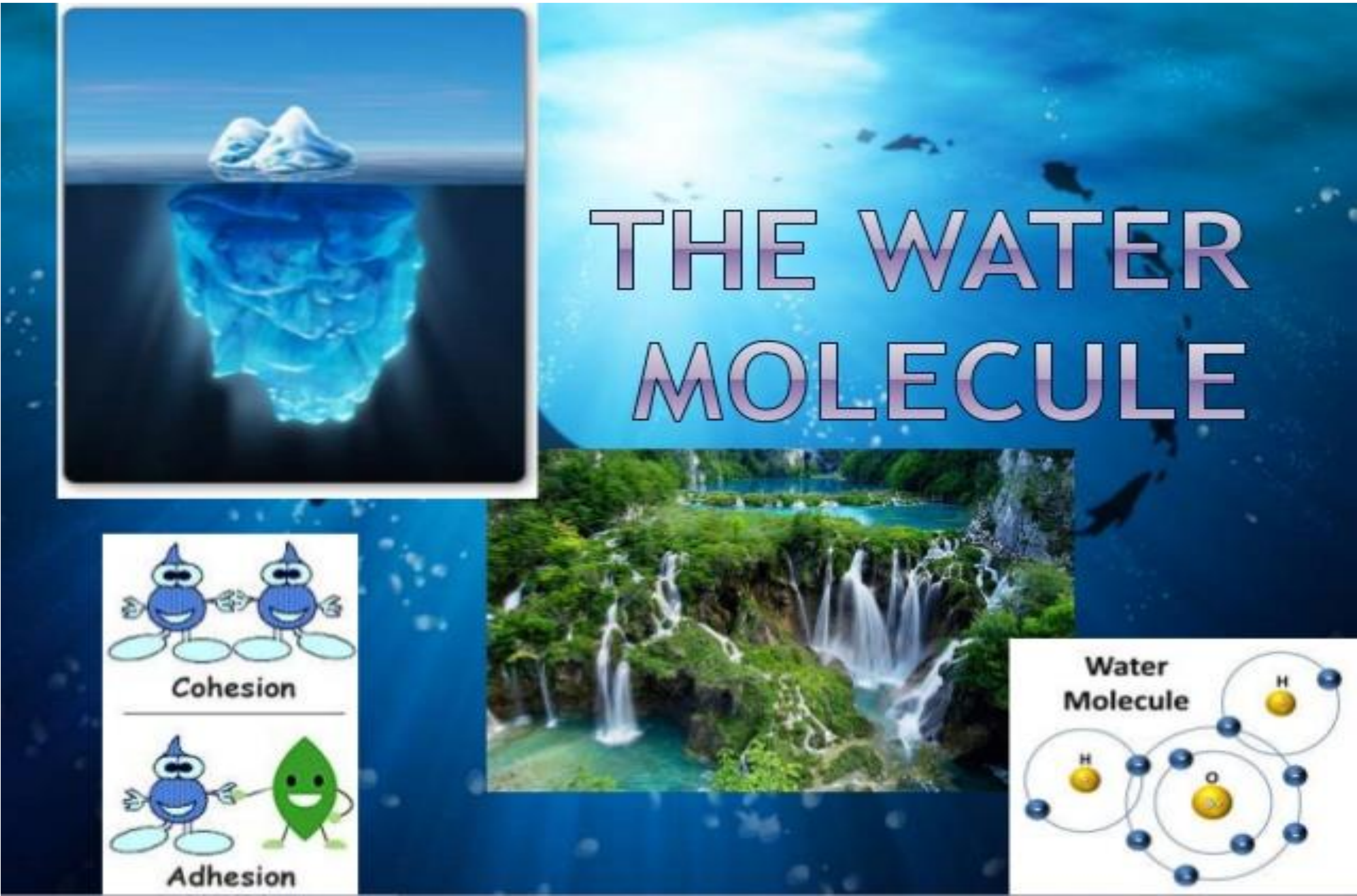
# Dr. Saba Alabachi



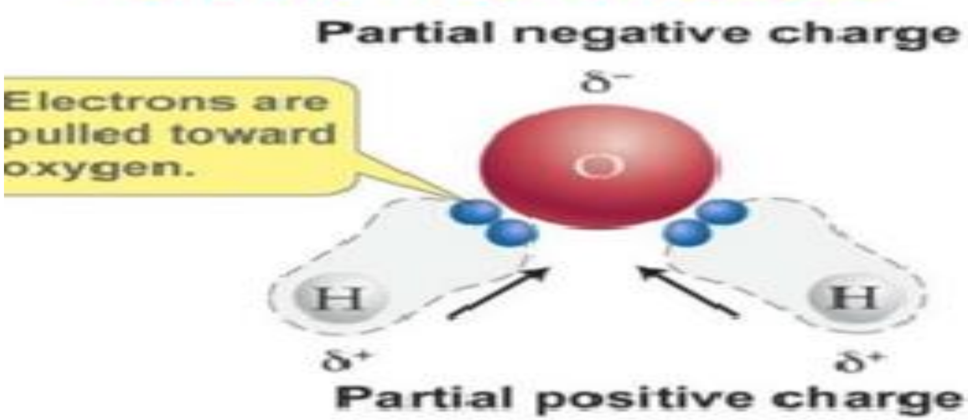
# DID YOU KNOW??

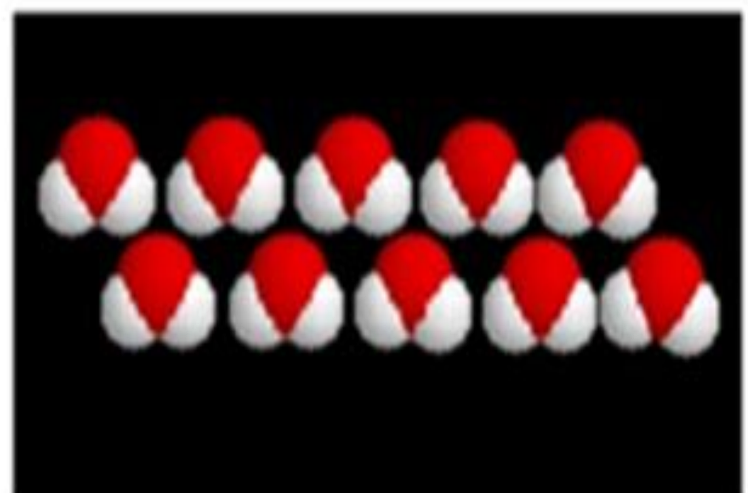
- *Life began in water*
- *About ¾ of Earth is covered in water.*
- *All living things need water*
- *Your cells are approximately 70-95% water*
- *Water is the "universal solvent" because it can dissolve many things!*

# THE WATER MOLECULE:

- It is a very stable.
- <u>**Polar molecule:**</u> It has a "+" and "–" end. This polarity has a large impact on the properties of water.

## POLAR MOLECULE



# POLARITY OF WATER

- Because of the electron arrangements in the water molecule, a polarity results that allows water to form hydrogen bonds with one another and other **polar substances.**

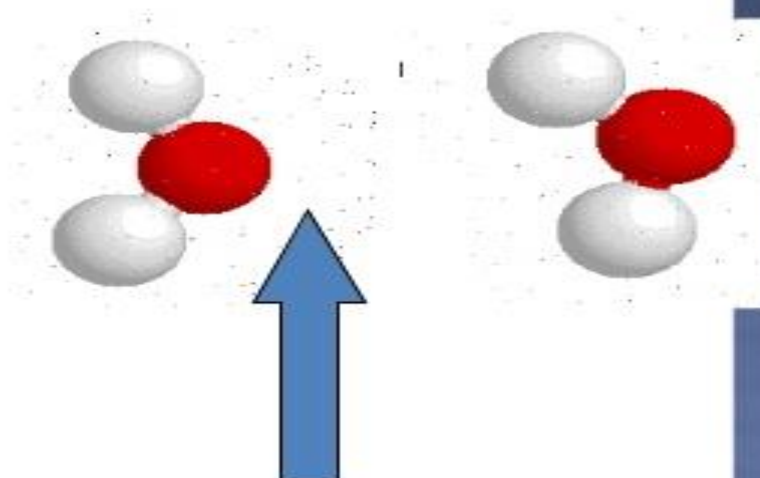
- **Polar** substances are HYDROPHILIC (water-loving)
- **Nonpolar** ones are HYDROPHOBIC (water-dreading) and are repelled by water.

Water molecules are very good at forming hydrogen bonds, weak associations between the partially positive and partially negative ends of the molecules.

## PROPERTIES OF WATER (#1-6)

**#1. Hydrogen Bonding: caused by the oxygen end (-) attracted to the hydrogen end (+) of another $H_2O$.**

- **Weak bond**



**Because the water contain hydrogen bond, it has the following properties:**

## 1- Heat of vaporization:

It is the amount of energy that must be added to a liquid substance, to transform a quantity of that substance into a gas. It is equal 540 cal/gm of water. This high quantity of heat to evaporate one gram of water is very useful to maintain the amount of water inside body, so that evaporation of water becomes as little as possible.

## 2- High melting point:

The melting point of water is high when it comparison with the melting point of other solvents as methanol, ethanol, acetone and chloroform. The biological important of high water melting point is to maintain of organisms from freezing.

The higher melting point is required higher temperature to turn the liquid into a solid.

# 3- High heat capacity:

**Calorie** is defined as the amount of heat energy needed to raise the temperature of one gram of water by one degree Celsius at a pressure of one atmosphere.

The high heat capacity of water has a great deal to do with regulating extremes in the environment الظواهر المتطرفة, that is mean the organisms are acquires and loses high temperature with minimize changing in the body temperature.

# Solutions

In chemistry, a solution is a special type of homogeneous mixture composed of two or more substances. When the solid is dissolved in aqueous there are three things happen:

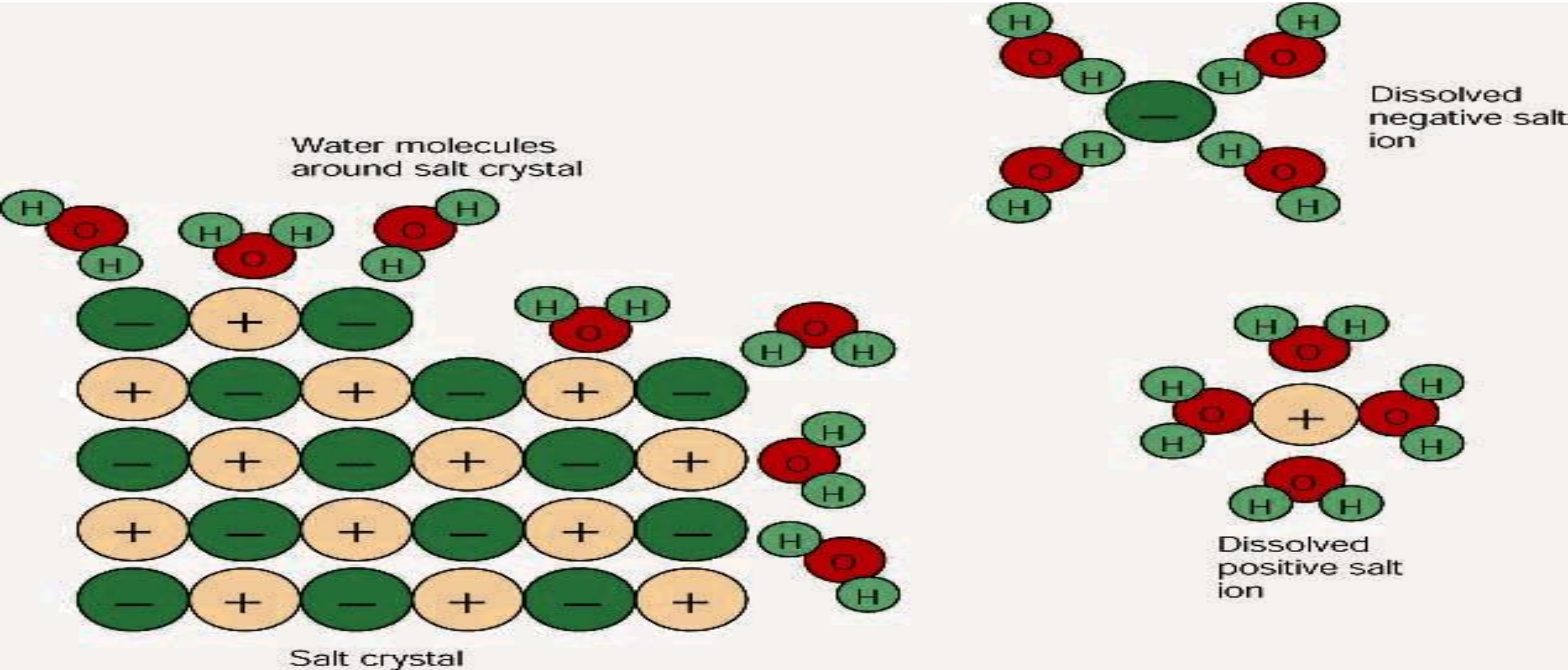
**1-** Break the bonds that bind the molecules or ions to the solid compound.

**2-** Break the bonds that bind the liquid molecules.

**3-**Formation of new bonds between liquid solvent molecules and the molecules or ions of dissolved compound.

**The water is high polar compound, therefore it is a good solvent for polar molecules and ions. For examples:**

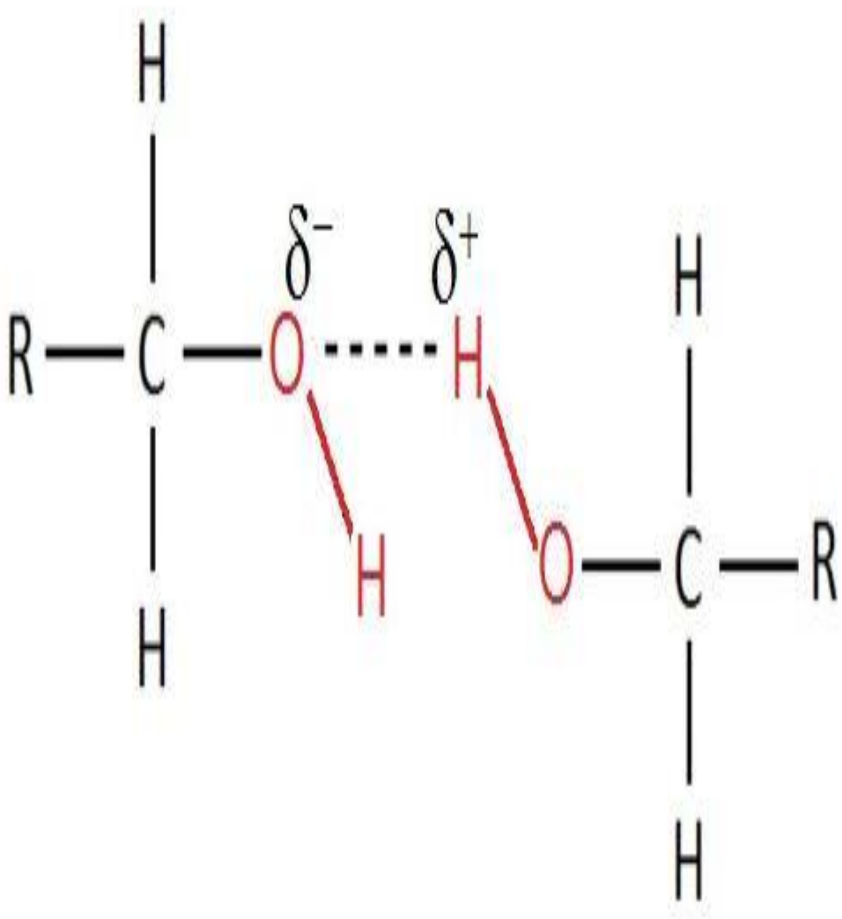
**1-** The water can be dissolved sodium chloride (solid, have ionic bonds between + and – charges(.

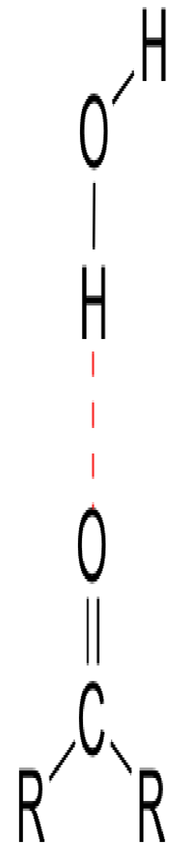


**2-** The water can be dissolved the organic compounds which contain polar groups, as saccharides, alcohols, aldehydes and ketones. These compound were soluble because :

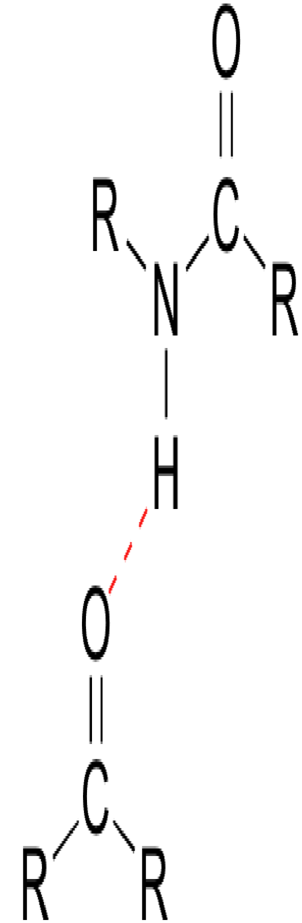
The solubility of these compounds is due to the tendency of the water molecule to form a hydrogen bond with hydroxyl groups of saccharides and alcohols or carbonyl groups of aldehydes and ketones.

# Hydrogen bonds:





hydrogen bonding between a ketone (acceptor) and water (donor)



hydrogen bonding between a ketone (acceptor) and an amide (donor)

# Solubility of non-polar compounds:

Because water is polar and oil is nonpolar, their molecules are not attracted to each other. The molecules of a polar solvent like water are attracted to other polar molecules.

In general, polar solvents dissolve polar solutes, and nonpolar solvents dissolve nonpolar solutes. This concept is often expressed as **"Like dissolves like."**

To converted non-polar compounds to soluble compounds in solution you must be bind with other polar molecule which is soluble in water , for examples:

## 1- Bind with plasma proteins:

The plasma or serum proteins as albumin acts as a plasma carrier by non-specifically binding several hydrophobic steroid hormones, fatty acids, bilirubin, thyroid hormones and some drugs as penicillin and aspirin in the blood.

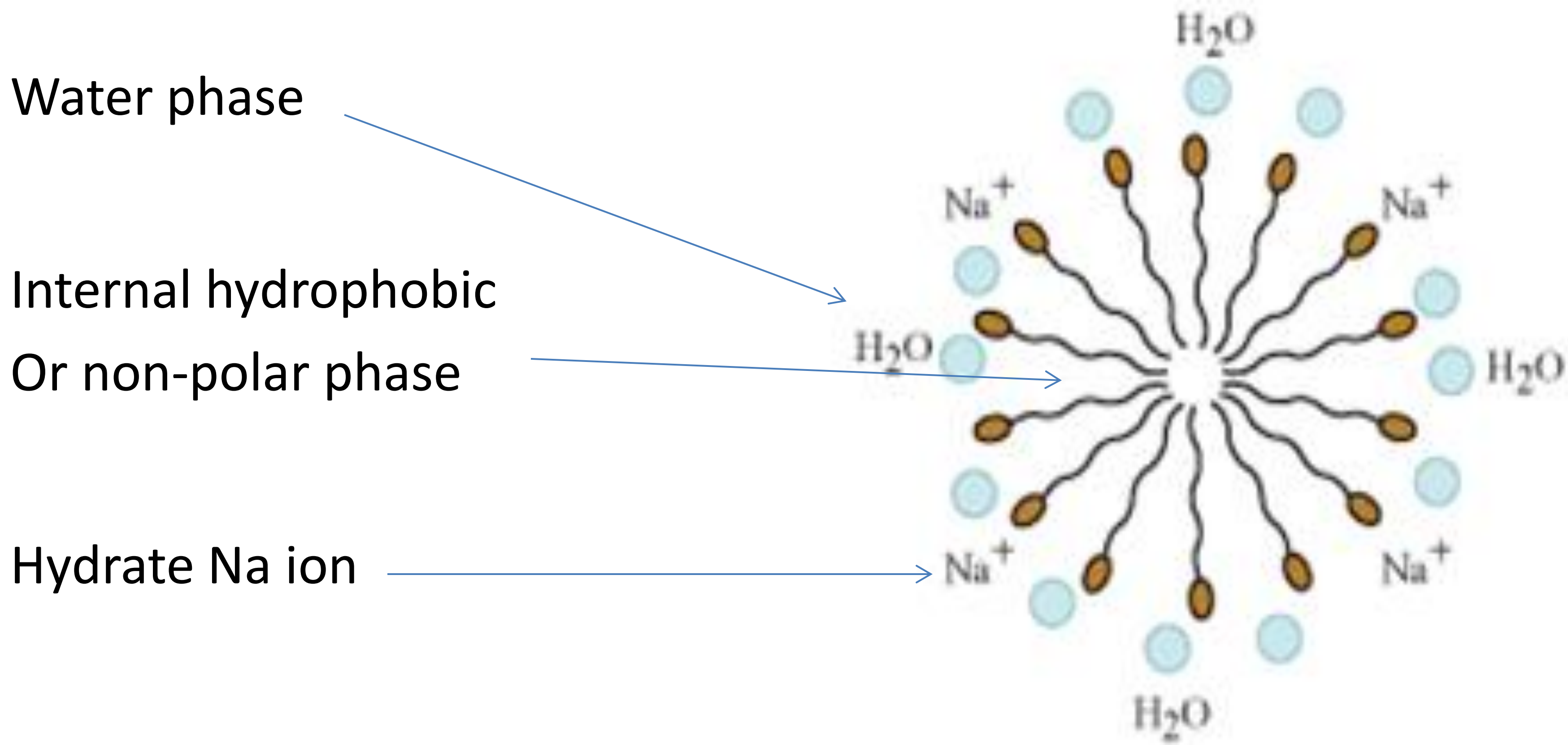
Albumin molecule has electric charge on side chains, therefore it is polar and soluble in water. At the same molecules of albumin there is non-polar areas to bind with the non-polar compounds.

# 2- Micelles formation:

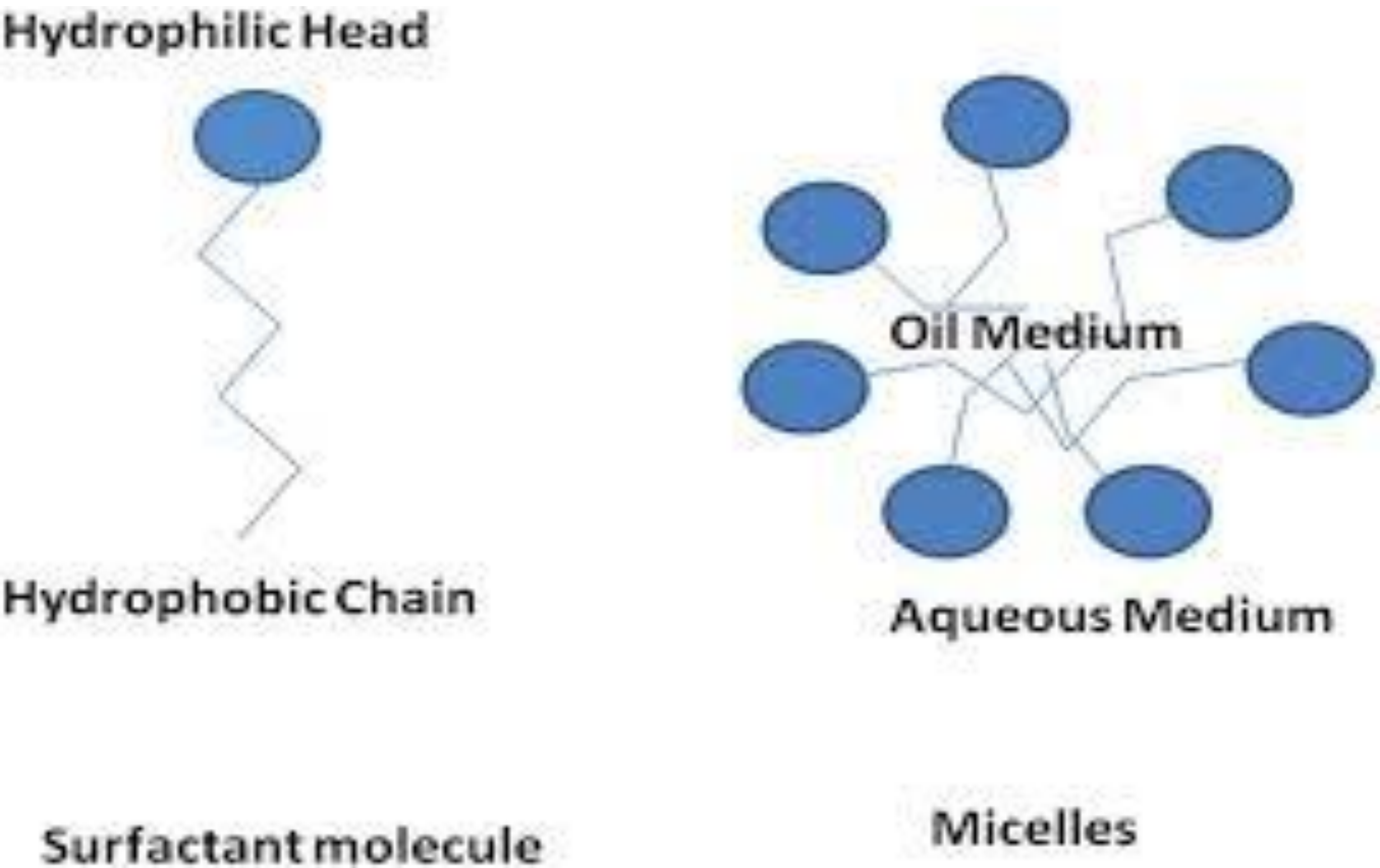
The fatty acids contains hydrophobic non-polar hydrocarbon long chains and the molecules contains hydrophilic polar carboxylic groups.

A typical micelle in aqueous solution forms an aggregate with the hydrophilic **"head"** regions in contact with surrounding solvent, sequestering the hydrophobic **single-tail** regions in the micelle center.

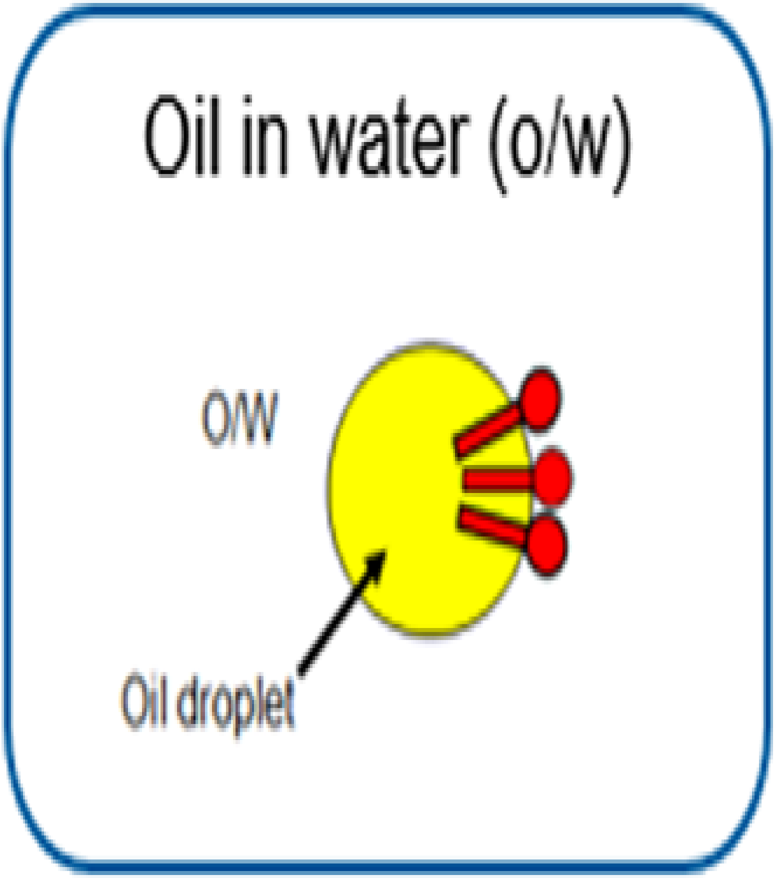
As a result the **emulsification** was formed and soluble in water. Other examples is bile salts which contains hydrophobic surface go inside and other surfaces polar, hydrophilic heading to the top toward the water and linked with it.

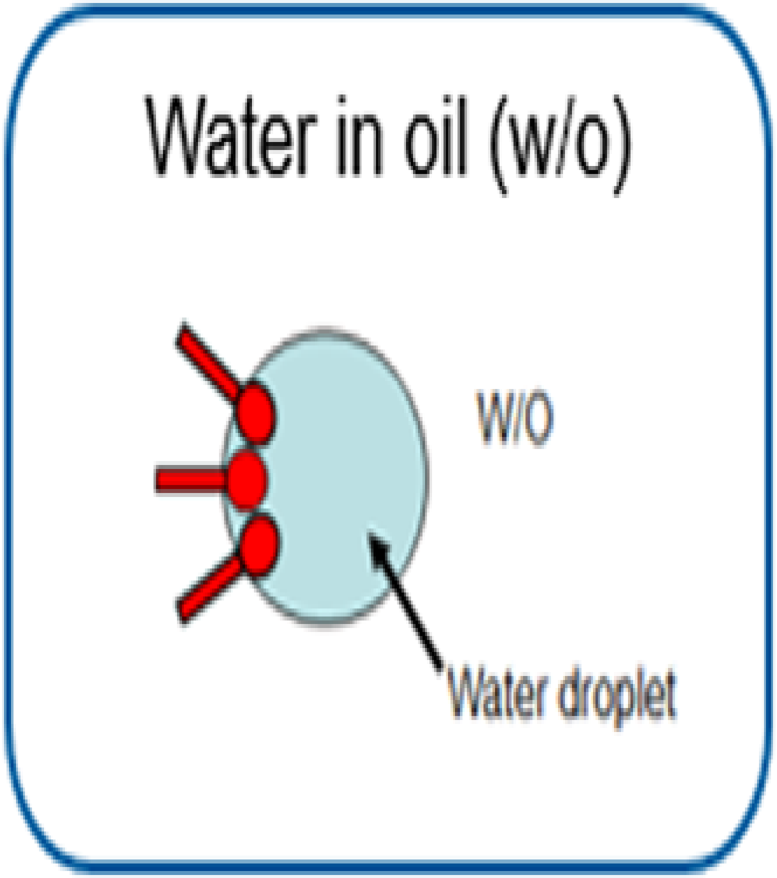


# Micelles formation in water



# Emulsification in water



# Dissociation of water

Pure water is a poor conductor of electricity because it does not ionize.

Ionization of water does occur results in the production of H+ and OH- ions. At room temperature, one in a billion water molecules will ionize:

$$H_2O(l) \longleftrightarrow H^+(aq) + OH^-(aq)$$

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

As a result, the term for the concentration of water is considered to be a constant in the equilibrium equations involving dilute aqueous reactions. Therefore:

$$K = \frac{[H^+][OH^-]}{(\text{constant})}$$

$$K(\text{constant}) = [H^+][OH^-]$$

$$K_w = K(\text{constant}) = [H^+][OH^-]$$

The constant, Kw, is called the ion-product constant. At 25°C, the value of Kw is 1 x 10-14

$$Kw = [H^+][OH^-] = 1 \times 10^{-14}$$

**$[H^+] = 1 \times 10^{-7}$**

***(true for neutral solutions)***

# pH

**pH :** is a logarithmic scale used to specify the acidity or basicity of an aqueous solution. It is approximately the negative of the base 10 logarithm of the molar concentration, measured in units of moles per liter, of hydrogen ions.

$$p\,H = -\log[\,H+\,]$$

# p H values of human body fluids

| Compartment | pH |
|---|---|
| [27] Gastric acid | 1.5-3.5 |
| Lysosomes | 4.5 |
| Human skin | 4.7 |
| Bile | 7.8 |
| Urine | 6.0 |
| Cytosol , Saliva | 7.2 |
| **Blood (natural pH)** | **7.3–7. 5** |
| Cerebrospinal fluid (CSF) | 7.5 |
| Mitochondrial matrix | 7.5 |
| Pancreas secretions | 8.1 |

The pH of different cellular compartments, body fluids, and organs is usually tightly regulated in a process called **acid-base homeostasis**. The most common disorder in acid-base homeostasis is **acidosis**, which means an acid overload in the body, generally defined by pH falling below 7.35. **Alkalosis** is the opposite condition, with blood pH being excessively high.

The pH of blood is usually slightly basic with a value of pH 7.365. This value is often referred to as physiological pH in biology and medicine. **Plaque** can create a local acidic environment that can result in tooth decay by demineralization. Enzymes and other proteins have an optimum pH range and can become inactivated or denatured outside this range.

# Buffer solution

**A buffer solution:** is an aqueous solution consisting of a mixture of a weak acid and its conjugate base, or vice versa. Its pH changes very little when a small amount of strong acid or base is added to it. Buffer solutions are used as a means of keeping pH at a nearly constant value in a wide variety of chemical applications. In nature, there are many systems that use buffering for pH regulation.

# Buffer systems of the blood

The kidneys and the lungs work together to help maintain a blood pH of 7.4, any increment in pH causes alkalosis, in the opposite condition the decrement of pH causes acidosis. Therefore, the blood contains buffer solutions that has ability to maintain the pH of the blood from any change that may occur. These solutions are:

# 1- Bicarbonate-carbonic acid system

The bicarbonate buffer system is an acid-base homeostatic mechanism involving the balance of carbonic acid ($H_2CO_3$), bicarbonate ion ($HCO_3^-$), and carbon dioxide ($CO_2$) in order to maintain pH in the blood.

**When resistant the acid:**

$$NaHCO_3 + HCL \longrightarrow H_2CO_3 + NaCL$$

$$H_2CO_3 \longleftrightarrow H_2O + CO_2$$

The [H+] was increased when it added to the blood which is coming from tissues, then [$H_2CO_3$] will be increased subsequently $CO_2$ dissolved in blood will be increased. As a result, the excess comes out in the form of exhalation through the lungs.

## When resistant the alkaline:

$$H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

$$H^+ + OH^- \longrightarrow H_2O$$

When added OH ions to blood plasma, the [H+] will be decreased which increased the dissociation of $H_2CO_3$ to $H^+$ and $HCO_3$. As a result create amount of $CO_2$ gases in lungs will be dissolved in blood plasma to maintain the balance.

# 2- Mono and di hydrogen phosphate buffer:

The di hydrogen phosphate ion is weak acid, therefore it ionized to mono hydrogen phosphate and hydrogen ion :

$$H_2PO_4^- \rightleftharpoons HPO_4^- + H^+$$

Pka for acid = 6.8 nearby to the pH of blood 7.4 therefore, it is a good buffer for the blood.

$$7.4 = 6.8 + \log \frac{HPO^{4-}}{H_2PO^{4-}} \quad , \quad \log \frac{HPO^{4-}}{H_2PO^{4-}} = 0.6 \quad , \quad \frac{HPO^{4-}}{H_2PO^{4-}} = 5.01$$

[$HPO^{4-}$] is five times than [$H_2PO^{4-}$] that is mean the phosphate buffer is a good buffer for acidic system.

The phosphate buffer performs a more minor role than the carbonic-acid-bicarbonate buffer in regulating the pH of the blood. The phosphate buffer consists of phosphoric acid ($H_3PO_4$) in equilibrium with di hydrogen phosphate ion ($H_2PO^{4-}$) and ($H^+$).

The pK for the phosphate buffer is 6.8, which allows this buffer to function within its optimal buffering range at physiological pH. The phosphate buffer only plays a minor role in the blood, however, because H3PO4 and H2PO$^{4-}$ are found in very low concentration in the blood.

# 3- Serum proteins buffer

Serum blood contains many proteins which contains in chemical structure amino acids which have weak acidity , as **glutamic acid** and **aspartic acid**. Also contains amino acids which have weak basic as **lysine**, **arginine** and **histidine**. These acids are good buffer solutions, but these proteins are weak buffers if compares with bicarbonate and phosphate buffers.

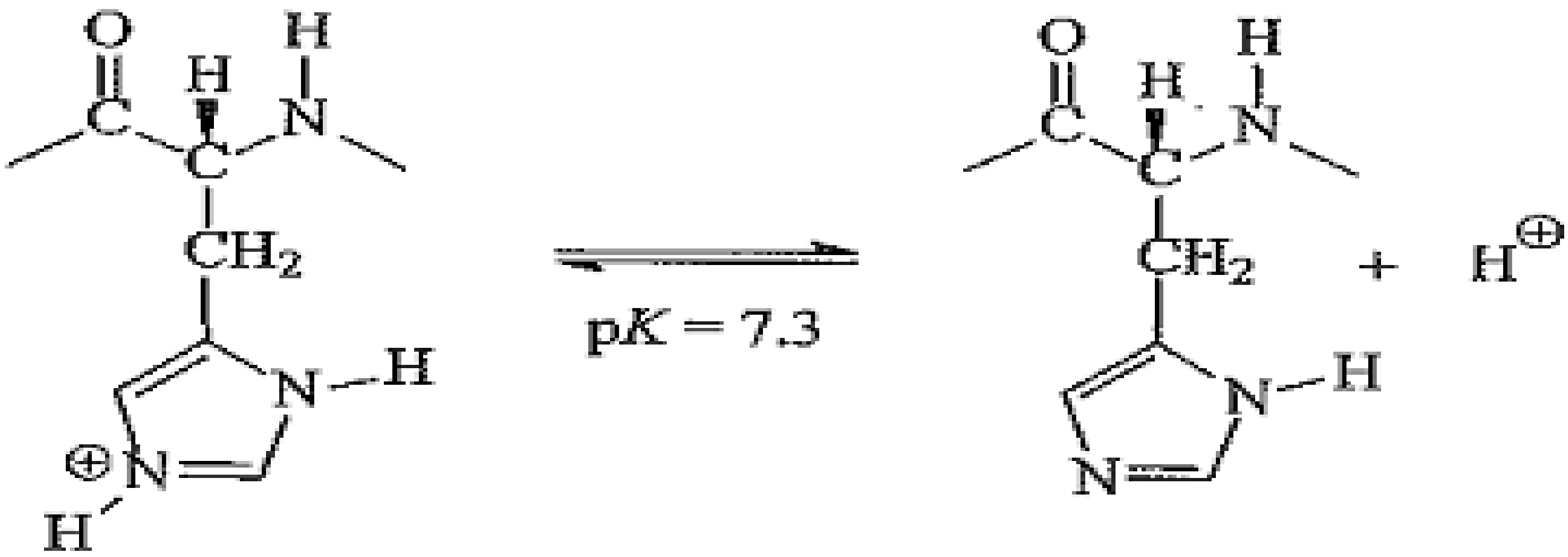
# 4- Hemoglobin buffer

Hemoglobin can accept $H^+$ as it has histidine, which is a basic amino acid. Moreover, deoxygenated hemoglobin has higher tendency to accept $H^+$ ( it's a better base as compared to oxygenated hemoglobin).

At the level of **tissues**, where $CO_2$ is more, hemoglobin accepts $H^+$.

At the level of the **lungs**, where $O_2$ is more hemoglobin releases $H^+$ and combines with $O_2$ (oxyhemoglobin is a stronger acid).

$O_2$+




Deoxygenated hemoglobin

Tissues

Oxyhemoglobin

**Or**

$HbO_2^- + H_2CO_3 \Leftrightarrow HHb + O_2 + HCO_3^-$