alkene can be made to add to another alkene to form dimer. The reaction need not stop at this point. The dimer can add to another alkene to form a trimer. This reaction can continue untell a high molecule is formed the process is called polymerization to produce polymer.

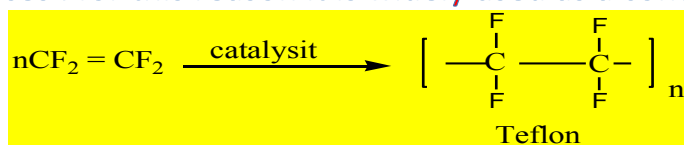


n: is a molecules number of chain that form several hundreds to several thousands.

Several halogen containing monomers, vinyl chloride form polyvinyl chloride called (PVC) by polymerization:

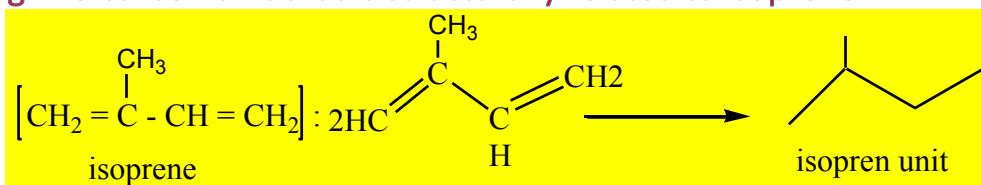


This polymer is widely used to make plastic bottles, Toflon, which is made from them monomer Tetraflouro ethylene is one of the most chemically inert of all organic substances . for this reason it is widely used as a containing for cooking .

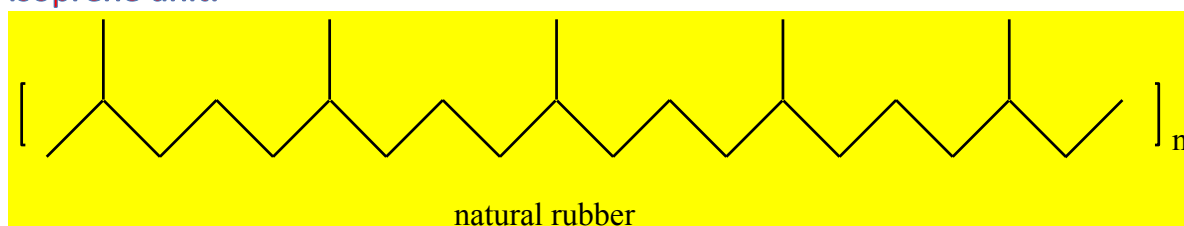


### Polymerization in living systems:

Polymerization also occurs in living system, a large number of compounds called terpenes are found in living system. These compounds are all polymers made of repeating five-carbon unit that is structurally related to isoprene:



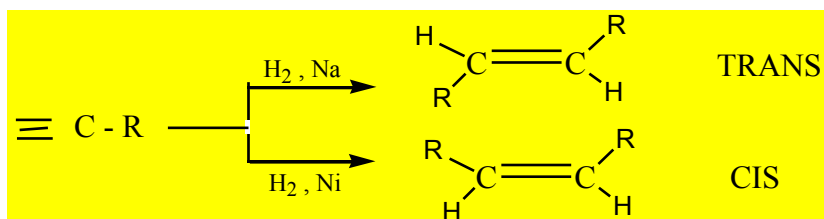
Natural rubber is an example of polymer made by combine thousands of isoprene unit:





### Reaction of alkynes:

Addition hydrogen, halogen and hydrogenhalids to alkynes is very much like addition to alkenes, except that here two molecules of reagent can be consumed for each triple bond. It is generally possible, by proper selection of conditions, to limit reaction to the first stage of addition. Can be reduced to alkenes product cis-alkene and trans alkene as shown:



Dr. MAHMOUD ALFAHDAWI

# First -dentistry-SECOND SEMISTE Lecture ( 3 )

2020-2021

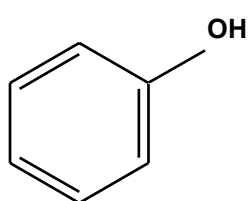
Dr. Mahmoud

## **PHENOLS**

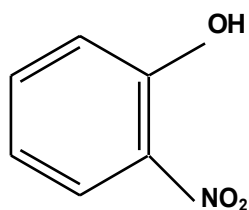
Aromatic hydroxy compounds in which the hydroxy group is attached to an aromatic ring are called **phenols**

### **Properties of phenols:**

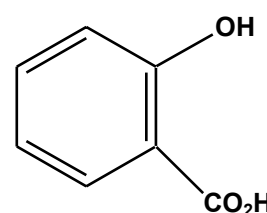
Simple phenols are liquids or low-melting solids, frequently with a very characteristic odor, moderately soluble in water and very soluble in most organic solvents. Simple phenols are generally very toxic, some like phenol itself being absorbed through the skin with the production of severe burns. Typical examples of phenols are:



Phenol

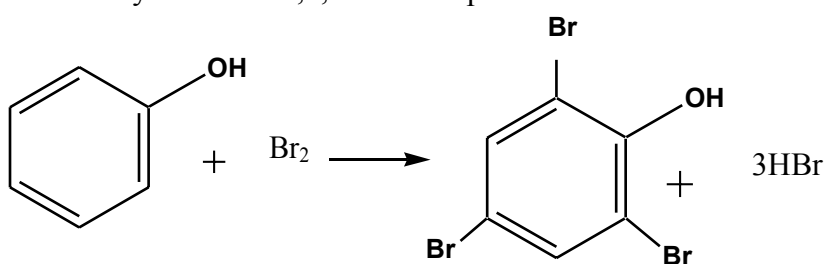


2-Nitrophenol



Salicylic acid

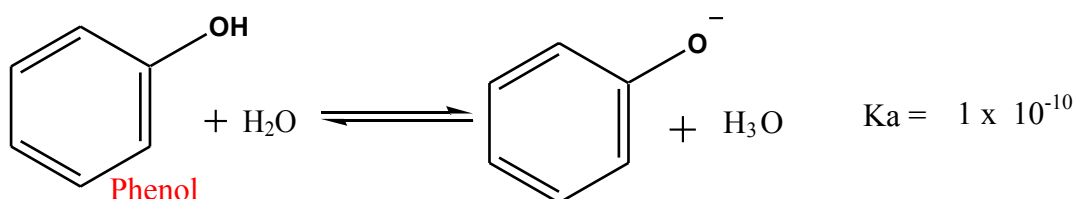
Phenols undergo electrophilic aromatic substitution reactions. The hydroxyl group is strongly activating and ortho-, para- directing. For example, phenol itself reacts with bromine without catalyst to form 2,4,6-tribromophenol:



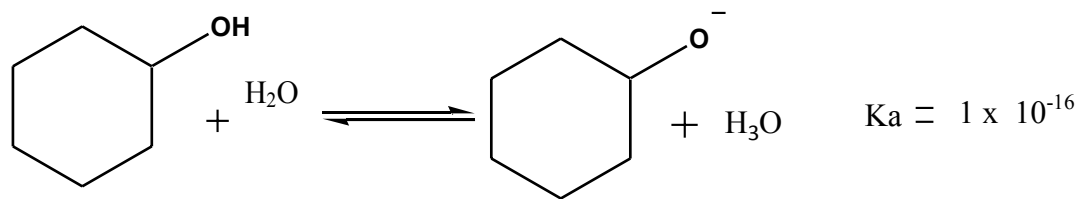
Phenol

2,4,6-Tribromophenol

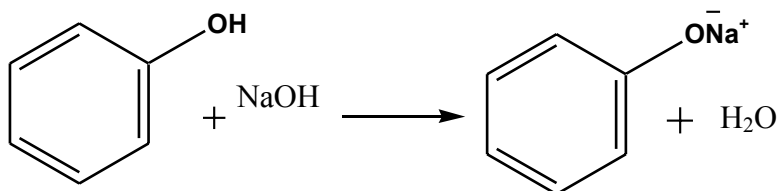
Phenols differ from alcohols in important way: they are much stronger acids than are alcohols:”



Phenol

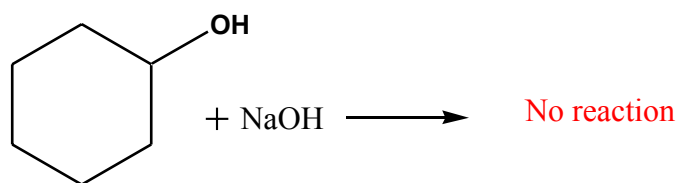


cyclohexanol



phenol

sodium phenoxide

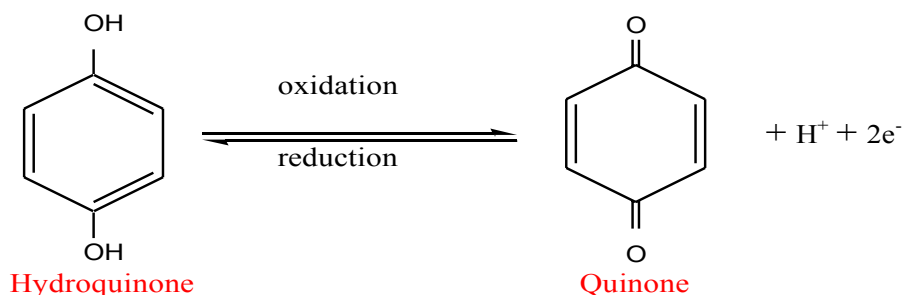


cyclohexanol

Phenol, or carbolic acid as it is sometimes, has antiseptic properties in dilute solution. In fact, all phenolic compounds appear to have germicidal properties. Several commercial germicides contain phenols. Lyso® contains o-phenylphenol, and n-hexylresorcinol is the active ingredient in Screts® lozenges and several mouthwashes

hexachlorophene was used in germicidal soaps, some toothpaste and deodorants until it was discovered to have undesirable side effects.

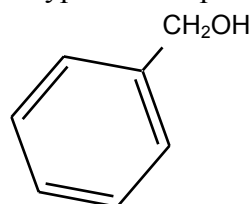
Aromatic 1,2- and 1,4-dihydroxy compounds are phenols that undergo an important oxidation-reduction reaction. For example, hydroquinone is easily oxidized to quinone. This reaction is reversible, because quinone is easily reduced to hydroquinone:



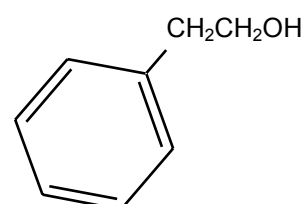
Hydroquinone and quinones are important in the respiratory systems of living systems. When hydroquinone is oxidized, it loses two electrons. In effect it transfers two electrons from itself to another molecule. It is this property that makes hydroquinone are involved in transferring electrons to molecular oxygen in the respiratory system. One such compound is ubiquinone(also known as coenzyme .

### AROMATIC ALCOHOLS

Aromatic compounds, which contain a hydroxy group on a side chain, behave like typical alcohols. Typical examples of these compounds are:



Benzyl alcohol



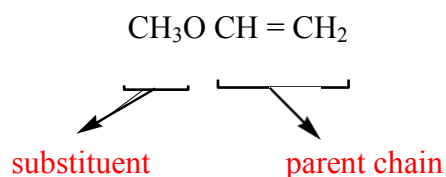
2- phenylethanol

### Ethers

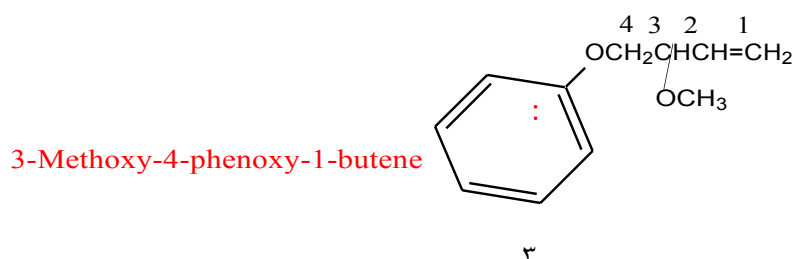
Ethers are compounds that containing oxygen atom bonded to two alkyl groups, two aryl groups or one aryl and one alkyl group. The simpler ethers are usually known by their common names .

$\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$  **diethyl ether**.

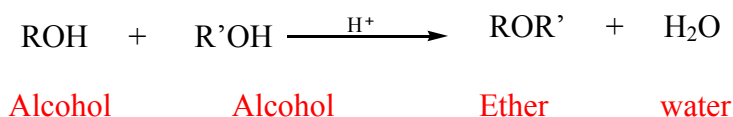
-To name ethers by the IUPAC rules, the more complicated group attached to the oxygen is chosen as the parent. The other group and the oxygen are considered as substituents on this chain for example:



-The Substituent is named as a prefix and its name is constructed by replacing the -yl of the alkyl name of phenyl by -oxy. Example



Chemically ethers are moderately inert. They do not react with reducing agents or bases under normal conditions. However, they are extremely volatile and highly flammable (easily oxidized in air). Ethers may be prepared by the dehydration reaction between two alcohol molecules. The reaction requires heat and acid:



Dithyl ether was the first anesthetic used. It functions as by interfering with the central nervous system. It functions by accumulating lipid material of the nerve cells, thereby interfering with nerve impulse transmission. This results in **analgesia**: a lessened perception of pain.

Epoxides are special kinds of ethers. These compounds are special because they have a three member ring that contains an oxygen atom. They are far more reactive than typical ethers.

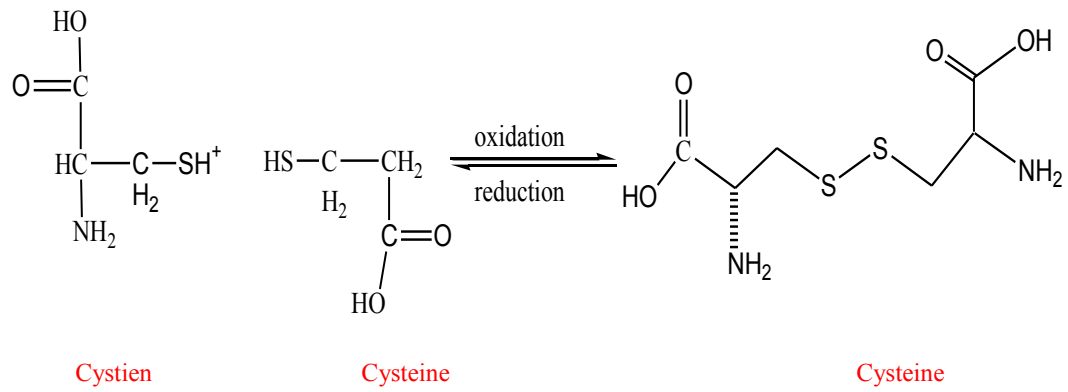
One example of an epoxide in nature is squalene 2,3-epoxide. This compound is formed in a series of reactions that leads to the biosynthesis of cholesterol

## Thiols

Thiols are sulfur analogs of alcohols. The IUPAC names of thiols are formed by adding the suffix- thiol, and so forth to the name of the parent hydrocarbon. Common names are obtained by first naming the alkyl group followed by the word mercaptan

- Thiols are more volatile than are the corresponding alcohols and have a very disagreeable odor. Various thiols are found in nature, e.g. 1-propanethiol is released when an onion is peeled and thiols are responsible for the odor of garlic. Thiols are highly reactive and are present in small quantities in living systems where they play key roles:
- Thiols are involved in protein structure and conformation. It is the ability of two thiol groups to easily undergo oxidation to a disulfide bond (-S-S-) that is responsible for this involvement. Cysteine is an amino acid that contains a sulfhydryl group. Cysteine is found in many proteins and plays an important role in the conformation of the protein by forming disulfide bonds with other cysteine molecules within the protein:

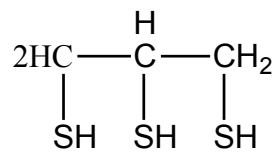
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-



**- Forming Disulfide Bonds**

Many extra cellular proteins contain disulfide cross-links (intracellular proteins almost never do). The cross-links can only be established after the protein has folded up into the correct shape

- **BAL (British Anti-Lewisite)** is used as an antidote for mercury poisoning. The two thiol groups of BAL complex with mercury and remove it from the system before it can do any damage.



BAL



- **Coenzyme A** is a thiol that serves as a carrier of acetyl groups (CH<sub>3</sub>CO-) in biochemical reactions. It plays a central role in metabolism by shuttling acetyl groups from one reaction to another. Coenzyme A is made up of the nucleotide ADP, the vitamin pantothenic acid, and the thiol-containing β mercaptoethyl amine group. When the two-carbon acetate group is attached to the coenzyme A, the product is acetyl coenzyme A (acetyl CoA). The bond between coenzyme A and the acetyl group is a high-energy thioester bond. It can release a great deal of energy when the bond is broken and thus the acetyl group can participate in other biochemical reactions.

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# First -dentistry-SECOND SEMISTE

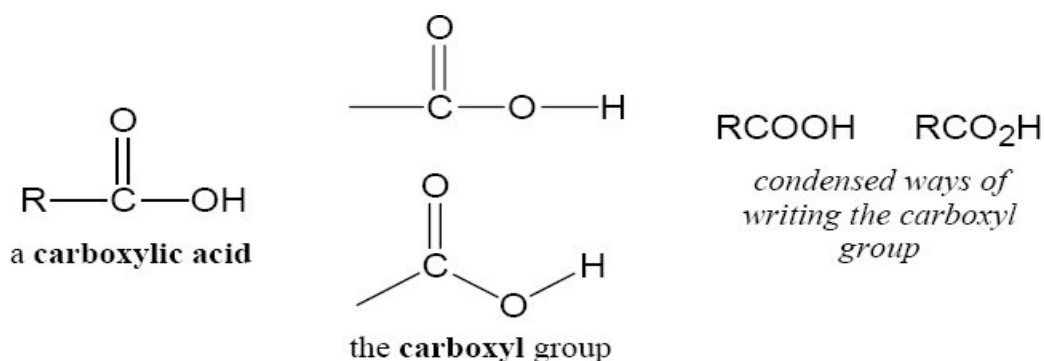
Lecture ( 5 )

2020-2021

Dr. Mahmoud

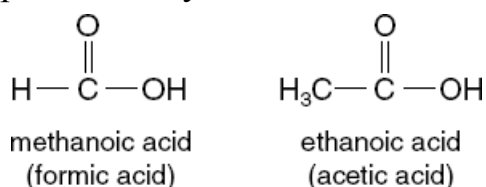
## Carboxylic Acids

**Carboxylic acids** are weak organic acids which contain the **carboxyl group** ( $\text{RCO}_2\text{H}$ ):



The tart flavor of sour-tasting foods is often caused by the presence of carboxylic acids.

Carboxylic acids occur both in nature and in the laboratory. Vinegar, for example, is a dilute solution of acetic acid,  $\text{CH}_3\text{COOH}(\text{aq})$ ; butanoic acid,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}(\text{aq})$ , is responsible for the rancid odor of spoiled butter; and hexanoic acid,  $\text{CH}_3(\text{CH}_2)_4\text{COOH}(\text{aq})$ , is partially responsible for the characteristic odor of goats. In fact, hexanoic acid is often called caproic acid from the Latin name for goat, caper. The two simplest carboxylic acids are:



Methanoic acid and ethanoic acid are generally referred to by their common names, formic acid and acetic acid, respectively.

Acetic acid is a clear, colorless liquid with a pungent odor. Household vinegar is an approximately 5% acetic acid solution. The pure compound is commonly called glacial acetic acid because it freezes at  $18^\circ \text{C}$ .

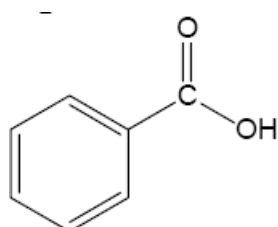




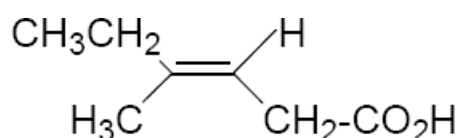
Formic acid is responsible for the irritants in certain plants, such as stinging nettles. Formic acid is a colorless, fuming liquid that is very soluble in water. It is the major irritant in ant bites and was first isolated by the distillation of ants.

## Nomenclature of Carboxylic Acids

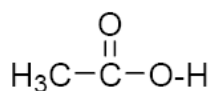
- Select the longest carbon chain containing the carboxyl group. The -e ending of the parent alkane name is replaced by the suffix -oic acid.
- The carboxyl carbon is always numbered "1"
- Name the substituents attached to the chain in the usual way.
- Aromatic carboxylic acids (i.e., with a CO<sub>2</sub>H directly connected to a benzene ring) are named after the parent compound, benzoic acid.



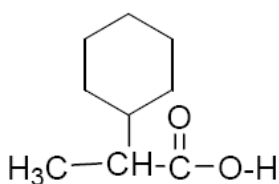
Benzoic acid



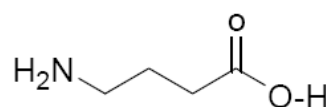
4-methyl-3-hexenoic acid



ethanoic acid



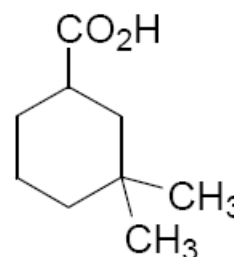
2-cyclohexylpropanoic acid



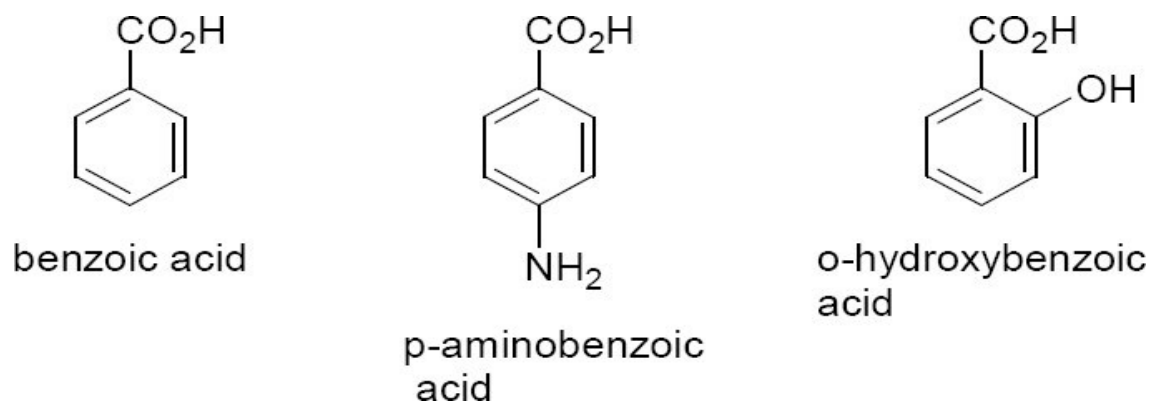
4-aminobutanoic acid

Cycloalkanes with carboxyl substituent are named as cycloalkanecarboxylic acids.

**3,3-dimethylcyclohexanecarboxylic acid**



Aromatic acids of the form Ar-CO<sub>2</sub>H are named as derivatives of benzoic acids, with ortho, meta and para indicating the location relative to the carboxyl group.

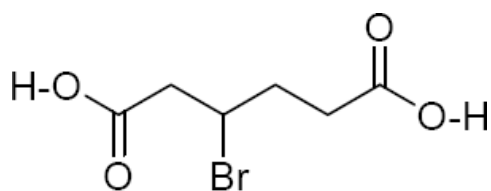


### Dicarboxylic Acids

Aliphatic dicarboxylic acids are named by simply adding the suffix -dioic acid to the root name.

The root name comes from the longest carbon chain containing both carboxyl groups.

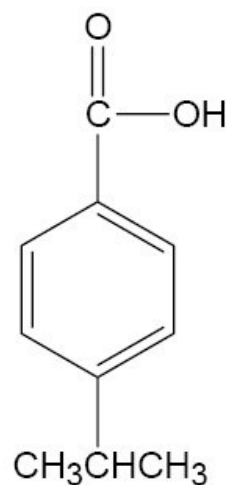
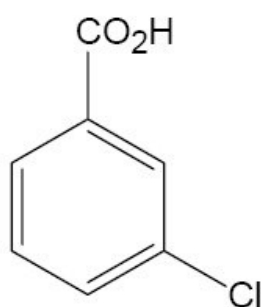
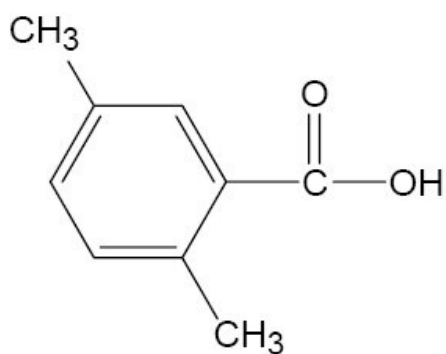
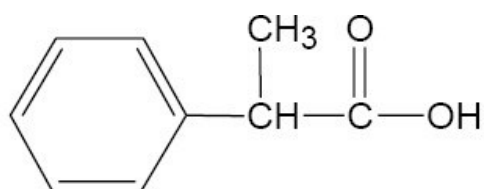
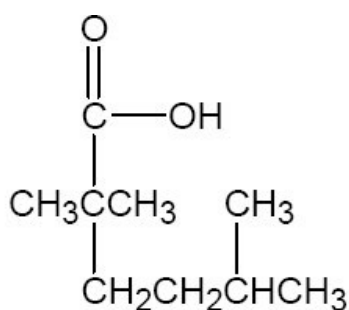
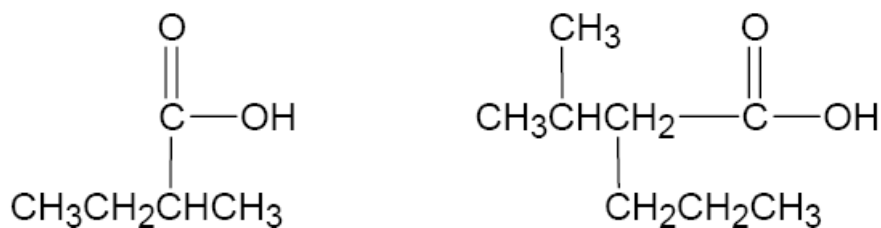
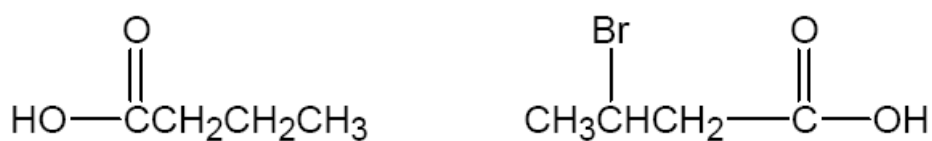
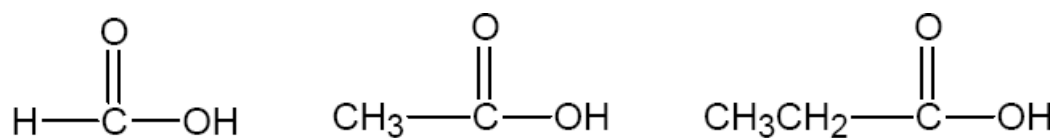
Numbering starts at the end closest to a substituent.



3-bromohexanedioic acid

## Examples: Naming Carboxylic Acids

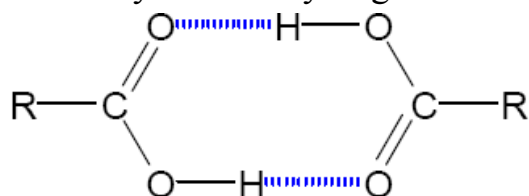
- Name the following compounds:



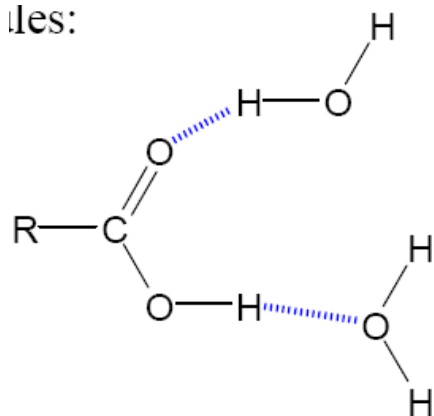
- Draw structural formulas for the following molecules:
  - 2-methylpropanoic acid
  - 2,2,5-trimethylhexanoic acid
  - 4,5-dimethyl-3-nitrooctanoic acid
  - *para*-bromobenzoic acid
  - 2,4,6-trinitrobenzoic acid
  - 4-ethylpentanedioic acid (what's wrong with this name?)

### Physical Properties of Carboxylic Acids

- Carboxylic acids hydrogen bond to themselves to form a **dimer**:



- Carboxylic acids also form hydrogen bonds to water molecules:



- Since carboxylic acids can form more than one set of hydrogen bonds, their boiling points are usually higher than those of other molecules of the same molecular weight (MW).
- Low-MW carboxylic acids are generally liquids at room temp. (often, they are somewhat oily); higher- MW carboxylic acids are generally waxy solids.
- Short-chain carboxylic acids are also generally more soluble in water than compounds of similar MW, since they can hydrogen bond to more than one water molecule.
- As the number of carbons in a carboxylic acid series becomes greater, the boiling point increases and the solubility in water decreases.
- Many carboxylic acids that are liquids at room temperature have characteristically sharp or unpleasant odors.
- Like most acids, carboxylic acids tend to have a sour taste (e.g., vinegar, citric acid, etc.).

### Boiling Point:

↑ Carboxylic acid  
Alcohols  
Aldehydes/Ketones  
Ethers  
Alkanes

### Water Solubility:

↑ Carboxylic acid  
Alcohols  
Aldehydes/Ketones  
Ethers  
Alkanes

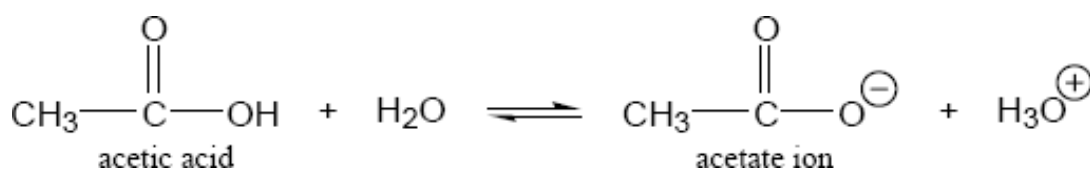
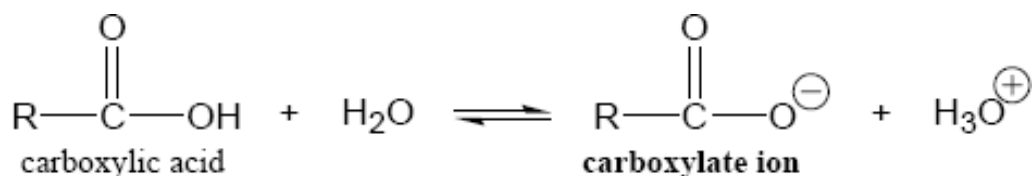
Name	Molecular weight	Boiling point	Solubility in water
Pentane	72 g/mol	35°C	Insoluble
Diethyl ether	74 g/mol	35°C	Insoluble
Butanal	72 g/mol	76°C	7.1 g / 100 mL H <sub>2</sub> O
1-Butanol	74 g/mol	118°C	9.1 g / 100 mL H <sub>2</sub> O
Propanoic acid	74 g/mol	141°C	Infinite

## Examples: Predicting Physical Properties

- Arrange the following compounds in order of increasing boiling point. (All of the compounds have about the same molecular weight.)
  - 1-pentanol
  - hexane
  - butanoic acid
  - pentanal
- Which member of each of the following pairs of compounds would you expect to have a higher solubility in water?
  - 2-butanone *or* propanoic acid
  - hexanoic acid *or* ethanoic acid

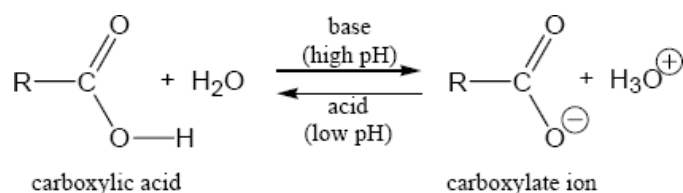
## The Acidity of Carboxylic Acids

- Carboxylic acids are weak acids; in water, they dissociate to produce hydronium ions and **carboxylate ions**:





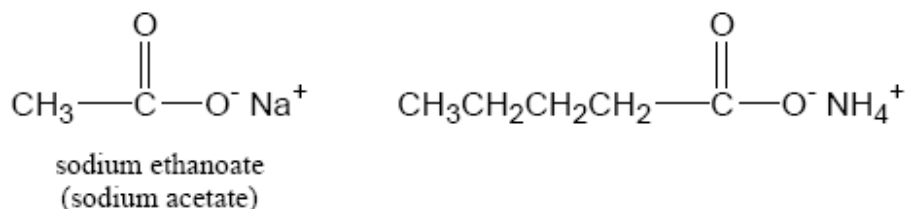
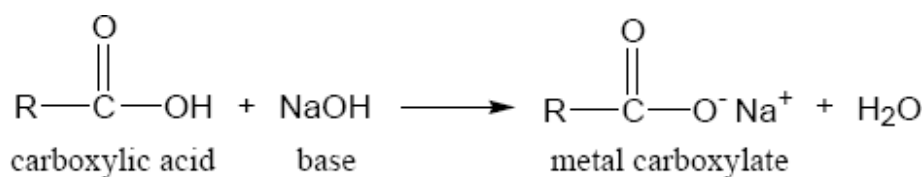
- The dissociation of a carboxylic acid is a reversible reaction, and the position of the equilibrium can be affected by the addition of acid (low pH) or by adding base (high pH):



- At the *physiological pH* of 7.4 (the pH of most body fluids) the carboxylate form of most carboxylic acids is the predominate form.

### Carboxylate Salts

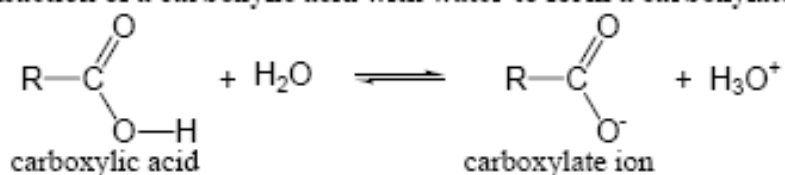
- Carboxylic acids react with strong bases such as sodium hydroxide (NaOH) and potassium hydroxide (KOH) to produce carboxylate salts.
- Carboxylate salts are named by naming the metal first and changing the **-ic acid** ending of the carboxylic acid name to **-ate**.



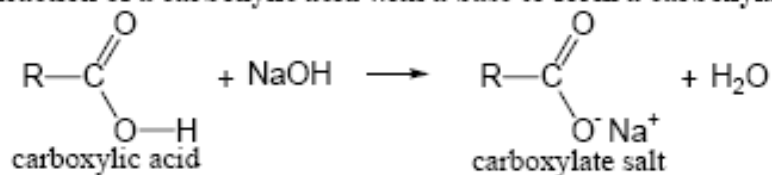
- Carboxylate salts are ionic compounds, and are typically solids at room temperature.
- Because they contain charges, carboxylate salts are typically much more soluble in water than the carboxylic acids from which they are derived.

## Reactions of Carboxylic Acids

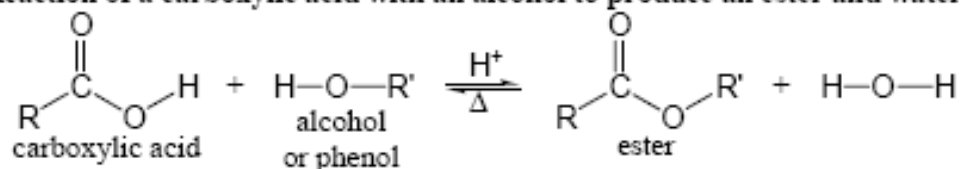
1. Reaction of a carboxylic acid with water to form a carboxylate ion.



2. Reaction of a carboxylic acid with a base to form a carboxylate salt and water.



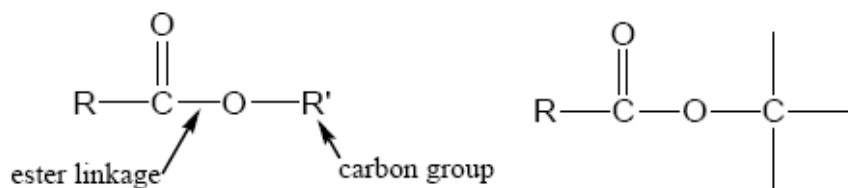
3. Reaction of a carboxylic acid with an alcohol to produce an ester and water.



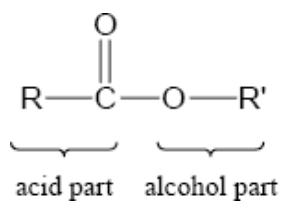
## Carboxylic acids derivatives

### Esters

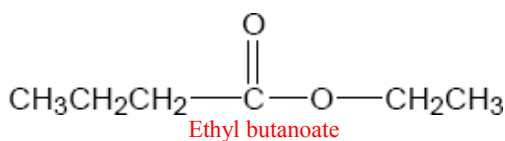
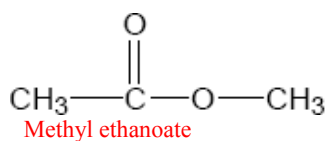
• An **ester** is a derivative of a carboxylic acid in which there is a carbon group connected to the single-bonded oxygen:



## Nomenclature of Esters

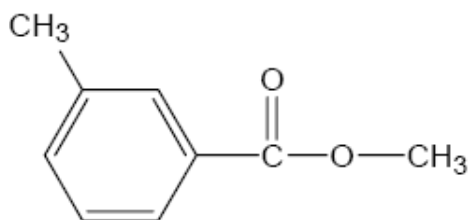
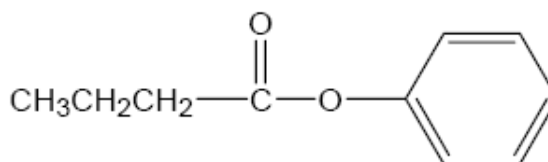
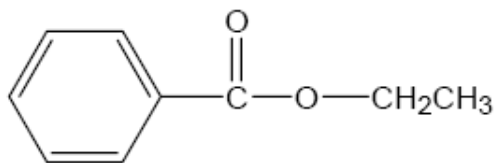


- Name the alkyl or aromatic portion contributed by the “alcohol part” first.
- The “acid part” is named as a carboxylic acid, with the **-ic acid** suffix changed to **-ate**.



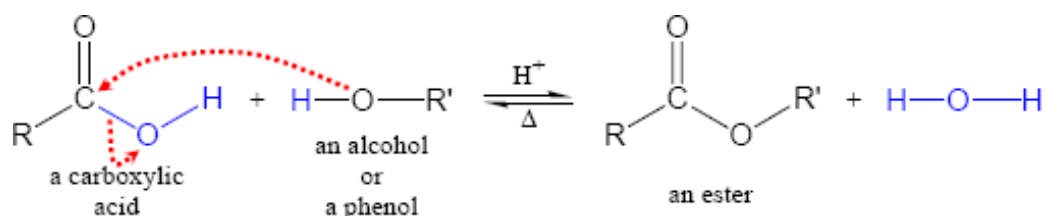
### Examples: Ester Nomenclature

- Name the following compounds:



## Synthesis of Esters:

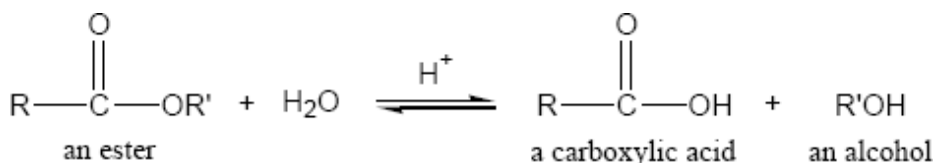
- The simplest way to synthesize an ester is to heat a carboxylic acid with an alcohol or phenol (plus an acid catalyst); the oxygen of the alcohol adds to the carboxyl group, splitting out a molecule of water in the process (an *esterification reaction*).



## Reactions of Esters:

### -Ester Hydrolysis

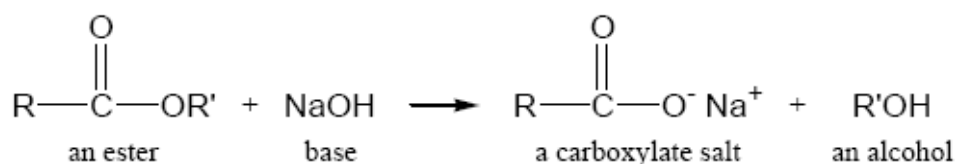
- Esters may be broken apart under *acidic conditions* by water (a **hydrolysis** reaction) to form a carboxylic acid and an alcohol.



- This is essentially the reverse reaction of the synthesis of esters from carboxylic acids and alcohols.

### Saponification

- Esters may be broken apart under *basic conditions* by sodium hydroxide or potassium hydroxide to form carboxylate salts and alcohols.



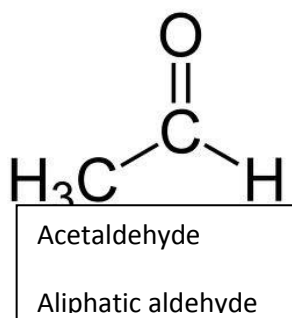
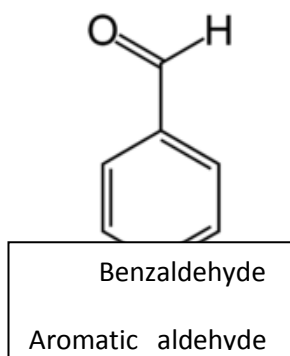
- This reaction is important in the production of **soaps**

***Dr. Mahmoud S.***

**Muter**

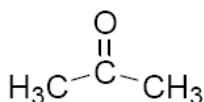
# Aldehydes and Ketones

Aldehydes and ketones are two more classes of compounds that contain the carbonyl group. An aldehyde contains a carbonyl group whose carbon is bonded to one hydrogen and either an alkyl or an aryl group. For example:

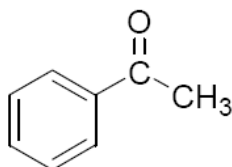


The aldehyde is often written RCHO.

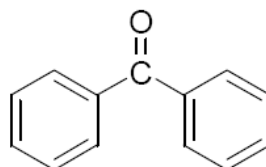
Ketones contain a carbonyl group whose carbon is bonded to two alkyl groups, two aryl groups, or one alkyl and one aryl group. For example:



acetone



acetophenone



benzophenone

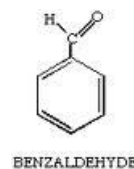
## Naming aldehydes and ketones

### Common names

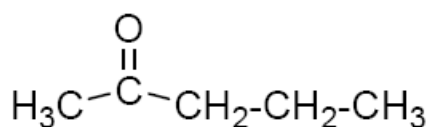
Common names are always used for aldehydes of five carbons or less. They are obtained from the name of carboxylic acid formed by oxidation of the aldehyde. The -oic acid ending of the name of carboxylic acid is replaced by -aldehyde. Thus, the aldehyde that yields formic acid when oxidized is called formaldehyde, the aldehyde that yields acetic acid when oxidized is called acetaldehyde, etc. examples:

$\text{CH}_3\text{CH}_2\text{CHO}$  propionaldehyde

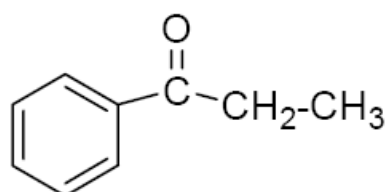
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$  butylaldehyde



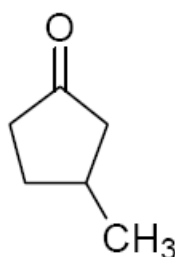
IUPAC nomenclature requires ketones to be named by replacing the -e ending of the alkyl name with -one. Alkane  $\rightarrow$  alkanone



2-pentanone

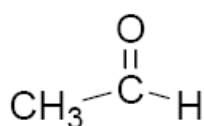


1-phenyl-1-propanone

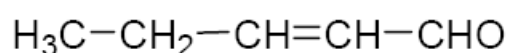


3-methylcyclopentanone

Systematic names (IUPAC) for aldehydes are obtained by replacing -e with -al.



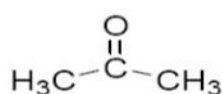
ethanal



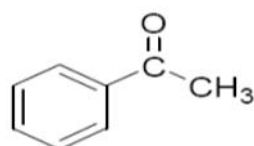
pent-2-enal

### Common Names of ketones

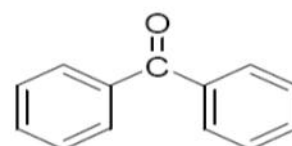
The wide spread use of carbonyl compounds means many common names are entrenched in their everyday use.



acetone



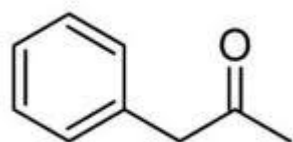
acetophenone



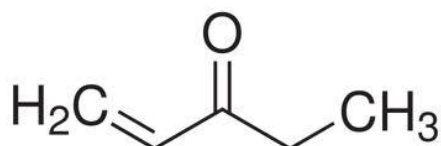
benzophenone

Also the common names of ketones are formed by placing the names of groups attached to the carbonyl group as a prefixes to the word ketone.

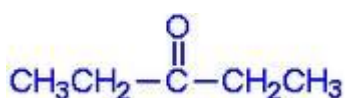
The names are written as separate words. For example:



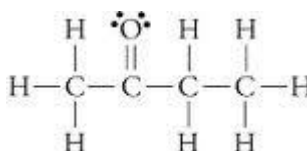
Benzyl methyl keton



Ethyl vinyl ketone



Di ethyl ketone

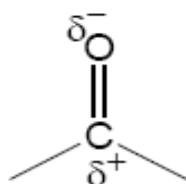


Ethyl methyl ketone

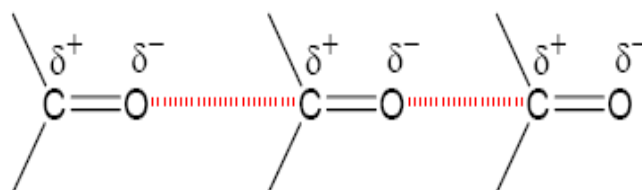
## Physical Properties of Aldehydes and Ketones

### The Polarity of the Carbonyl Group

- Carbonyl compounds are polar, containing a dipole along the carbon-oxygen double bond.

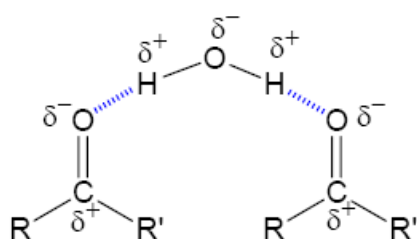


- This creates weak attractive forces between carbonyl compounds, but these attractions are not as strong as those that result from hydrogen-bonding.





- Since there is no hydrogen on the carbonyl oxygen, aldehydes and ketones *do not form hydrogen bonds with themselves*.
- Aldehydes and ketones therefore have boiling points that are in between those of alcohols and hydrocarbons of the same molecular weight:
  - Alcohols form hydrogen bonds, and have high boiling points.
  - Hydrocarbons are nonpolar, and have low boiling points.
  - Aldehydes and ketones are polar, so they have higher boiling points than hydrocarbons, but they are not as polar as molecules which can hydrogen bond.
- Carbonyl compounds cannot hydrogen-bond to each other, but they can hydrogen-bond to water through the carbonyl oxygen.
- Low-molecular weight aldehydes and ketones are water-soluble; water solubility decreases as the size of the molecule increases.



### Boiling Points:

↑ Alcohols  
Aldehydes/Ketones  
Ethers  
Alkanes

### Water Solubility:

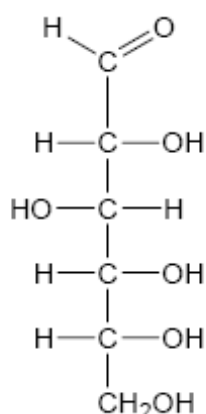
↑ Alcohols  
Aldehydes/Ketones  
Ethers  
Alkanes

Name	Molecular weight	Boiling point	Solubility in water
butane	58 g/mol	0°C	Insoluble
propanal	58 g/mol	49°C	Soluble
acetone	58 g/mol	56°C	Soluble
1-propanol	60 g/mol	97°C	Soluble

### Examples: Predicting Boiling Points

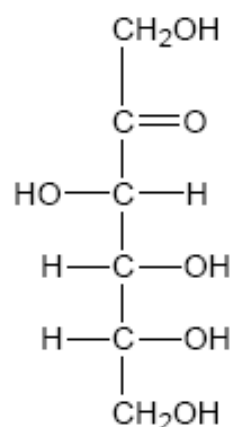
- Arrange the following compounds in order of increasing boiling point:
  - 2-pentanone
  - 2-methylpentane
  - 2-pentanol

## Important Aldehydes and Ketones



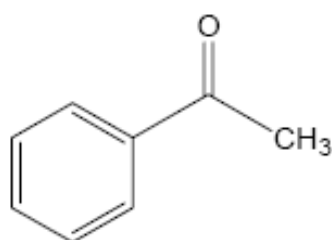
**Glucose**

One of the most important of the carbohydrates, which are *polyhydroxy aldehydes and ketones*; the metabolism of glucose is a major source of energy for living organisms



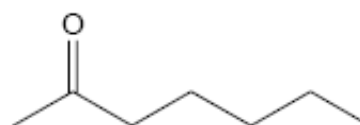
**Fructose**

Another important carbohydrate; a major component of corn syrup; found in honey, syrups, and preserves; in combination with glucose it forms the disaccharide sucrose.



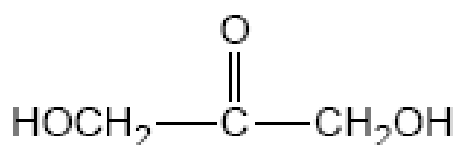
**Acetophenone**

Used in perfumery, and as an organic solvent; also used in the synthesis of some pharmaceuticals



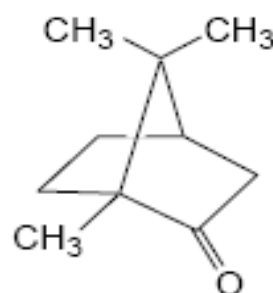
**2-Heptanone**

Found in oil of clove; also present in the odor of many fruits and dairy products, and is also responsible for the odor of blue cheese.



**Dihydroxyacetone**

Active ingredient in "bronzers" that provide fake suntan coloration; reacts with dead, outer skin cells to produce a darker color; fades as the dead skin cells slough off.

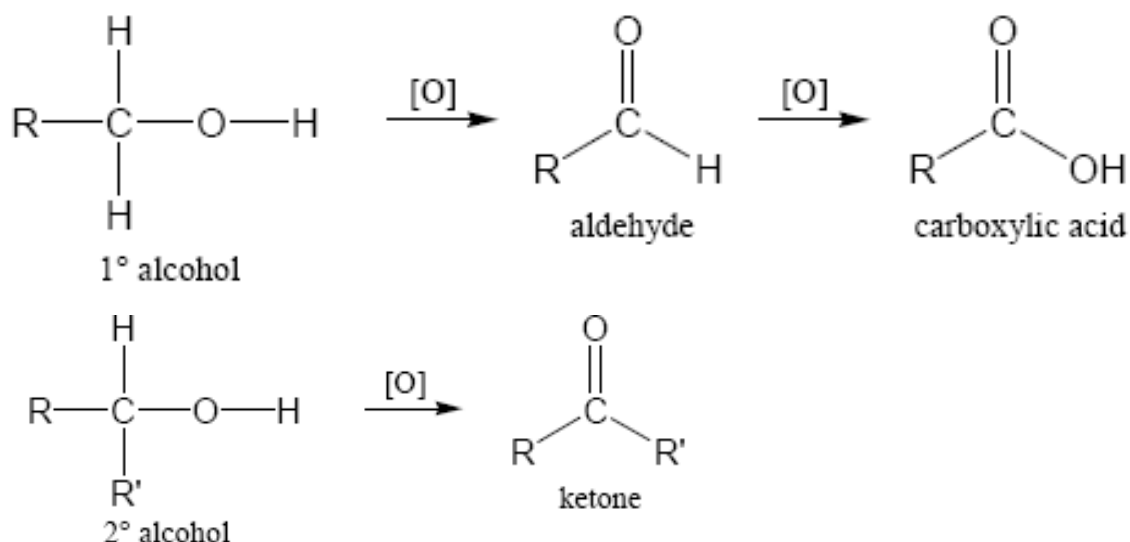


**Camphor**

Isolated by steam distillation from the camphor tree of China and Japan. Camphor is a counter-irritant (produces a superficial inflammation to reduce deeper inflammation) and antipruritic (anti-itching) medication; it appears to selectively stimulate cold sensors. It also stimulates the respiratory systems and inspires deep breathing, but can cause convulsions and respiratory collapse in larger doses.

## Preparing aldehydes and ketones

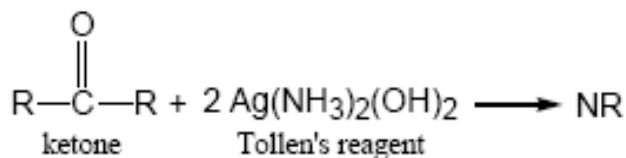
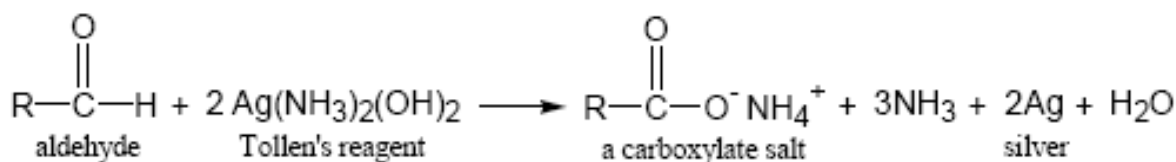
Alcohol can be oxidized as we learned. Primary alcohols are oxidized first to aldehyde, which are then further oxidized to carboxylic acid. Secondary alcohols are oxidized to ketones.



To use the oxidation of primary alcohol as a method of preparing aldehydes, it is necessary to stop the reaction at the intermediate aldehyde stage. This can be done by removing the aldehyde from the reaction mixture as soon as it formed. This can be done quite easily by distillation, because aldehydes have lower boiling points than that of alcohols. By carrying out the oxidation at a temperature slightly above the boiling point of the aldehyde.

### Tests for aldehydes:

- **Tollens' reagent** is a mild oxidizing agent composed of silver ions in an aqueous basic solution of ammonia.
- Aldehydes are oxidized to carboxylate salts (since the solution is basic), and the silver ions are reduced to solid silver, which coats the bottom of the test tube with a "silver mirror."
- Ketones are not oxidized, so no silver mirror forms.

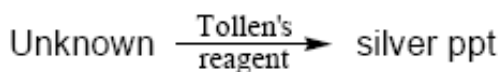
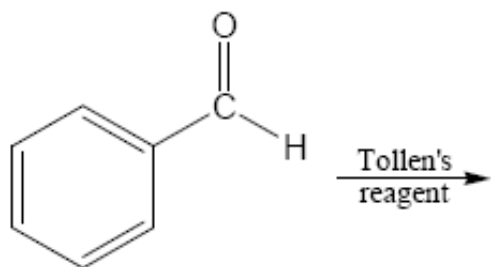
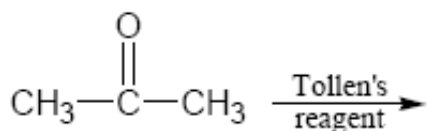
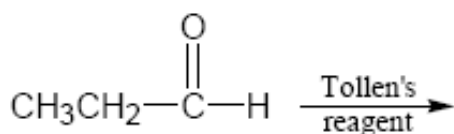


31

Another reagent often used to test for aldehydes is the Fehling's solution. The aldehyde is oxidized to the carboxylate ion and the cupric ion is reduced to cupric oxide, which precipitate as a red solid.

### Examples: The Tollens' Test

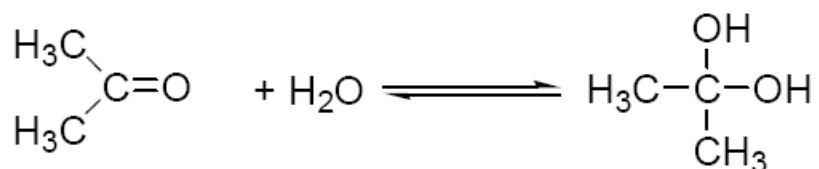
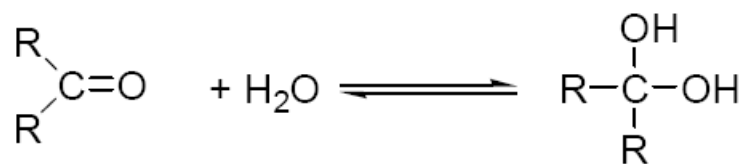
- What observations would be made in the following reactions?



### Reactions of Aldehydes and Ketones:

Addition reactions of aldehydes and ketones

- 1- **Addition of water ( hydration )**: In aqueous solution, ketones and aldehydes are in equilibrium with their hydrates.

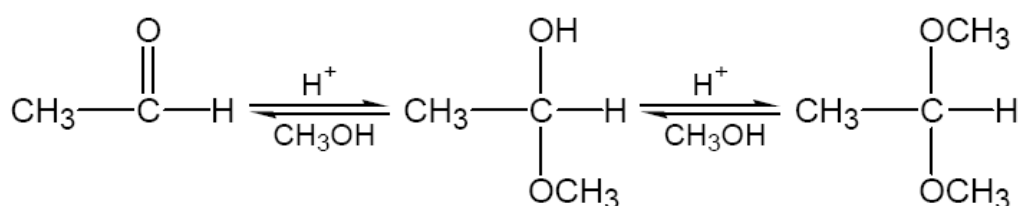
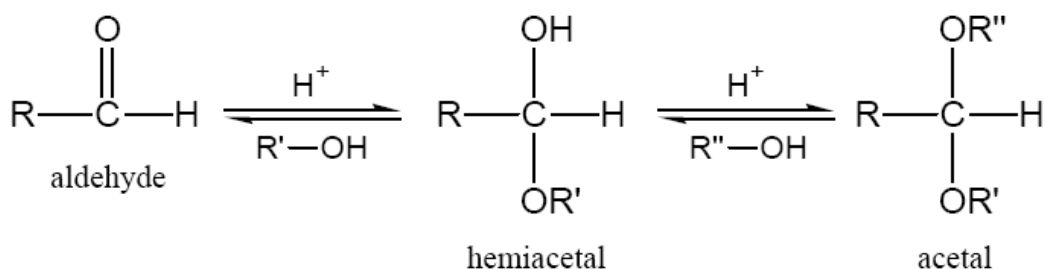


Aldehydes are more likely to form hydrates since they have the larger partial positive charge on the carbonyl carbon (larger charge = less stable = more reactive).

## 2- Addition of alcohols:

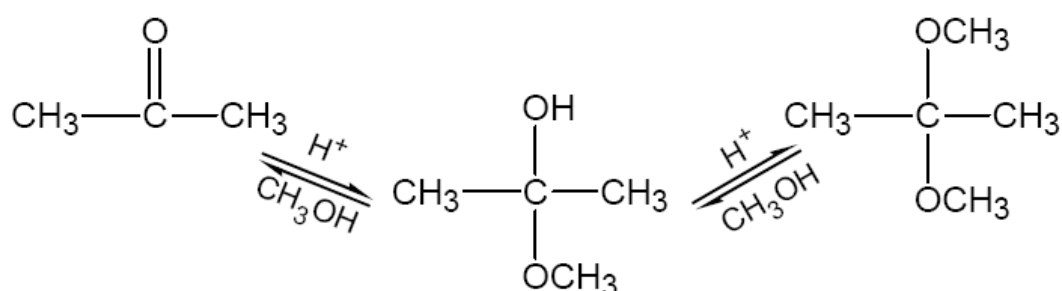
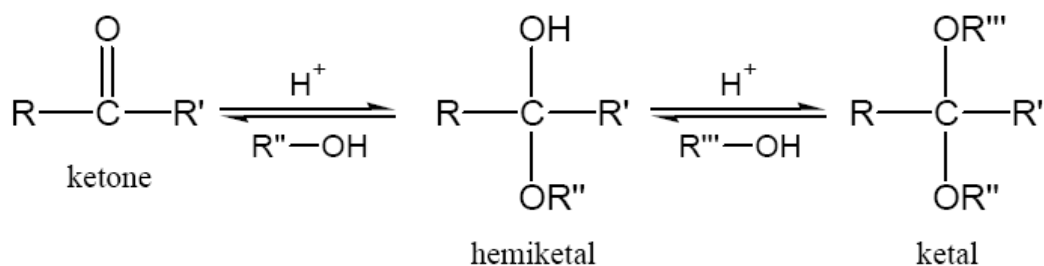
### - Addition of Alcohols to Aldehydes

- Aldehydes react with alcohols first to form **hemiacetals**, which then react with excess alcohol to produce **acetals**.

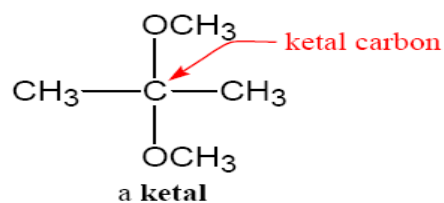
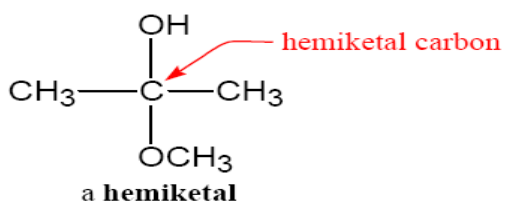
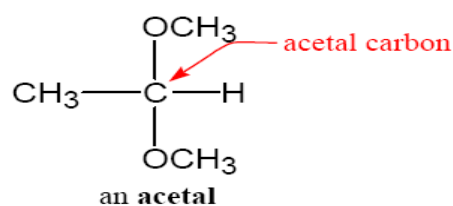
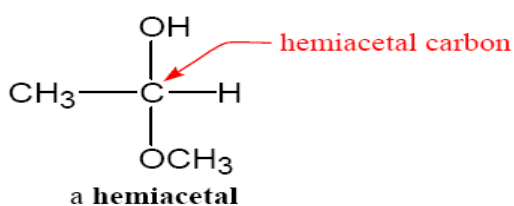


### - Addition of Alcohols to Ketones

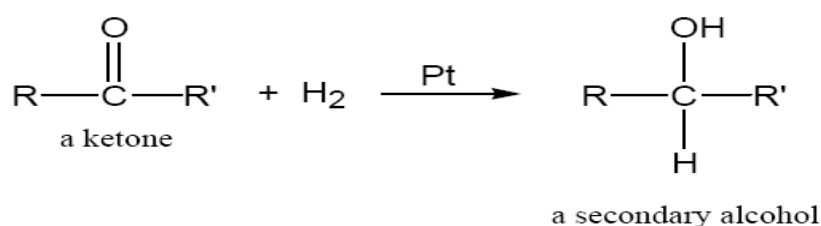
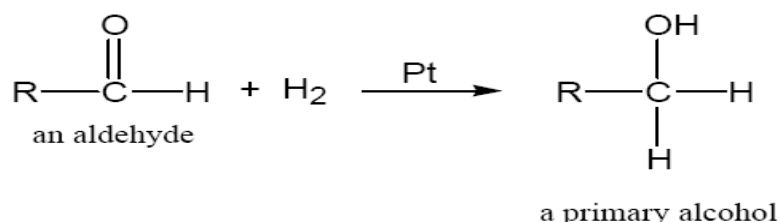
- Ketones react with alcohols first to form **hemiketals**, which then react with excess alcohol to produce **ketals**.



### Hemiacetals, Acetals, Hemiketals, and Ketals

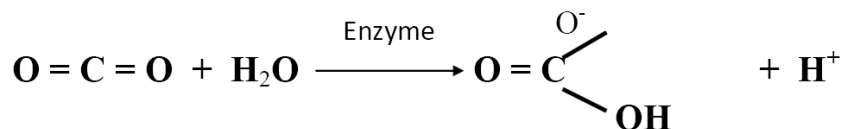


**3- Hydrogenation ( reduction ) of aldehydes and ketones:** Hydrogenation of aldehydes and ketones with hydrogen gas and a platinum catalyst produces alcohols.



#### 4- Addition reactions of aldehydes and ketones in living system:

One of the simplest addition reactions of a carbonyl group in living systems is the enzyme catalyzed reaction of carbon dioxide to bicarbonate ion according to the following equation:

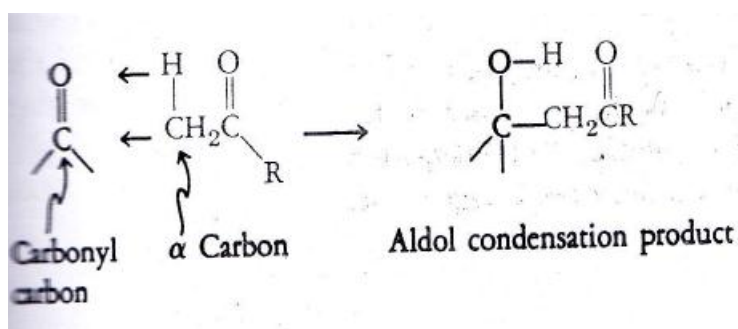


The enzyme that catalyzes this reaction is widely distributed in mammals. It is especially active in tissues that are involved in respiration, such as blood cells.

**5- Condensation reactions:** In condensation reactions, two compounds are joined together (or condensed) to form a large compound:

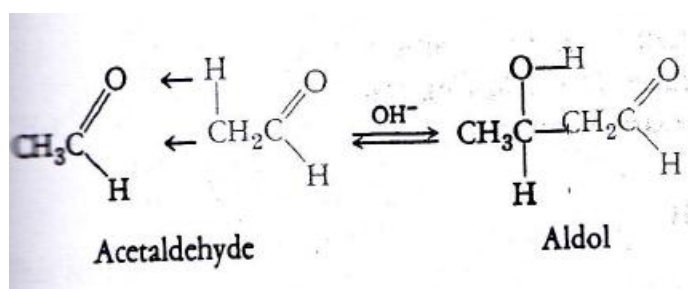
• **Aldol condensation:** this is a reaction in which the carbonyl carbon of one molecule forms a bond with the  $\alpha$ -carbon of another carbonyl containing molecule.

For example:



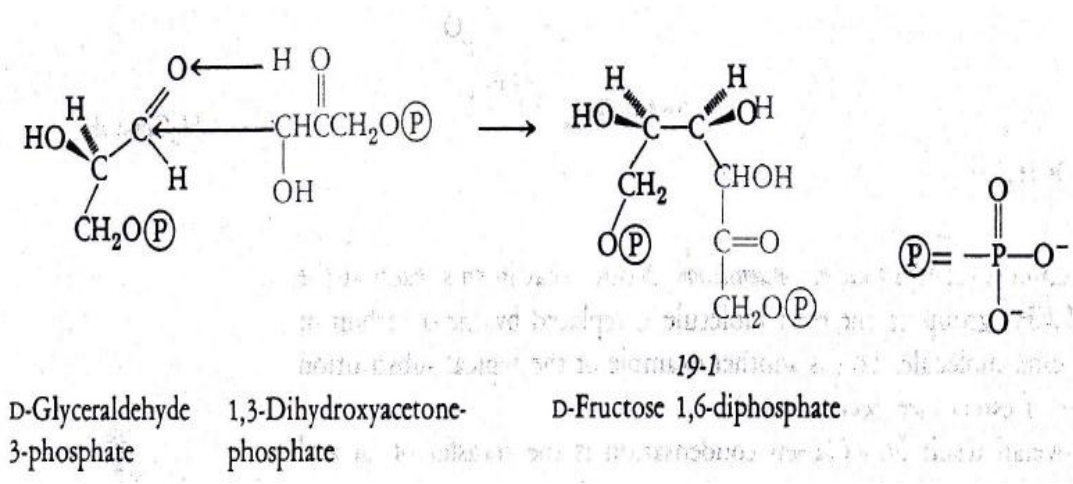
The name of aldol is derived from the structure of the product, which is both aldehyde and alcohol. Notice that this reaction is reversible. The reverse reaction is called a retro-aldol condensation.

The aldol condensation is an equilibrium. The equilibrium constant for formation of products is favorable for most Aldehydes. However, for ketones, the reaction is much less favorable.



**\* Condensation reactions In living system**

carbohydrates are prepared in the living systems by an enzyme-catalyzed aldol condensation:





# **First -dentistry-SECOND SEMISTE**

Lecture ( 7 )

2020-2021

Dr. Mahmoud

## **Carbohydrate**

Carbohydrate are the most abundant organic molecules in nature. They have a wide range of functions. Including providing a significant fraction of the energy in the diet of most organisms. The empiric formula for many carbohydrates is  $(CH_2O)_n$ , hence the name ("hydrate of carbon"). Carbohydrates are distributed in plants and animals, in plants glucose is synthesized from  $CO_2$  and  $H_2O$  by photosynthesis, and stored as starch or converted to the cellulose of the plant framework.

Animals can synthesize some  $CH_2O$  from fat and proteins but the bulk of animals  $CH_2O$  is derived from plants.

**Biochemical importance:** Glucose is the most important  $CH_2O$ :

1. Glucose is a major fuel of the tissues of mammals.
2. Converted to other  $CH_2O$  having highly specific functions, such as glycogen for storage and ribose and deoxy ribose in nucleic acids.
3. The most dietary  $CH_2O$  is glucose which is absorbed in to the blood stream and converted in the liver.
4. Serving as cell membrane components that mediate some forms of intercellular communication.
5. formation of exoskeleton of many insects.
6. Disease associated with carbohydrate metabolism include diabetes. Mellitus, galactosemia, glycogen storage diseases and lactose intolerance.

## Classification and structure of CH<sub>2</sub>O

1. **Monosaccharides:** simple sugars can be classified according to the number of carbon atoms they contain, in contrast may be classified in two type according to oxidized function group, are called aldoses and ketoses:

<u>N. of C atoms</u>	<u>Generic name</u>	<u>Example</u>
3	Trioses	Glyceraldehyde
4	Tetroses	Erythrose
5	Pentoses	Ribose
6	Hexose	Glucose
7	Heptoses	Sedoheptulose
9	Nonoses	Neuraminic acid

2. **Disaccharides:** Product from condensation two monosaccharide units. ex:

-maltose = Glucose + Glucose.

-sucrose = Glucose + Fructose.

-Lactose = Glucose + Galactose.

3. **Oligosaccharides:** Product from condensation of two to ten monosaccharide units. ex:

-Maltotriose = three  $\alpha$ -glucose residues.

4. **Polysaccharides:** Product from condensation more than ten molecules of monosaccharide. Ex:

-Starch : linear Polysaccharides

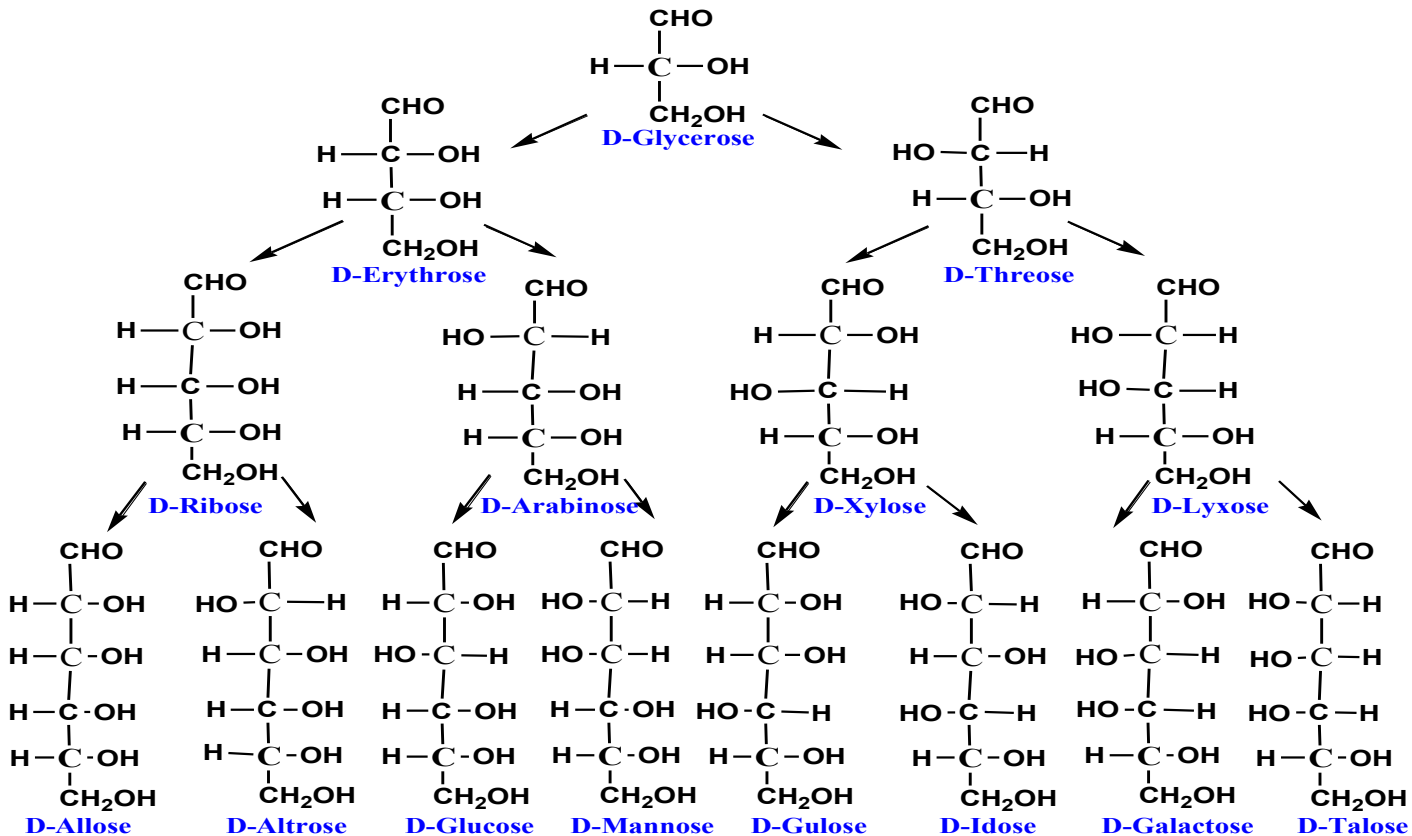
-Dextrin: branched Polysaccharides.

**Isomers and epimers:** compounds that have the same chemical formula but have different structures are called isomers, ex: fructose, glucose, mannose and galactose are all isomers of each other, having the same chemical formula (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>).

If two monosaccharides differ in configuration around only one specific carbon atom (exception of the carbonyl carbon), they are

defined as epimers of each other. (of course they are also isomers).

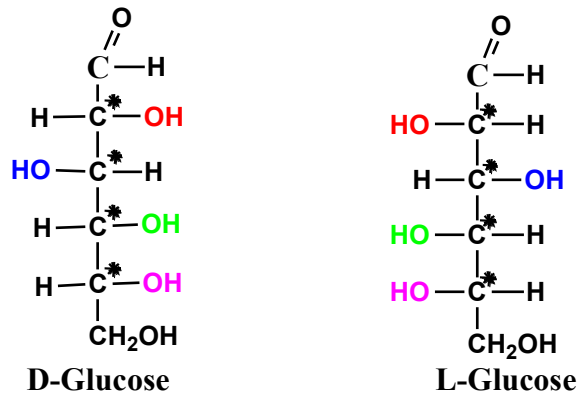
Ex: glucose and galactose are C-4 epimers –their structures differ only in the position of the -OH group at carbon 4.



### Stereochemistry of monosaccharides:

Presence of asymmetrical carbon atoms (carbon atoms attached to 4 different atoms or groups), also called kiral center. The orientation of the H and OH groups around the carbon atom adjacent to the terminal primary alcohol carbon (ex: carbon no.5 in glucose), determines whether the sugar belongs to the **D** (Dextrorotary, rotate the light plane to the right) or **L** (levorotary, rotate the light plane to the left), this called **optical activity**. The number of possible isomers of a compounds depends on the number of asymmetric carbon atoms (n) equal  $2^n$  (2=D and L).

Ex: glucose with 4 As carbon atoms, therefore has 16 isomers. Most of the monosaccharides occurring in mammals are of the D configuration and enzyme responsible for their metabolism are a specific for this configuration.



### Structure of D-Glucose:

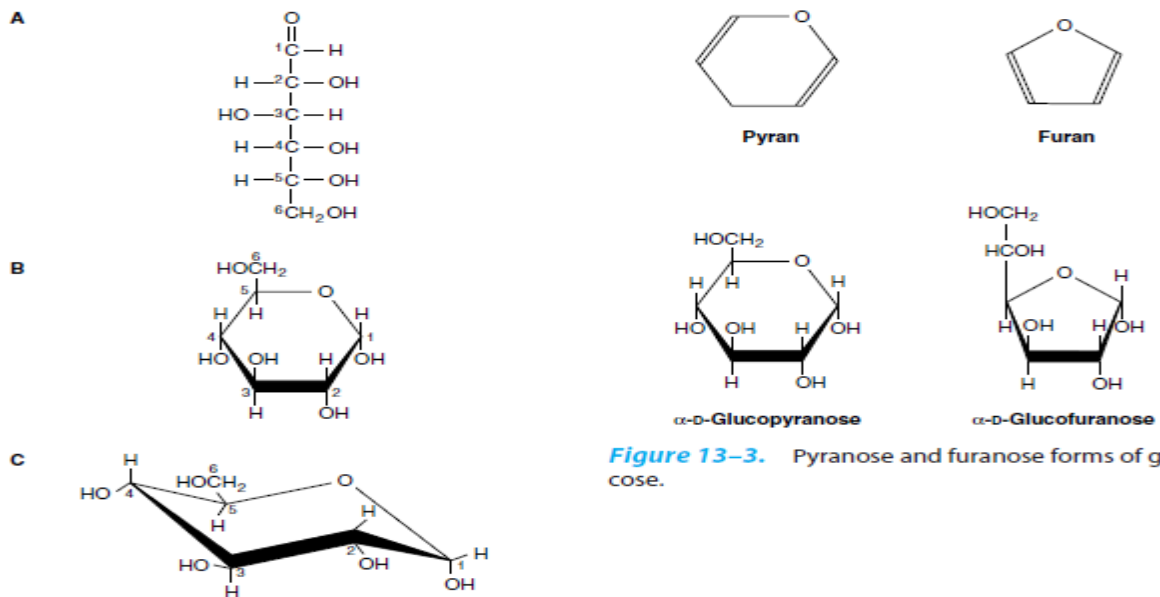


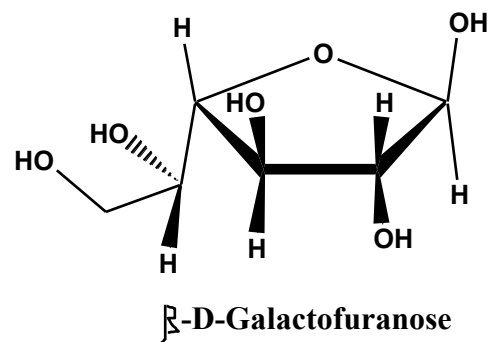
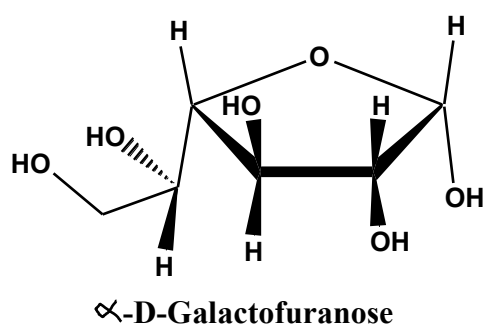
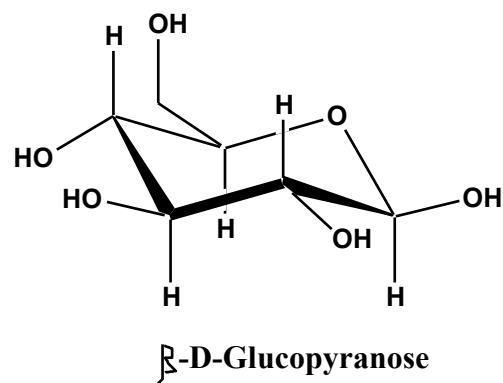
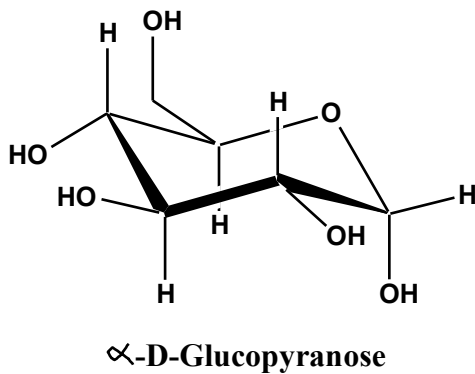
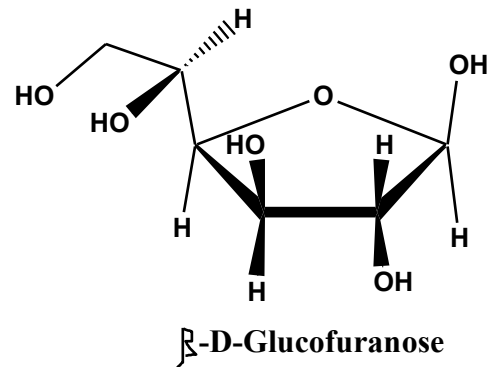
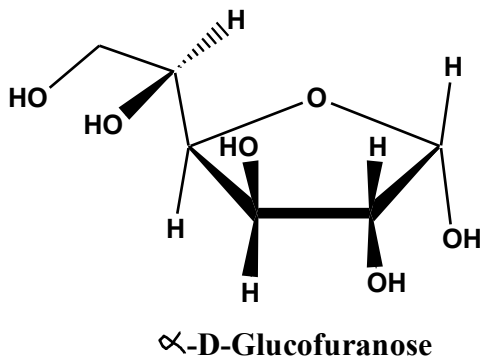
Figure 13-3. Pyranose and furanose forms of glucose.

Figure 13-1. D-Glucose. A: straight chain form. B:  $\alpha$ -D-glucose; Haworth projection. C:  $\alpha$ -D-glucose; chair form.

**Anomeric carbon:** Formation of a ring results in the creation of an anomeric carbon at carbon 1 of an aldose or at carbon 2 of a ketose. These structures are designated the  $\alpha$  or  $\beta$  configurations of the sugar, for example:  $\alpha$ -D-glucose and  $\beta$ -D-glucose. These two sugars are both glucose, but they are **anomers** of each other.

Enzymes are able to distinguish between these two structures and use one or the other preferentially.

Ex: glycogen is synthesized from  $\alpha$ -D-glucopyranose, while cellulose is synthesized from  $\beta$ -D-glucopyranose. The cyclic  $\alpha$  and  $\beta$  anomers of a sugar in solution are in equilibrium with each other, and may be spontaneously interconverted, this called **mutarotation**.

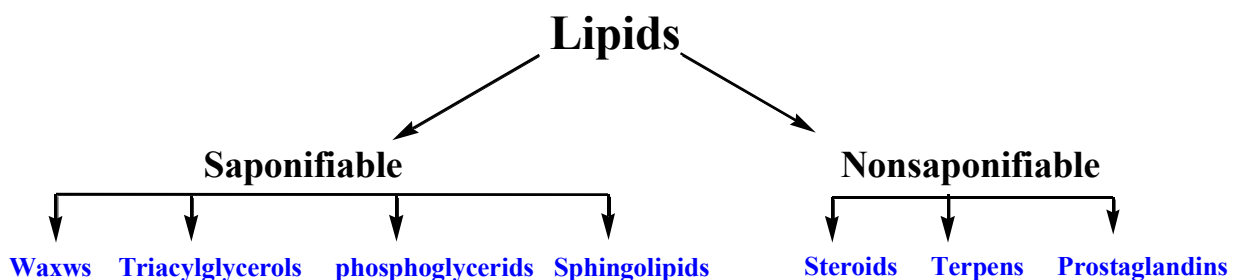


# Lipids

Class of compounds of living systems, that contain one or more carboxylic groups (COOH). Lipids are classified according to their solubility. Lipids are readily in non polar organic solvents and soluble in organic solvent such as diethyl ether, chloroform, or benzene but are insoluble in water, because the water is polar. when animal or plant material is crushed and mixed with these solvents, the compounds that dissolve are classified as lipids. This is one difference between lipids and the other two major classes of compounds of living systems, carbohydrates and proteins, which are insoluble in organic solvents because of their highly polar structure. Fats, vegetable oils, and waxes are examples of lipids that are familiar to everyone.

- The important function of lipids in living systems:
  1. Main energy reserve for living systems
  2. Form part of cell membranes
  3. Regulate the activities of cells and tissues

**Saponification:** one way for classified of lipid is according to whether or not they undergo saponification. Lipids that undergo alkaline hydrolysis are called **saponifiable lipids**. Lipids that do not undergo such a reaction are called **nonsaponifiable lipids**.

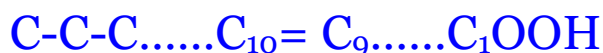


**Fatty acids:** Fatty acids are named for the fact that they are the major component of fats. They are carboxylic acids in which a long straight hydrocarbon chain is attached to the carboxyl group.

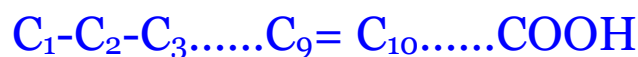
Fatty acids differ in chain length and in the number and positions of double bonds in the hydrocarbon chain. The hydrocarbon chain of fatty acid that contain one or more double bonds are called *unsaturated fatty acids*, while those don't contain double bonds are called *saturated fatty acids*. Only traces of free fatty acids are found in the cells.

**Naming of fatty acids:** we have two ways to indicate the double bond:

- (1) by using  $\Delta^9$  this indicate the double bond between C no. 9 and C no. 10 starting from carboxylic end:



- (2) by using  $W^9$  this mean the double bond between C no. 9 and C no. 10 starting from another end:



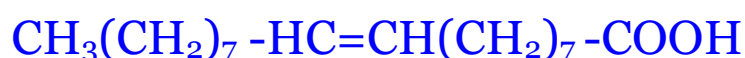
- (3) by x:y:z numbers where:

x= no of carbons atoms

y= no. of double bonds

z= no. carbon atom that contain double bonds

Example: Oleic acid (one C=C) **18:1:9** or  $\Delta^9$ **18:1** or **w<sup>9</sup>18:1**



The mammals can not synthesis fatty acid that cantain more than a double bond. Because the mammals don't have a enzymes to

synthesis this F.A this F.A called essential F.A like (linoleic, linolenic acid ).

$\text{CH}_3-(\text{CH}_2)_4-\text{HC}=\text{CH}-\text{CH}_2-\text{HC}=\text{CH}(\text{CH}_2)_7-\text{COOH}$   
 Linoleic acid : (18: 2,  $\Delta^{9,12}$ ) and may be cis or trans.

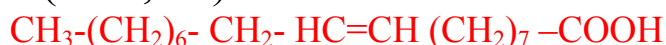
## Some important structure of fatty acids

1. **linolenic acid** (18:3,  $\Delta^{9,12,15}$ )



IUPAC Name: cis,cis,cis-9,12-Octadecatrienoic acid

2. **Oleic acid** (18:1,  $\Delta^9$ )



IUPAC Name: cis-9,12-Octadecenoic acid

3. **palmitic acid**  $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$  **Hexadecanoic acid**

4. **palmitoleic acid** (16:1,  $\Delta^9$ )



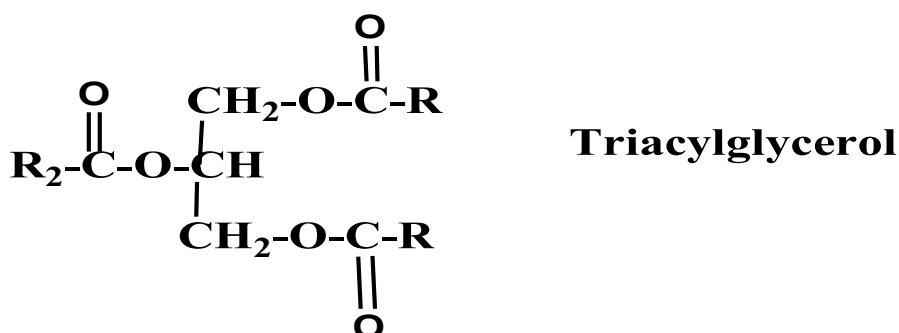
IUPAC Name: cis-9,12-Hexadecenoic acid

5. **Lauric acid**  $\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$  **Dodecanoic acid**

-Fats are solid in room temperature due to their contain of saturated f.a while oils is liquid in room temperature because it composed of unsaturated f.a.

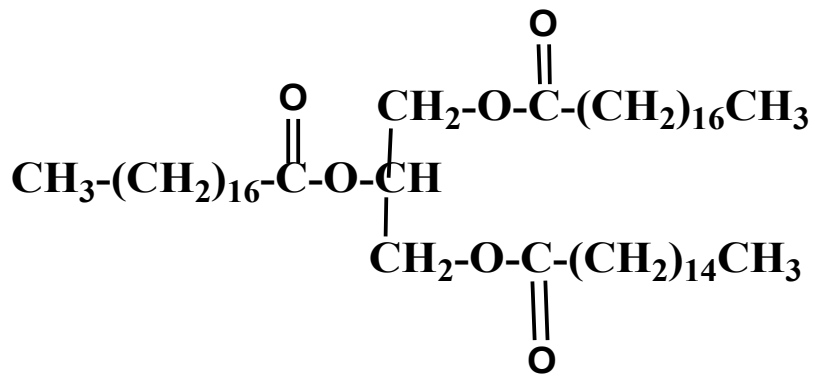
-most of lipids in living systems are Triacylglycerol (T.G) (ester of f.a and alcohol glycerol) because the main energy reserved are stored as T.G in cell and tissues of living system.

-Oil can be converted to fat by process called hydrogenation.





**EXAMPLE:** 1,2- distearyl-3-palmityl glycerol



## Chemical properties of T.G:

T.G Compound that containing f.a with glycerol combine by ester linkage. So their chemical properties depend on f. a by :

- Saturation or unsaturation.
- long of the chain (number of c atom).

The greater number of the C=C in molecule cause more unsaturated T.G and more liquid . we can measure the degree of unsaturation by iodine number.

**Iodine number:** is the number of I<sub>2</sub> in gm that would be add to 100gm of substance (lipid) for saturated f. a.

No. of I<sub>2</sub> =0 because is no double bonds so we don't add I<sub>2</sub>.

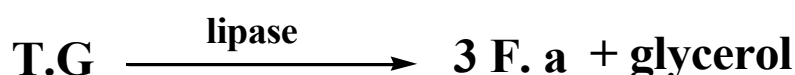
**EX:**

Oleic acid = 90

Linoleic acid = 131

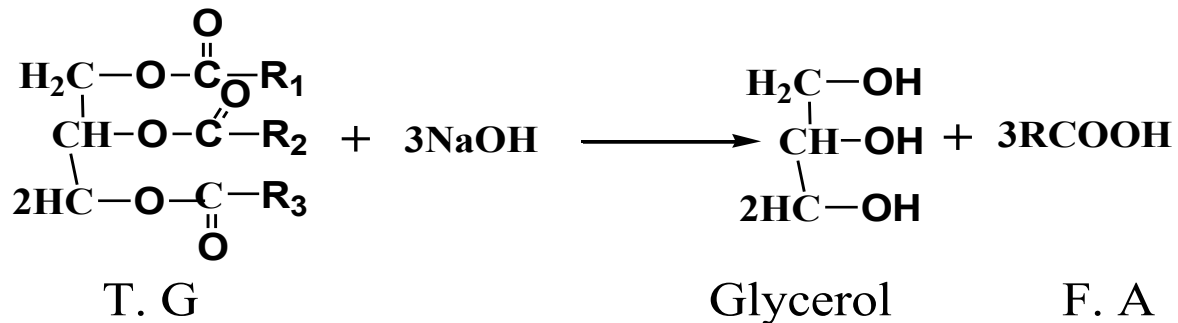
Linolenic acid = 274

T.G can be hydrolysis to give 3 f. a + glycerol, this by action of an enzyme called lipase.



Note: in small intestine the first step of hydrolysis occur by lipase secreted by pencrease.

Saponification of T.G (formation of soap) reaction of T.G with a strong base like NaOH or KOH to form 3 salt (Na or K salts) + glycerol.



The normal range of T.G in human serum is 40- 165 mg/100ml over this range cause hyperlipidemia.

**Q1/** Why the T.G is a good energy source ?

Ans :

1. The complete oxide of T.G give 9 calari/gm while in case of CHO or Proteins we obtained 4 Cal/ gm .
2. T.G is very nonpolar compound so they stored nearly unhydrous (with out water), while CHO and proteins are less polar so they are highly hydrate and stored with water (each gm of glycogen with 2 gm of water).

## Classification of lipids:

**1. Simple lipids:** means that they are esters of f. a with various alcohols.

a. Fats: ester of fatty acid with glycerol . fat in the liquid state is known as an oil.

b. Waxes: are esters of f.a with higher molecular weight monohydroxy alcohols .

**2. Complex lipids :** it is ester of fatty acid.

a. glycolipids: this contain the sphingosine fatty acid combination with one or more suger molecule.

b. phospholipids:

- glycerophospholipids (phosphotidyl choline)

- sphingophospholipids (alcohol sphingosine)

c. Other complex lipids such as susulpholipids, aminolipid and lipoproteins

**3. derived lipids:** this including :

a. fatty acid (saturated and unsaturated)

b. glycerol

c. steroids

d. alcohols

e. fatty aldehyde

f. ketone bodies.

# First -dentistry-SECOND SEMISTE

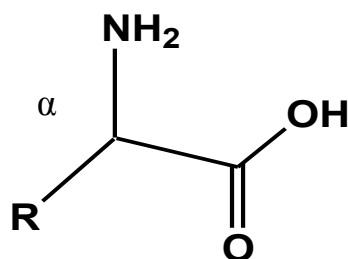
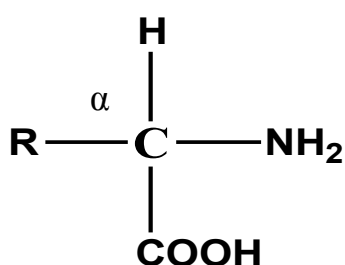
Lecture ( 8 )

2020-2021

Dr. Mahmoud

## AMINO ACIDS & PROTEINS

There are 20 amino acids, that are incorporated in proteins, these are standard amino acids. Proteins are high molecular weight polypeptides, may also contain substances in addition to amino acids (heme, carbohydrate, lipid), play very important role in living systems. The metabolism of amino acids gives rise to many compounds of biomedical importance. All amino acids contain both amino and carboxylic acid functional groups. In an  $\alpha$ - amino acid, both are attached to the same ( $\alpha$ ) carbon atom, and different in side chain (R), (except glycine because side chain is H atoms). These groups exhibit all the expected reactions of these functions.



### *Classification of amino acids*

Amino acids or side chains of them can be classified to different classes, depending on their chemical features like:

- hydrophobic or hydrophilic character
- polar or non polar nature
- aliphatic or aromatic
- according the reaction
- according the nutrition

### *classified nutritionally in to three groups:*

#### **1. Essential A. Ac.**

There are 8 amino acids they are don't synthesized in the body and must be taken in diet in amount adequate to support the infant growth or to maintain health in adults like: (Valine, Leucine, Isoleucine, Phenylalanine, Tryptophan, Lycine, Threonine, Methionine)

#### **2. Non-Essential A. Ac.** They can be synthesized by the body. (12 Amino acids).

3. **Semi- Essential A. Ac.** These are growth promoting factors since they are not synthesized in sufficient quantity during growth. This type include only 2 standard amino acids (**Arginin, Histidine**). They become essential in growing, pregnancy, and lacting women.

**Amino acid are classified in to three groups depending on their reactions:**

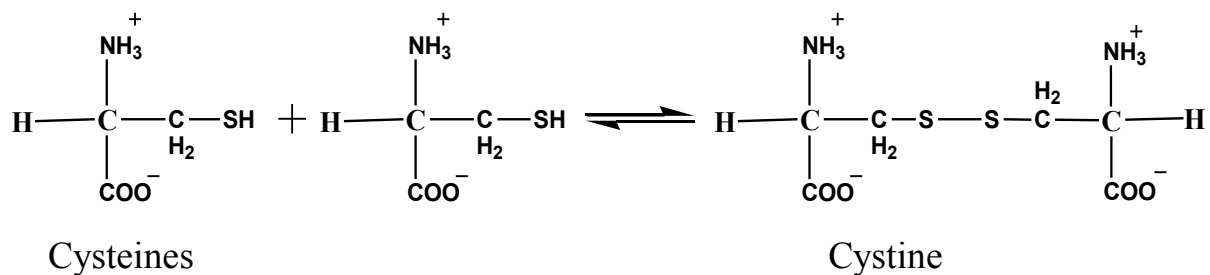
1. **Neutral:** they amino acid are aliphatic, aromatic, and cyclic structures, or containing of hydroxyl or sulfur group. (**Ala, Val, Gly, Leu, Ile, Phe, Trp, Ser, Thr, Cys, Met, Pro**).
2. **Acidic:** This class contain 4 standard A. Ac. (**Asp, Asn, Gly, Gln**).
3. **Basic:** This class contain only 3 standard A. Ac. (**His, Lys, Arg**).

20 A.A called ((standard amino acid)) occurs in almost all proteins and are coded in DNA. Some amino acid may become chemically modified after being assembled in proteins, which called (**unusual L-α-amino acids**) by the processes occurs after formation of the poly peptides back bone, which forms by post processing:

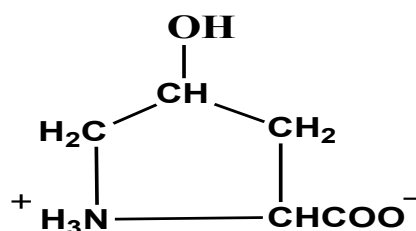
- Oxidation
- Phosphorylation
- methylation
- carboxylation
- formylation
- acetylation.

These modification are important for protein function and structures for examples:

- a. **Cystine** : which formed by oxidation of the SH groups of the two Cysteines to form (- s—s-) disulfide bond :

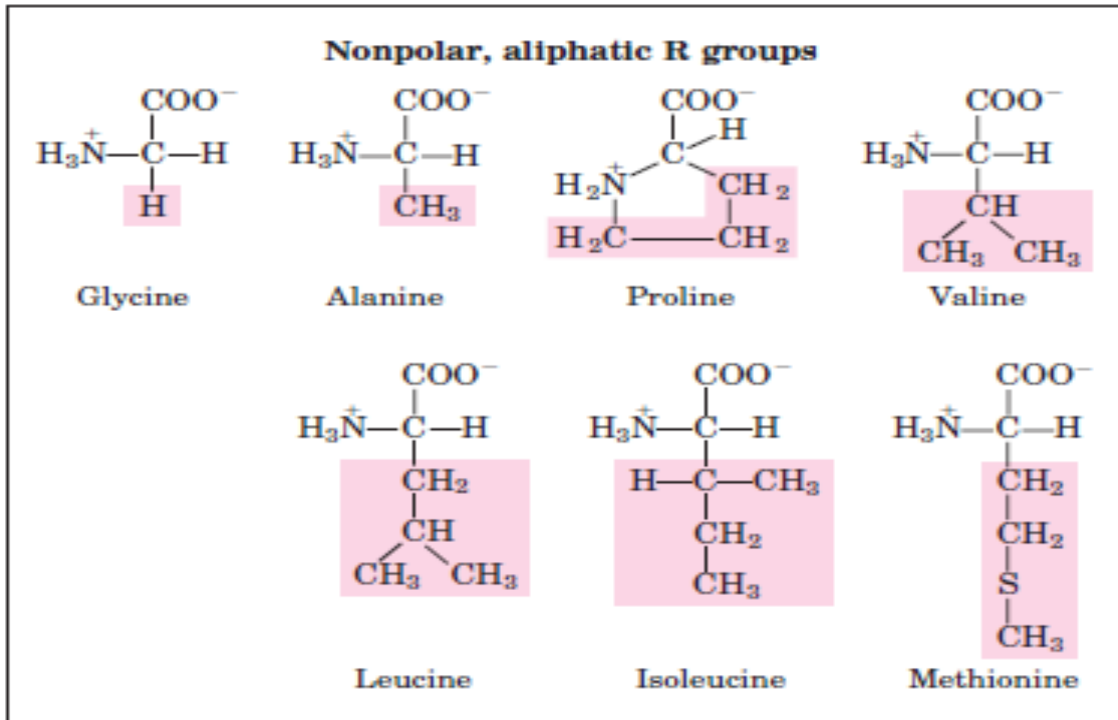


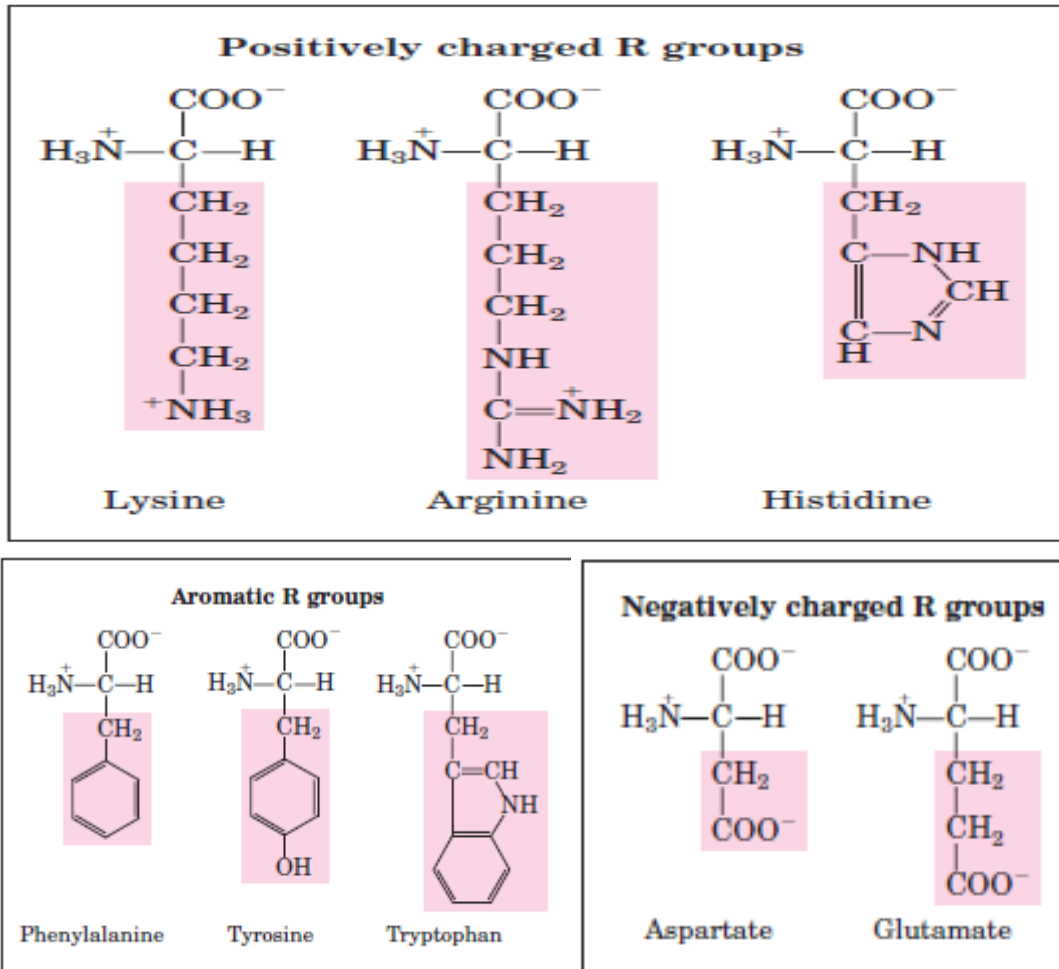
- b. **4-Hydroxyproline:** This amino acid is important for collagen structure.





10. Cys and Met are sources of sulfur for the sulfur compound in the body.



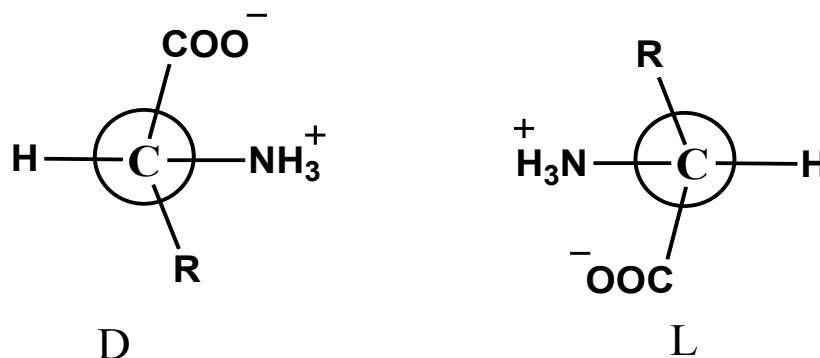


**The 20 common amino acids of proteins.**

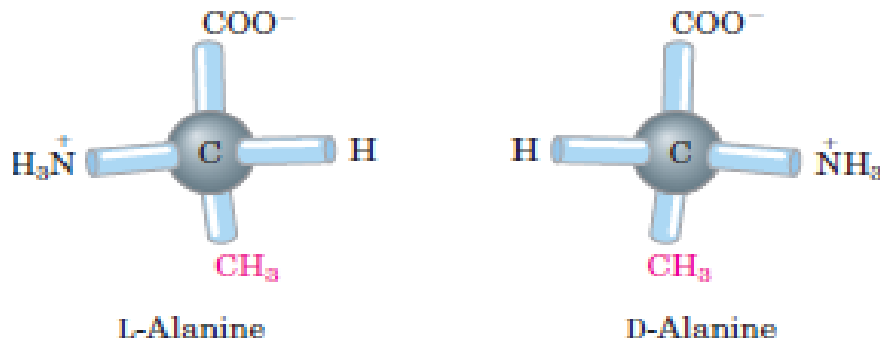
**Physical and chemical properties of amino acids**

**1. Optical isomerism**

All amino acids except Gly have optical activities and rotate the plane of polarized light and exist as Levo (L) or Dextro (D) isomers. These proper due to chiral center of  $\alpha$ -carbon atom.







Optical activity depend on the PH and side chain (R).

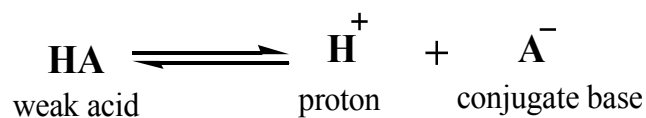
- Few amino acids like (Thr) and (Ile) have an additional asymmetric carbon in their structure.

## 2. Ultra Violet absorption

Aromatic A.A which are (Tyr, Trp, Phe) can absorb Uv-light in the region around 280nm, because they have aromatic rings. This absorption is frequently used for the analytical detection of proteins.

## 3. Amphoteric nature (Buffers)

Amino acids solution resists change in PH following the addition of an acid or base. A buffer can be created by mixing a weak acid (HA) with its conjugate base (A<sup>-</sup>). If an acid such as HCl is added to such a solution, A<sup>-</sup> can neutralize it, in the process being converted to HA. If a base is added, HA can neutralize it in the process being converted to A<sup>-</sup>. Maximum buffering capacity occurs at a PH equal to the PK<sub>a</sub>, but a conjugate acid/base pair can still serve as an effective buffer when the PH of a solution is within approximately <sup>-</sup> 1 PH unit of the PK<sub>a</sub>.



The dissociation constant of the acid is:

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$$

$$\text{PH} = \text{pk}_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

We can obtain of PH by **Henderson equation**:

The  $-NH_2$  group,  $-COOH$  group and charged side chains of A. A are ionized depending on the PH of solution. These groups act as proton donors (acids) or as proton acceptors (bases). This property is called **ampholytes**. All specific PH A.Ac can varies both, changes in equal number, this PH is called **Isoelectric PH** and The PH at which the net charge on A. A is **zero** is called **Isoelectric point (PI)**.

$$PI = \frac{PKa1 + PKa2}{2}$$

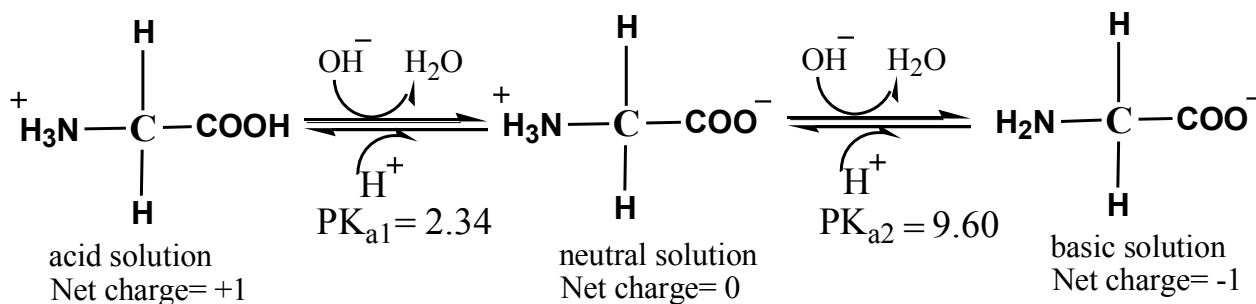
In this point become :  $[A^-] = [HA]$

And due to : **PH = pk<sub>a</sub> + log1**

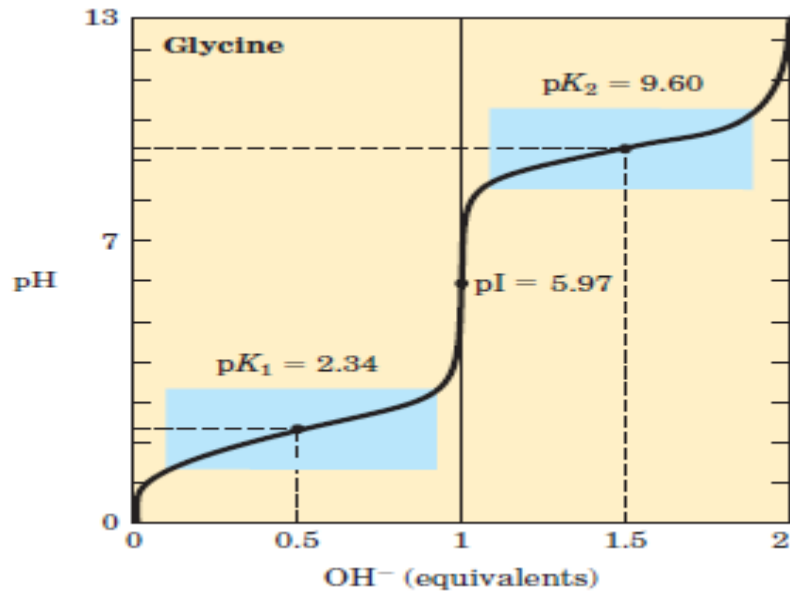
due to :

$$PH = pk_a$$

Amino acids can be titrated potentiometrically and give titration curve, for **example**: Ionic forms of **Glycine** in basic solution ;

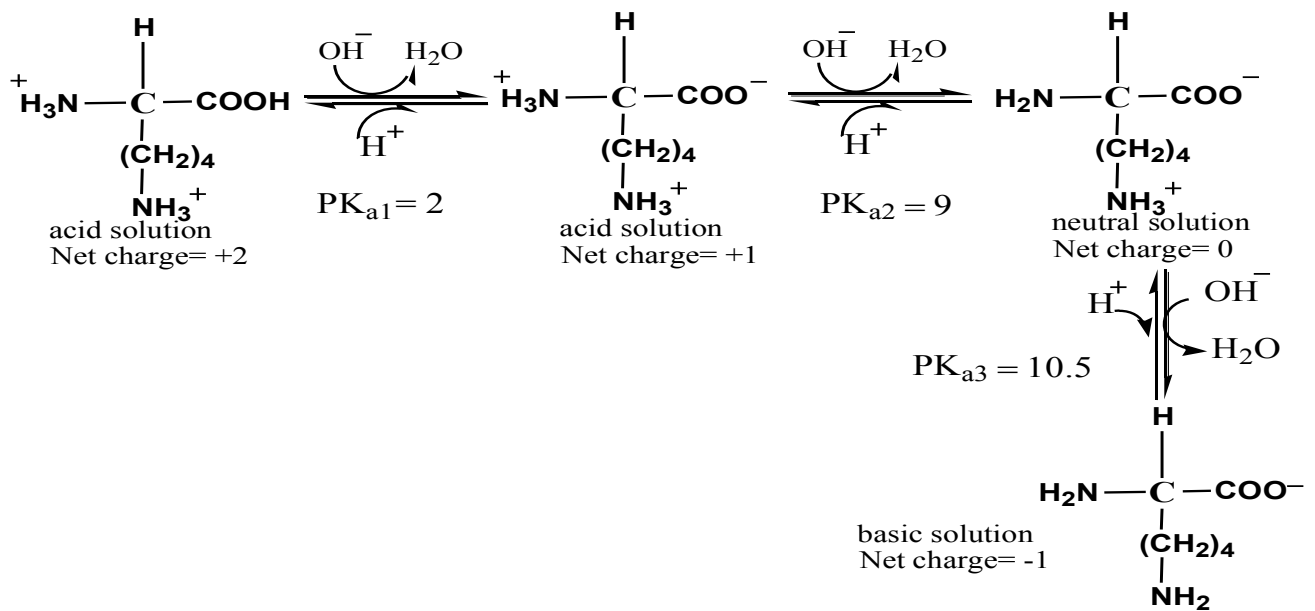


Isoelectric point:  $PI = \frac{PKa_1 + PKa_2}{2} = \frac{2.34 + 9.60}{2} = 5.97$



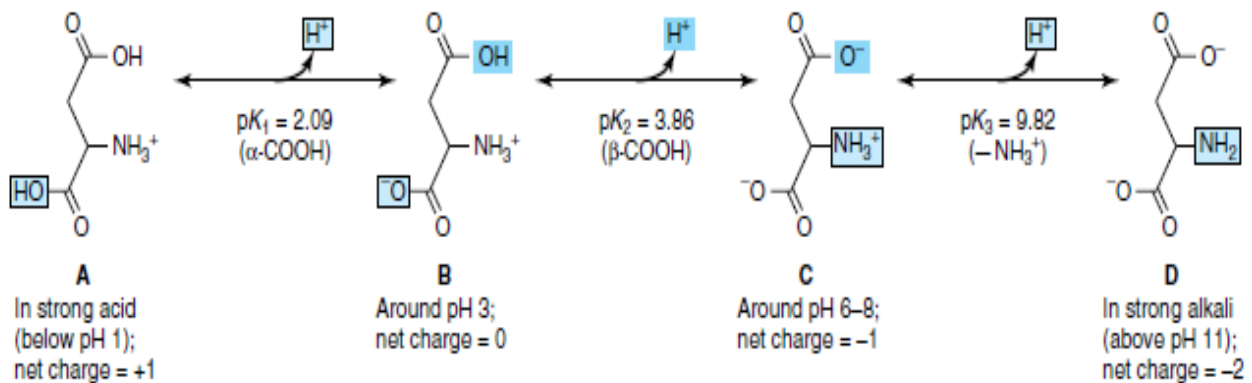
Neutral A.Ac are treated as diprotic acids (Gly, Ala, Thr). While acidic A. AS (Asp, Glu) and basic A. As (Lys, His, Arg) are treated as triprotic acids.

Ex: Titration curve of Lys:



$$\text{PI} = \frac{\text{PK}_{a2} + \text{PK}_{a3}}{2} = \frac{9 + 10.5}{2} = 9.7$$

## Ex: Titration curve of Asp:



The calculation of PI from PK values on either side of the isoelectric AA<sup>o</sup> structure. The calculation of PI is of value in the clinical laboratory to estimated the mobility of compounds in electrical fields and to select appropriate buffer for separation and also to separate A. Ac on charge resin like DEAE cellulose , CM cellulose or Dowex resin.

**Q1/** Two amino acids with PI values of 6 and 8 . can you separated these two A.AS at a buffer with PH 7.08?

**Q2/** Write the equilibrium equation for His. Draw the structure of His each ionization state, and calculate isoelectric point, (when  $pK = ?$

# First -dentistry-SECOND SEMISTE

Lecture ( 9 )

2020-2021

Dr. Mahmoud

## Nucleic acids

Nucleic acids consist from nucleotides which are the monomers or the building units of Nucleic acids . Nucleotides form apart of many coenzymes and serve as donors of phosphoryl groups ( e.g. ATP & GTP ) . Nucleotides consist from : **nitrogen base** , **pentose** , and **phosphoric acid** .

**1. Nitrogen base :** The nucleotides include two types of nitrogen bases ,

- **purine** (Adenine,Guanine)

- **pyrimidine** (Thymine,Cytosine,Uracil). purine and Pyrimidine are nitrogen- containing heterocycles cyclic compounds whose rings contain both carbon and other elements .

□ There are two common purine bases in nucleic acids :

- **Adenine**: is found in **DNA & RNA** .

- **Guanine**: is found in **DNA & RNA** .

□ There are three common **pyrimidin** bases in nucleic acids :

\_ **Cytosine** : is found in **DNA & RNA** .

\_ **Thymine** : is found in **DNA** only.

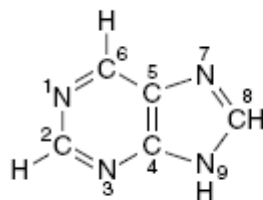
\_ **Uracil** : is found in **RNA** only.

**RNA** : ribonucleic acid .

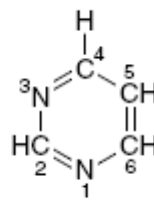
**DNA** : deoxyribonucleic acid .

-In addition to the **pyrimidine bases** mentioned above the nucleic acids include small amounts of other bases like **5-methyl cytosine** , **5-hydroxy methyl cytosine** and **dihydrouracil** .

-In addition to there are other **purine bases** like **1-methyl guanine** , **2-methyl adenine** and **dimethyl guanine** .



Purine



Pyrimidine

The conjugated double bonds of purine and pyrimidine derivatives absorb ultraviolet light . the mutagenic effect of ultraviolet light results from its

absorption by nucleotides in DNA with accompany chemical changes . While spectra are PH dependent, at PH 7.0 all the common nucleotides absorb light at a wavelength close to 260 nm . the concentration of nucleotides , and nucleic acids thus often is expressed in term of " absorbance at 260 nm. "

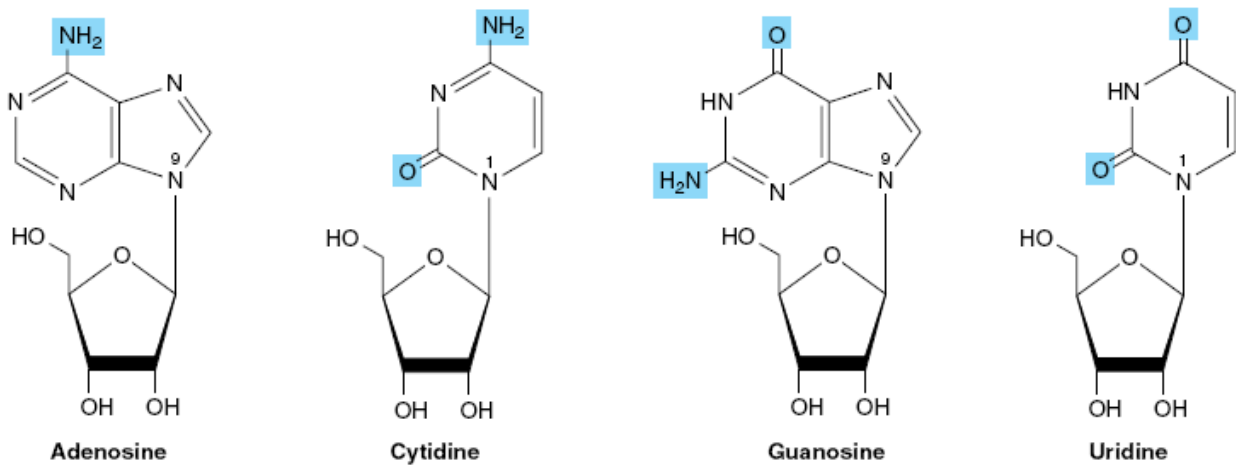
**2. Pentose :** there are two types of pentose in the nucleotides , the first one is **ribose** which is found in the nucleotides that are derivated from RNA , while the second is **deoxy ribose** which is found in the nucleotides that are derivated from DNA .

## Nucleosides

Nucleosides are derivatatives of purines and pyrimidines that have a sugar linked to a ring nitrogen of heterocyclic . the sugar in **ribonucleosides** is D\_ribose and in **deoxyribonucleosides** it is deoxy-D-ribose . The sugar is linked to the heterocyclic base via a  **$\beta$ -N-glycosidic bond** to **N-1** of pyrimidine or to **N-9** of purine .

# This means that : **nitrogen base + ribose = Nucleoside** .

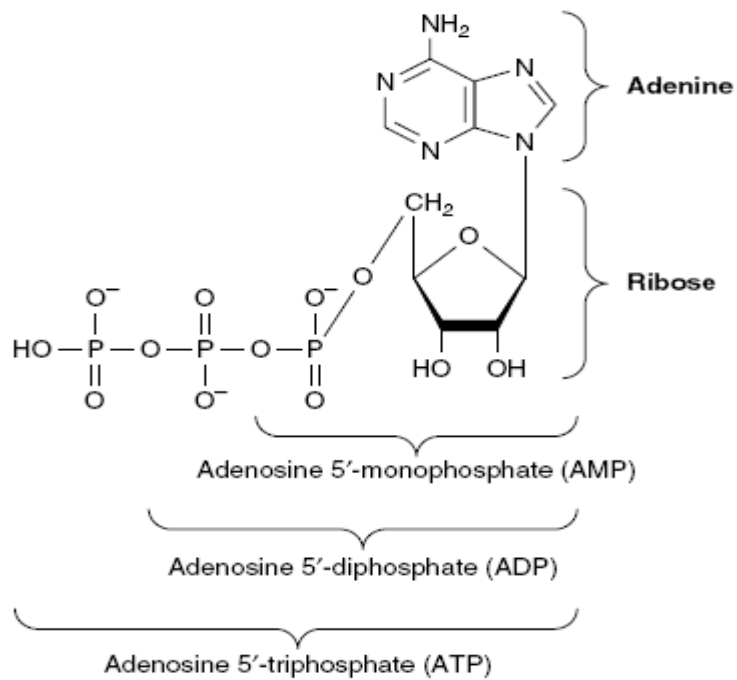
Like : adenosine , cytidine , guanosine , and uridine .



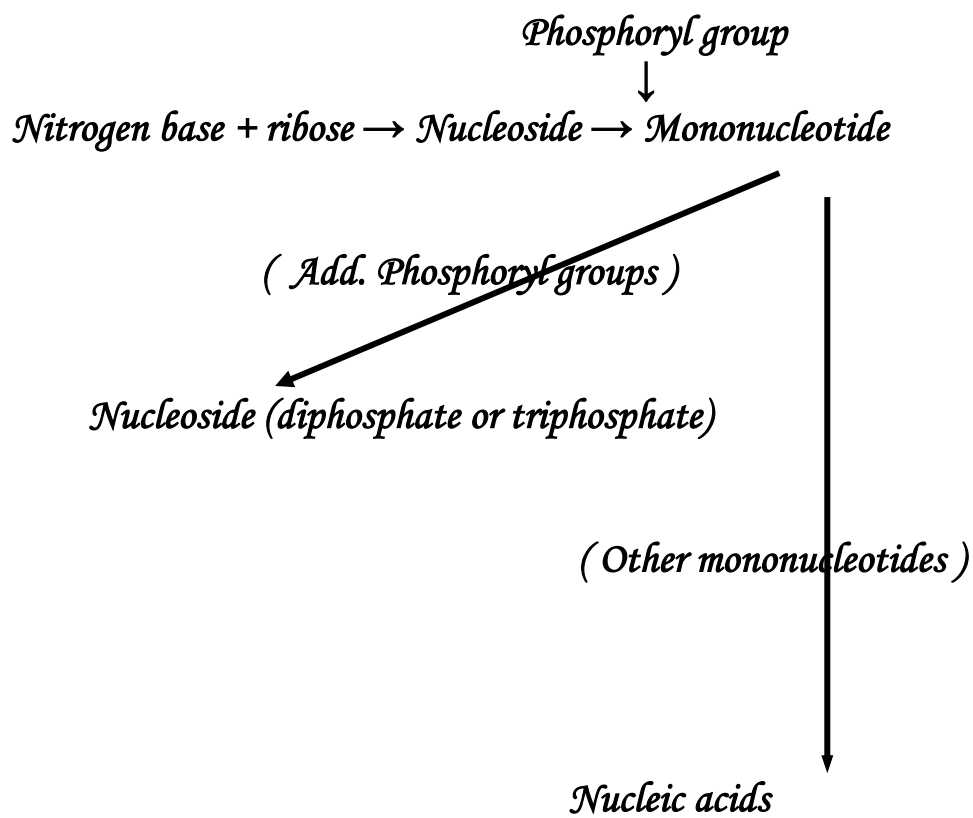
# **Nucleosides + phosphoryl group = mononucleotide** .

Additional phosphoryl groups linked to the phosphoryl group of mononucleotides form nucleoside diphosphate and and triphosphate.

# **Mononucleotide + add. Phosphoryl group = nucleoside di or tri phosphate** .



**Figure 33-4.** ATP, its diphosphate, and its monophosphate.



*Illustration diagram of nucleic acid component .*

## Functions of some nucleosides tri or di and monophosphates :

- **Function as group transfer agents** , like **ATP** which is the principal carrier of chemical energy in the cell . ATP transfers phosphate group from the process which produces energy to other needs . In spite of the ( **ATP** , **ADP** , **AMP** ) is the principal nucleoside mono , di , and tri phosphate for phosphate group transport , **GTP** and **UTP** participate in the transport of phosphate group and energy .
- **Precursors of nucleic acids** .
- **GTP** serves as an allosteric and as energy source for protein synthesis
- **cGMP** serves as second messenger during relaxation of smooth muscle .
- **UDP** participate in biosynthesis of glycogen .
- **CTP** participates in biosynthesis of phosphoglycerides .

## Nucleotides and chemotherapy

Synthetic **nucleotide analogs** are used in chemotherapy . synthetic analogs of **purine** , **pyrimidine** , **nucleosides** , and **nucleotides** altered in either the heterocyclic ring or the sugar moiety have numerous applications in clinical medicine . Their toxic effects reflects either inhibition of enzymes essential for nucleic acids synthesis or their incorporation into nucleic acids .

### Examples :

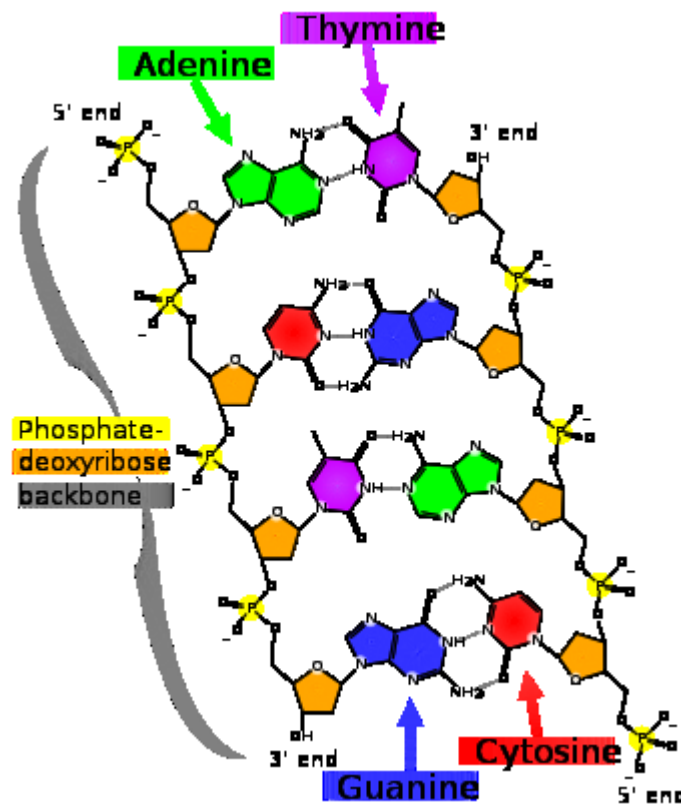
- Oncologists employ **5-fluoro** or **5-iodo uracil** , **3- deoxyuridine** , **6-thioguanine** , and **6-mercaptopurine** which are incorporated into **DNA** .
- The **purine analog allopurinol** , used in treatment of hyperuricemia and gout , inhibits purine synthesis and xanthine oxidase activity .
- **Cytarabine** is used in chemotherapy of cancer .
- **Azathioprine** which is catabolized to 6-mercaptopurine , is employed during organ transplantation to suppress immunologic rejection .

## DNA:

DNA consists from four types of monomeric **deoxynucleotide** units: **deoxyadenylate** , **deoxyguanylate** , **deoxycytidylate** , and **thymidylate** . these monomeric units of DNA are held in a polymeric form by 3,5 phosphodiester bridges constituting a single strand . The informational content of DNA ( the genetic code ) resides in the sequence of the four bases along the backbone of DNA molecule .



Backbone made of sugars and phosphate groups joined by ester bonds .

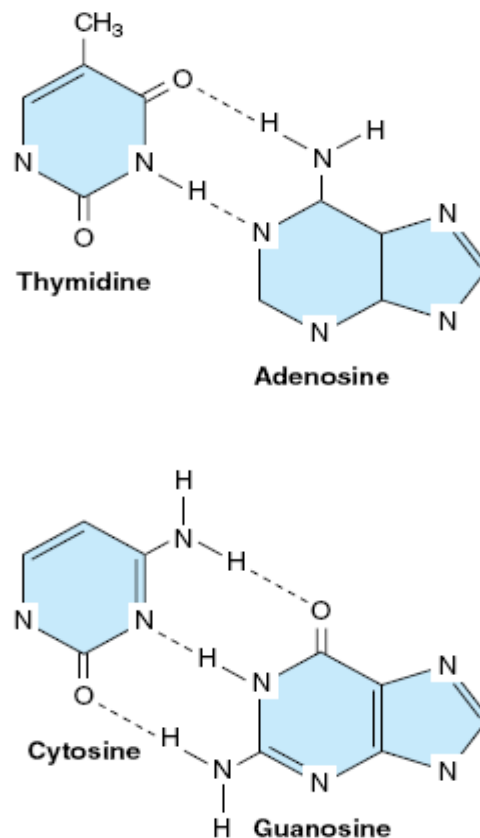


### *Chemical structure of DNA*

The polymer possesses a polarity , one end has a 5-hydroxyl or phosphate terminal while the other has 3-phosphate or hydroxyl terminal . In DNA molecules the concentration of deoxynucleotide ( A ) equals that of thymidine ( T ) , ( A = T ) , ( G = C ) .

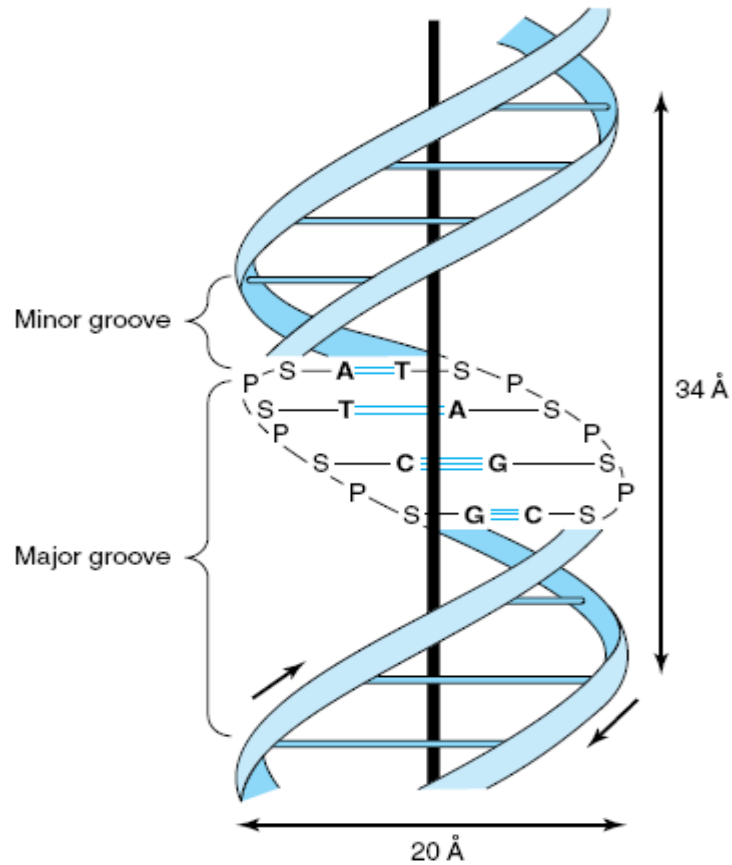
DNA molecules consist from two strands of polydeoxynucleotides that are complementary to each other in a form of double helix . the double stranded structure of DNA can be separated into two component strands in solution by increasing the temperature and these separated of DNA renature when a physiologic temperatures are achieved .

The two strands of this double stranded helix are held in register by hydrogen bonds between purine and pyrimidine bases . The pairings between purine and pyrimidine on the opposite strands are very specific and are dependent upon the hydrogen binding of A with T , and G with C .



**Figure 35-3.** Base pairing between deoxyadenosine and thymidine involves the formation of two hydrogen bonds. Three such bonds form between deoxycytidine and deoxyguanosine. The broken lines represent hydrogen bonds.

This base pairing explains that in double stranded DNA molecules the content of A equals that of T and the content of G equals that of C . The two strands of the double helical molecule are antiparallel , one strand runs into 5 to 3 direction and the other in the 3 to 5 direction . In the double stranded DNA molecules the genetic information resides in the sequence of nucleotides on one strand , the template strand , this is the strand of DNA that is copied during RNA synthesis .



**Figure 35–2.** A diagrammatic representation of the Watson and Crick model of the double-helical structure of the B form of DNA. The horizontal arrow indicates the width of the double helix (20 Å), and the vertical arrow indicates the distance spanned by one complete turn of the double helix (34 Å). One turn of B-DNA includes ten base pairs (bp), so the rise is 3.4 Å per bp. The central axis of the double helix is indicated by the vertical rod. The short arrows designate the polarity of the antiparallel strands. The major and minor grooves are depicted. (A, adenine; C, cytosine; G, guanine; T, thymine; P, phosphate; S, sugar [deoxyribose].)

## RNA:

Ribonucleic acid ( RNA ) is a polymer of purine and pyrimidine ribonucleotides linked together by 3,5- phosphodiester bridges analogous to those in DNA .

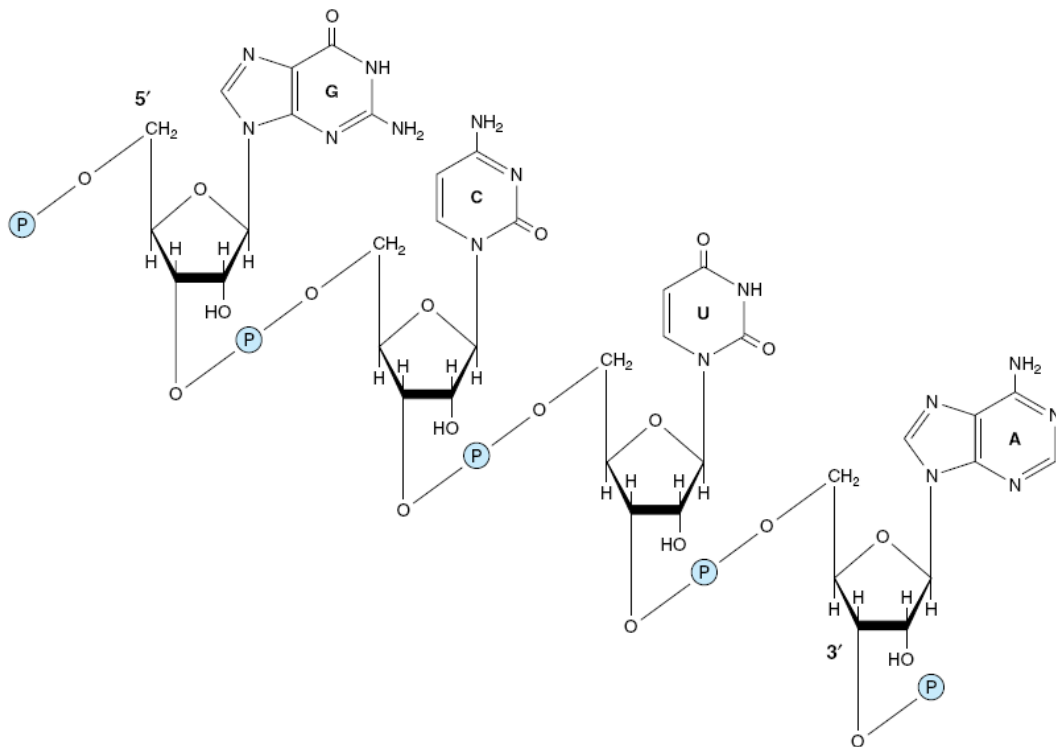


Figure of RNA

Although sharing many features with DNA , RNA possesses several specific differences :

1. In RNA , the sugar moiety is ribose rather than deoxyribose of DNA .
2. The pyrimidine components of RNA differ from those of DNA . RNA contains the ribonucleotides of adenine , guanine , and cytosine it does not possess thymine except in the rare case . Instead of thymine RNA contains the ribonucleotide of uracil .
3. RNA exists as a single strand , whereas DNA exists as a double stranded helical molecule . The single strand of RNA is capable of folding back on its self like a hairpin and thus acquiring double stranded characteristics .
4. Since the RNA molecule is a single strand complementary to only one of the two strands of a gene , its guanine content does not necessarily equal its cytosine content , nor does its adenine content necessarily equal its uracil content .

Information of within single strand of RNA is contained in its sequence of purine and pyrimidine nucleotides within the polymer, the sequence is complementary to template strand of the gene from which it was transcribed . Because of this complementarity , an RNA molecule can bind specifically by base pairing rules to its template DNA strand , it will not bind with other ( coding ) strand of its gene . The sequence of the RNA molecule ( except for U replacing T ) is the same as that of the coding strand of the gene



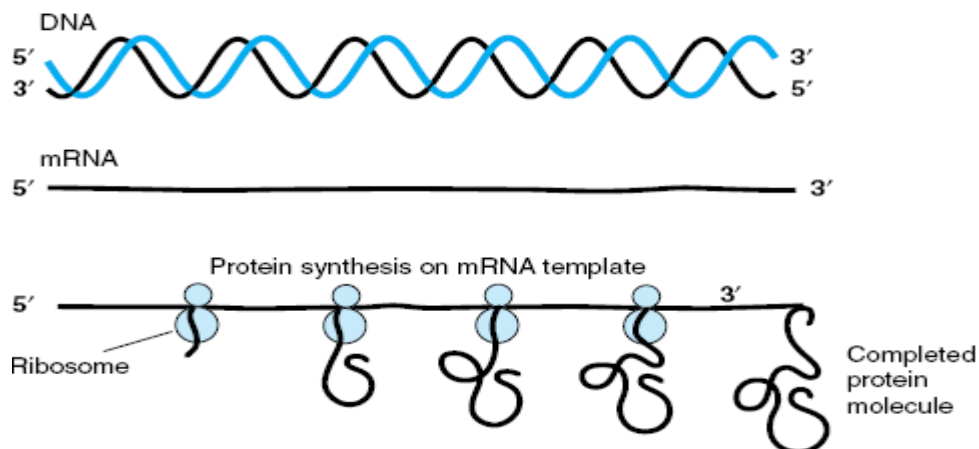
**Fig. of : The relationship between the sequences of RNA transcript and its gene**

There are three main classes of RNA molecules :

- messenger RNA ( mRNA ) ,
- transfer RNA ( tRNA ) ,
- ribosomal RNA ( rRNA ) .

Each differs from the others by **size** , **function** , and general **stability** .

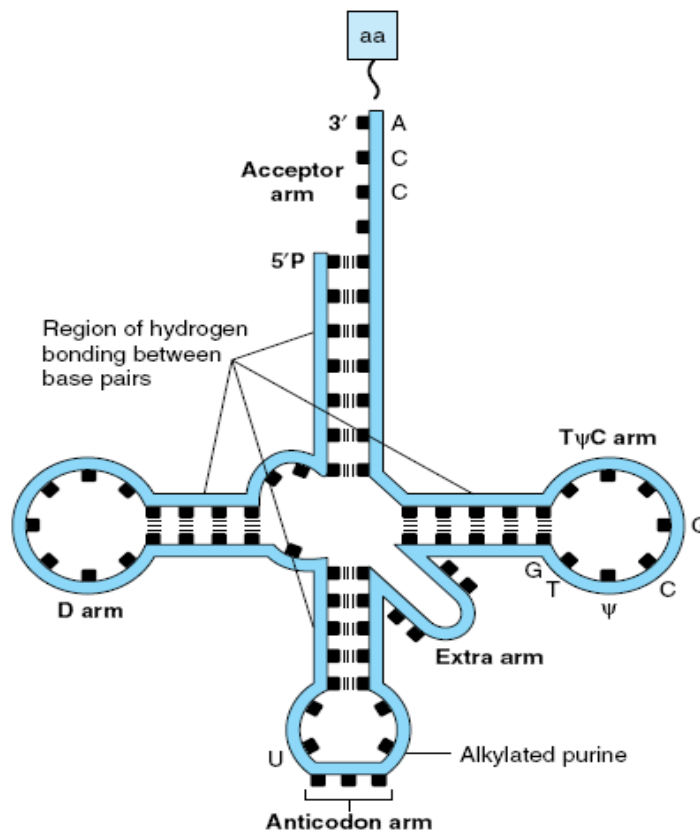
**mRNA :-** This class is the most heterogeneous in size and stability . All members of this class function as messengers conveying the information in gene to the protein synthesizing machinery , where each serves as template on which a specific sequence of amino acids is polymerized to form a specific protein molecule .



### The expression of genetic information in DNA into mRNA transcript

This means that mRNA carries information from DNA to the ribosome , the site of protein synthesis in the cell . The coding sequence of the mRNA determines the amino acid sequence in the protein that is produced .

**tRNA :-** tRNA molecules vary in length from 74 – 95 nucleotides that transfer a specific amino acid to a growing polypeptide chain at the ribosomal site of protein synthesis during translation . It has sites for amino acid attachment and anticodon region for codon recognition that binds to a specific sequence on the mRNA chain through hydrogen bond . There are at least 20 species of tRNA molecules in every cell , at least one corresponding to each of the 20 amino acid required for protein synthesis . tRNA molecules have intrastrand complementary to generate structure that appears in two dimensions like a cloverleaf .



**Typical aminoacyl tRNA**

**Ribosomal RNA ( rRNA ) :** - A ribosome is a cytoplasmic nucleoprotein structure called ribonucleoprotein that acts as the machinery for the synthesis of protein from mRNA template . On ribosome the mRNA and tRNA molecules interact to translate into a specific protein molecule information transcribed from the gene . Many ribosomes are associated with an mRNA to form which is called polysome .

## **Enzymatic hydrolysis of nucleic acid**

Specific nucleases digest nucleic acids . These nuclease can be classified in several ways . Those which exhibit specificity for deoxyribonucleic acid are referred to as deoxyribonucleases . Those which specifically hydrolyze ribonucleic acids are ribonucleases within both of these classes are enzymes capable of cleaving internal phosphodiester bonds to produce either 3-hydroxyl and 5-phosphoryl terminal or 5-hydroxyl and 3-phosphoryl terminal and these are referred to endonucleases .

Some are capable of hydrolyzing both strands of a double stranded molecule , whereas others can only cleave single strands of nucleic acids . Some nucleases can hydrolyze only unpaired single strands , while others are capable of hydrolyzing single strands participating in the formation of double stranded molecule . Some nucleases are capable of hydrolyzing a nucleotide only when it is present at a terminal of a molecule , these are referred to as exonucleases . Exonucleases act in one direction ( 3 – 5 or 5 – 3 ) only .

These enzymes which attack the phosphodiester bridges in DNA and RNA are grouped into a and b enzymes or ( 3 and 5 ) according to side of bridge attacking .

A enzymes hydrolyze the ester bond between the phosphate group and carbon atom ( number 3 ) the most common example of is the enzyme phosphodiesterase which is present in the rattlesnake poison which hydrolyze the third carbon bonds in DNA and RNA to produces nucleoside phosphate . This enzyme needs for free hydroxyl group in the terminal of ( 3 carbon atom ) .

B enzymes hydrolyze the ester bond between phosphate group and carbon atom ( number 5 ) .

The enzymatic hydrolysis of nucleic acid is important in the determination of nucleotide sequence in the nucleic acids .