College of Environmental Sciences

Department of Environmental Health

2nd Class

First Lecture

Biochemistry

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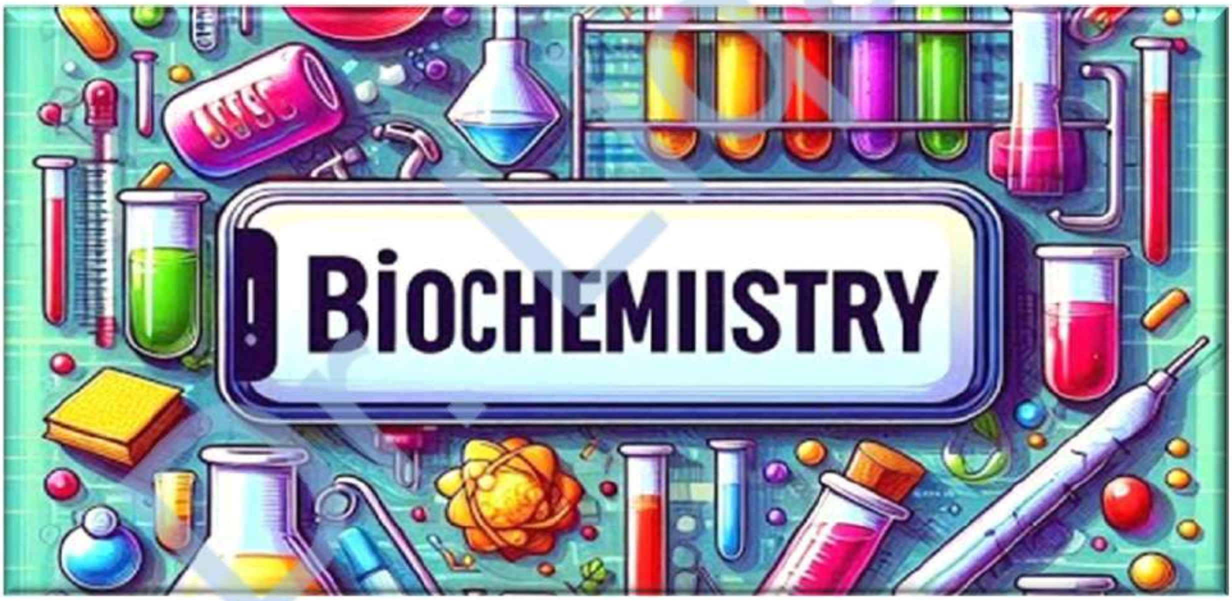


Definition of biochemistry and its importance

Definition: ***Biochemistry is the study of molecules in living organisms.***

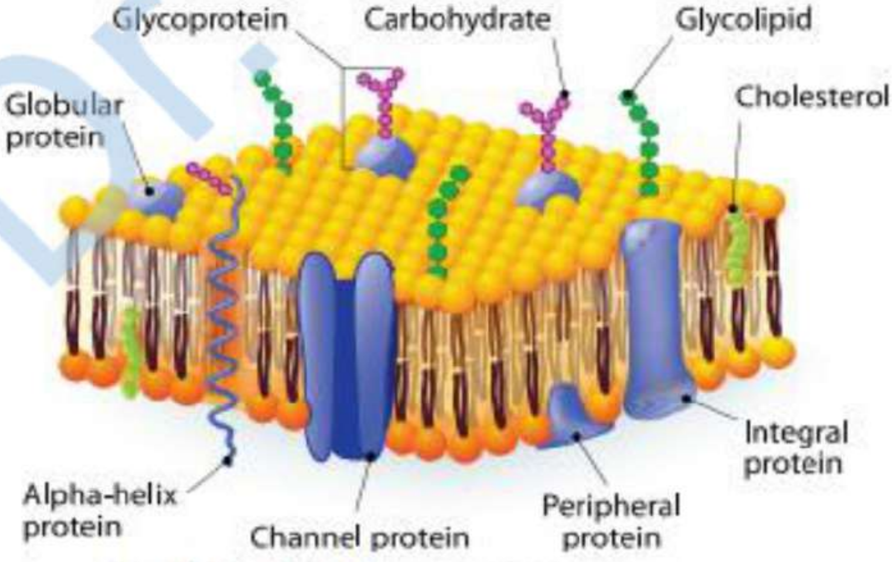
The importance of biochemistry: There is no doubt that there has been great progress in the field of biochemistry in the last ten years, so it has become today an interesting science for the following reasons:

1. Understand the structural foundations of many paths in the life sciences.
2. Know the chemical structure of DNA and solve the genetic code.
3. Determination of the three-dimensional of some molecules of proteins.
4. There is a fairly large similarity, between E.coli bacteria and humans at the level of building large molecules. This led to an understanding of the transfer of genetic information from deoxyribonucleic acid (DNA) to ribonucleic acid RNA and protein, as both humans and bacteria use ATP as an energy-rich substance.
5. Increasing the correlation of biochemistry in medicine, for example, the study of measurements of the activity of certain enzymes enables the pathological diagnosis of certain diseases. Studying the activity of SGOT or SGPT in the blood serum of a patient suspected of heart attack is valuable information for this disease.
6. At present it has been possible to reach the truth of some diseases, such as Sickle-Cell anemia and a large number of Inborn Error of Metabolic.
7. Biochemistry has also been seriously studying a number of studies that challenge scientists at the present time, for example, how can similar cells clump together for the purpose of forming complex tissue such as the liver, heart or muscle? How can stopping abnormal cell growth be controlled? And what is the mechanics of memory? What are the real causes of cancer? What are the causes of schizophrenia?

Cell parts and life processes in which they take place

1 . Cell membrane

The cell organelles are all surrounded by **a cell wall or membrane** and this **membrane plays an effective role in the passage of nutrients and waste into and out of the cell. The cell membrane is also called plasma membrane that the plasma membrane in both animal and plant cells and bacteria consists of complexes of phosphorylated protein and fat** as in the following figure. Most cells are immersed in a liquid rich in sodium and chloride ions and few potassium ions, while the cell contents are rich in potassium ions and few sodium and chloride ions. Thus, cell membranes involve active transport. **Active transport means the movement of ions or molecules from a low concentration environment and through the cell membrane to a higher concentration environment**. **Such a movement, which is opposite to the concentration gradient, requires energy in the form of adenosine triphosphate (ATP), so this process involves the action of certain enzymes that synthesize this energy. Large molecules, in general, do not pass directly through the cell membrane, but they can be taken into the cell by a process of cellular absorption (pinocytosis)**, and this begins with the formation of the cell membrane to form an absorption vessel that works to swallow large molecules and form a gap or lysosomes within the cell cytoplasm.



Model of Cell membrane

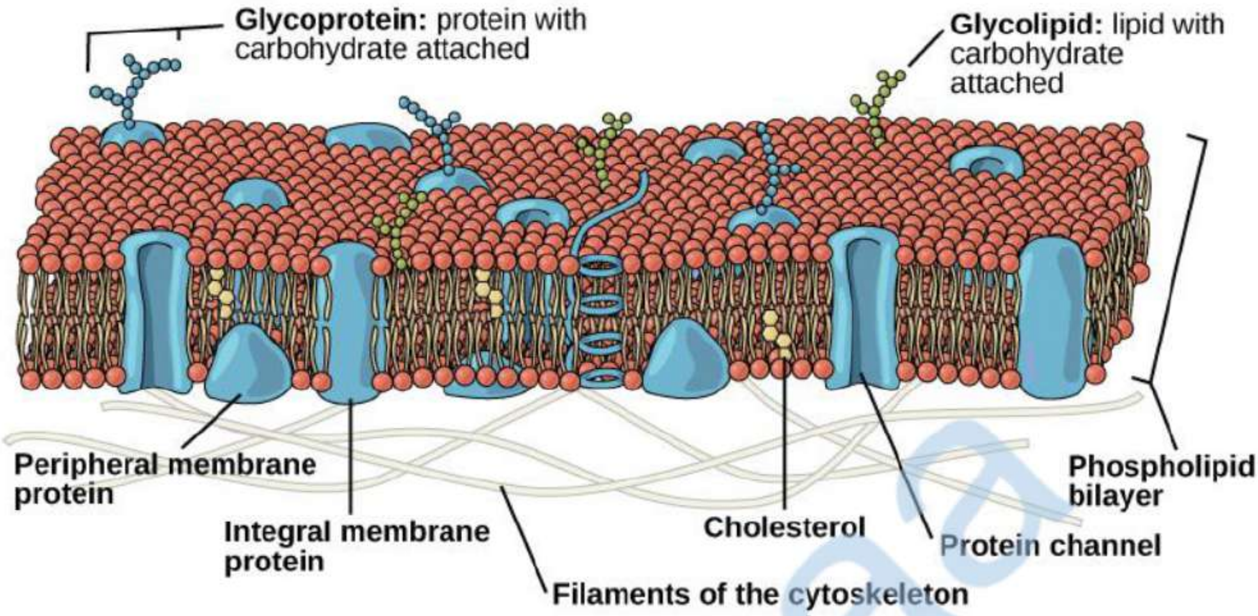


Figure: Cell membrane structure (plasma membrane)

2. The cytoplasm

The cytoplasm is the protoplasmic mass where the cell organelles are embedded in it and it is believed at present that **all the basic compounds and large molecules** that do not combine with specific organelles are found in the cytoplasm. **Most enzymes are found in the cytoplasm.**

3. The nucleus

The nucleus is a spherical or oval-shaped organelle, surrounded by a double membrane called the nucleus membrane, which regulates the flow of material into and out of the nucleus. In many cells, the outer membrane is attached to the nuclear membrane by one or more channels that pass through the cytoplasm. There is also usually a connection between the endoplasmic reticulum and the double nuclear membrane.

The nucleus contains chromosomes that consist of deoxyribonucleic acid, DNA and basic proteins called histones and the nucleus also contains one particle or dense and small spherical particles called Nucleoli, as these participate in the processes of formation of ribonucleic acid RNA.

At rest the deoxygenated DNA in high animal cells is diffused in the cell in an indefinite way, called chromatin, and during the period of cell division, this is organized in the form of distinct chromosomes. **The nucleus is the most important component of the cell, as it is the center of its activity, and it carries genetic traits and transmits them from one cell to another and from one generation to another, through division, in which it plays the main role.**

4 . Mitochondria

Both of these organelles have an **extended oval shape.** It is surrounded by a bilateral membrane, in which the outer layer is smooth, while the inner layer has many folds extending into the organelle cavity. **These shelve-like inner folds are called cristae and contain enzymes that form ATP by oxidative phosphorylation, and the matrix in the inner space of the mitochondriona contains proteins, neutral lipids, phosphorylated lipids, nucleic acids, as well as enzymes necessary for the Krebs cycle, as shown in the following figure. The nucleic acids in the mitochondria are mostly RNA and have little DNA, which is the opposite of what is in the nucleus.**

The production of energy in the form of ATP by the main oxidation processes and oxidative phosphorylation is the primary function of the mitochondria and is why they are called the energy houses of the cell. The number of mitochondria in each cell depends on how much energy the cell requires. For example, a cell that produces large amounts of proteins for export out requires a lot of energy, which requires a large number of mitochondria.

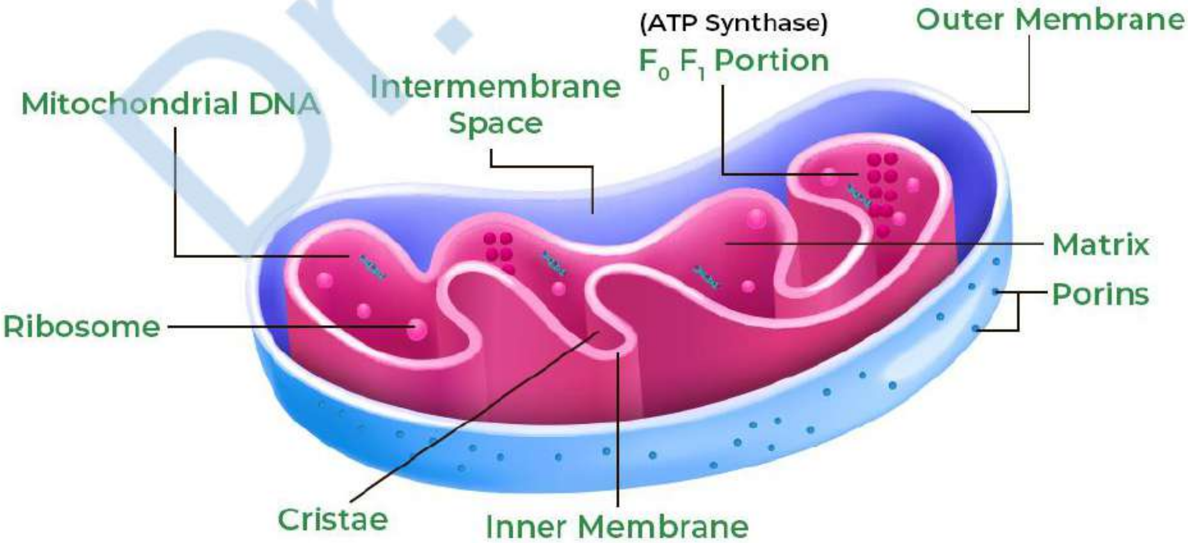


Figure: The structure of Mitochondria

5 . Microbody (Peroxisome)

Microbody (Peroxisome) are vessels with individual membranes and contain catalase enzymes, D-amino acid oxidizing enzymes, urate oxidase and other oxidizing enzymes. Microbody are involved in the oxidation of certain foods, and H2O2 is the product of oxygen reduction in these organelles. Hydrogen peroxide breaks down to form water and oxygen.

6 . Endoplasmic reticulum and ribosomes

The endoplasmic reticulum is a set of closed branched membrane channels that penetrate the cytoplasm and do not open in it. But it connects the nuclear membrane with other membranes surrounding the cytoplasm and other organelles. **There are two types of endoplasmic reticulum in the cell**. **One of them is smooth surface**. The **other is rough-surfaced and covered with dark granules containing 80% of the RNA in the cell.**

These granules are called ribosomes and there may be ribosomes united together forming a chain called polysomes, **which consists of the connection of a number of ribosomes to one molecule** of carrier RNA. **Ribosomes are the places of formation of proteins.**

7. Golgi bodies

Golgi bodies are vesicles stacked in parallel rows. With smooth membranes, the body of Golgi is often attached to a channel and acts as a station in the way of transporting materials produced from other organelles, for example. **In some cells, Golgi bodies store proteins formed in the endoplasmic reticulum. And that is temporarily. In order to transport and secrete an output through the cell membrane, Golgi bodies are believed to help in the formation of the cell membrane and are also believed to secrete some special substances such as hormones.**

8. Lysosomes

These organelles are spherical in shape. They contain a number of hydrolysis enzymes that have an optimal pH in the acid range. The membrane nature of lysosome is lipoprotein and this prevents the enzymes inside from escaping out into the cytoplasm of the cell, and When the cell dies or is injured and the membrane of lysosome is ruptured, the hydrolyzed enzymes will be released and lead to the self-degradation (digestion) of the cell contents.

9. Vacuoles

These particles are **spherical in shape** and are often near the golgi bodies and the channels that participate in the process of introducing or excreting substances into and out of the cell. **The vacuoles act as a temporary storage or as bodies that contribute to the process of removal of a foreign body from the cell.**

10. Chloroplasts

Plant cells contain highly pigmented particles. One of them is called chloroplast. These particles contain a green pigment (chlorophyll) and these play a major role in the process of photosynthesis and the chloroplast membrane contains membrane structures in the form of plates called grana as shown in the following figure, and chlorophyll and lipids are concentrated in the grana where photosynthesis occurs, and chloroplast is filled with a protein nature called stroma the basic substance. These contain enzymes involved in the process of fixing carbon dioxide in photosynthesis.

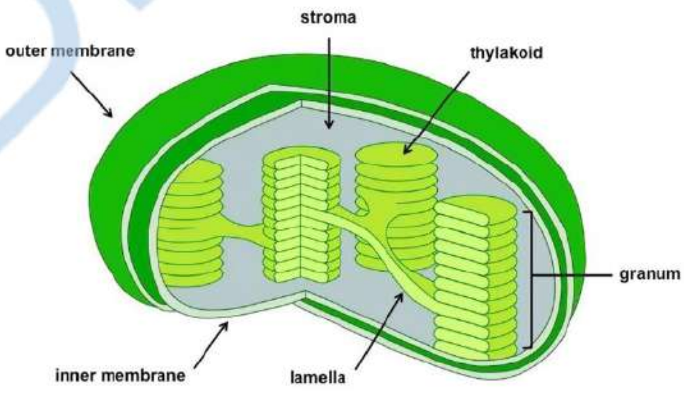
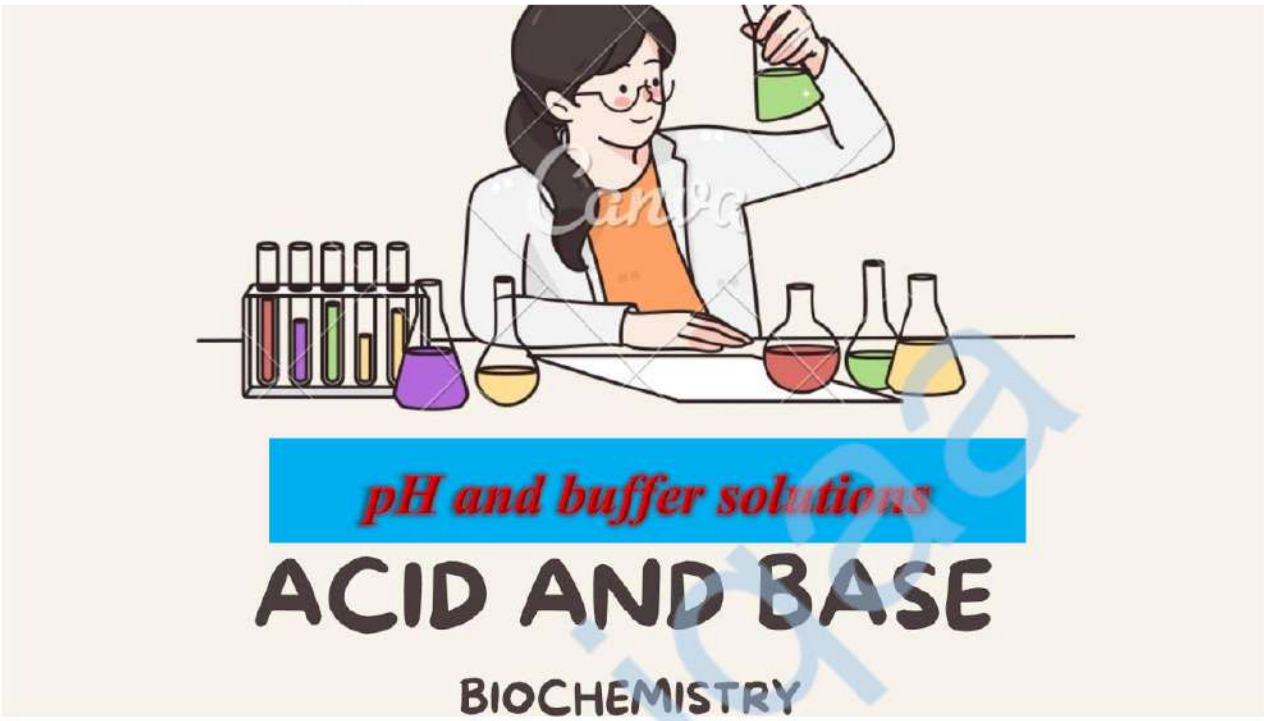


Figure: The structure of the chloroplast (chloroplast)

pH and buffer solutions

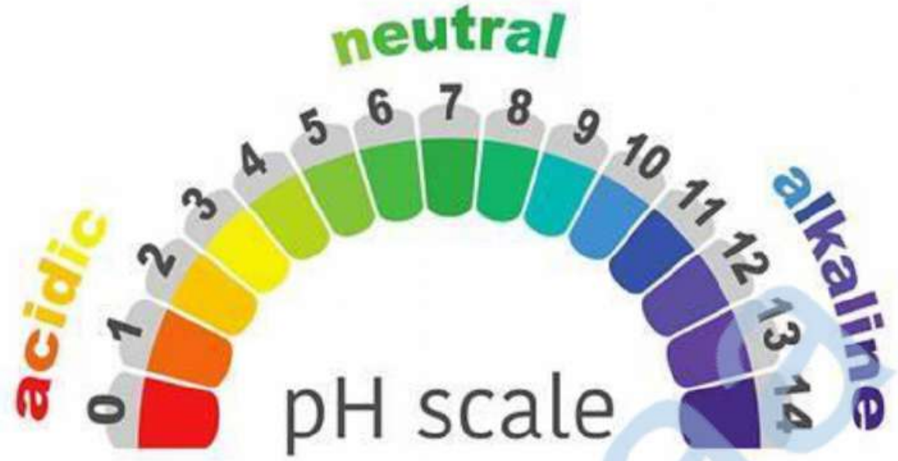


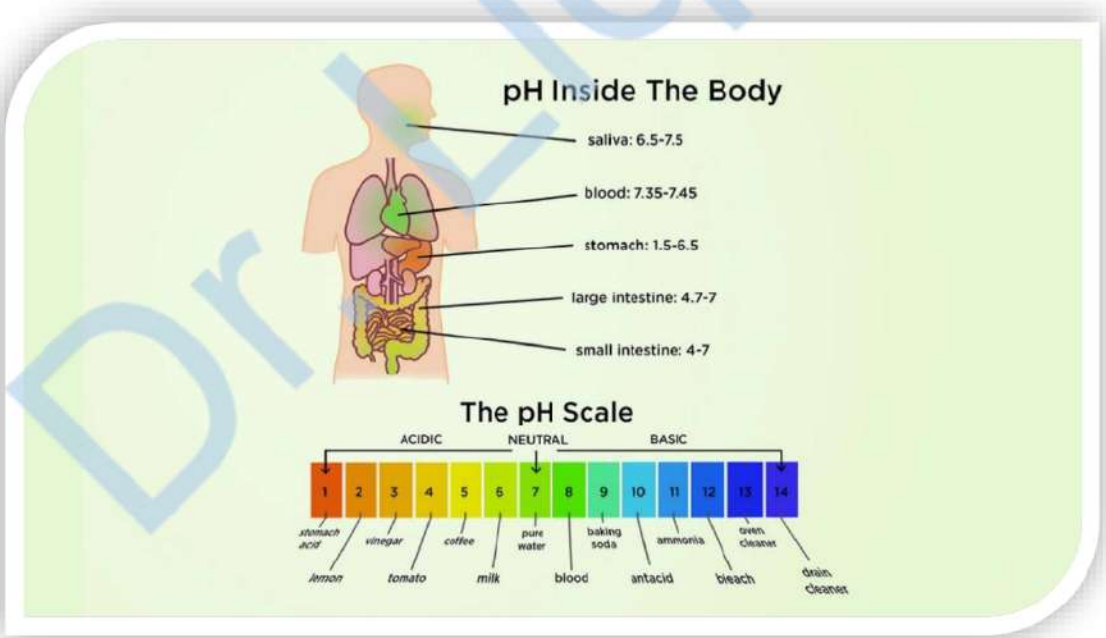
Bioreactions take place in aqueous solutions kept close to neutralization by the presence of buffers that are a mixture of a weak acid and a salt of that acid. A strong acid such as HCI dissociates completely, unlike a weak acid, which partially disintegrates, and this dissociation falls further with the presence of acid salt. pH in this mixture - which is the negative logarithm of the hydrogen ion concentration. It is a function of the ratio of weak acid and salt returning to it, and can be measured by the Henderson-Hasselbalch equation.

The cellular fluids of the tissues are regulated (conservative) in the presence of bicarbonate and phosphate salts as well as in the presence of high concentrations of proteins. Since bioreactions occur in an aqueous medium, it is likely kept close to neutralization. Therefore, the properties of acids, bases and buffers must be explained very briefly.

The best definitions of acids and bases in biochemistry are those of Bronsted, who defined acid as the substance that gives a proton and defined the base as the substance that accepts a proton. For each acid, there is a base associated with it called the conjugate base, and for each base there is an acid associated with it, called the conjugate acid, and the difference is the result of a missing or acquired proton.

pH of human body fluids





The pH of most body fluids tends to the basal side. The exception is gastric juice, which is strongly acidic. As for urine, it tends to acidic, as shown in the following figure:

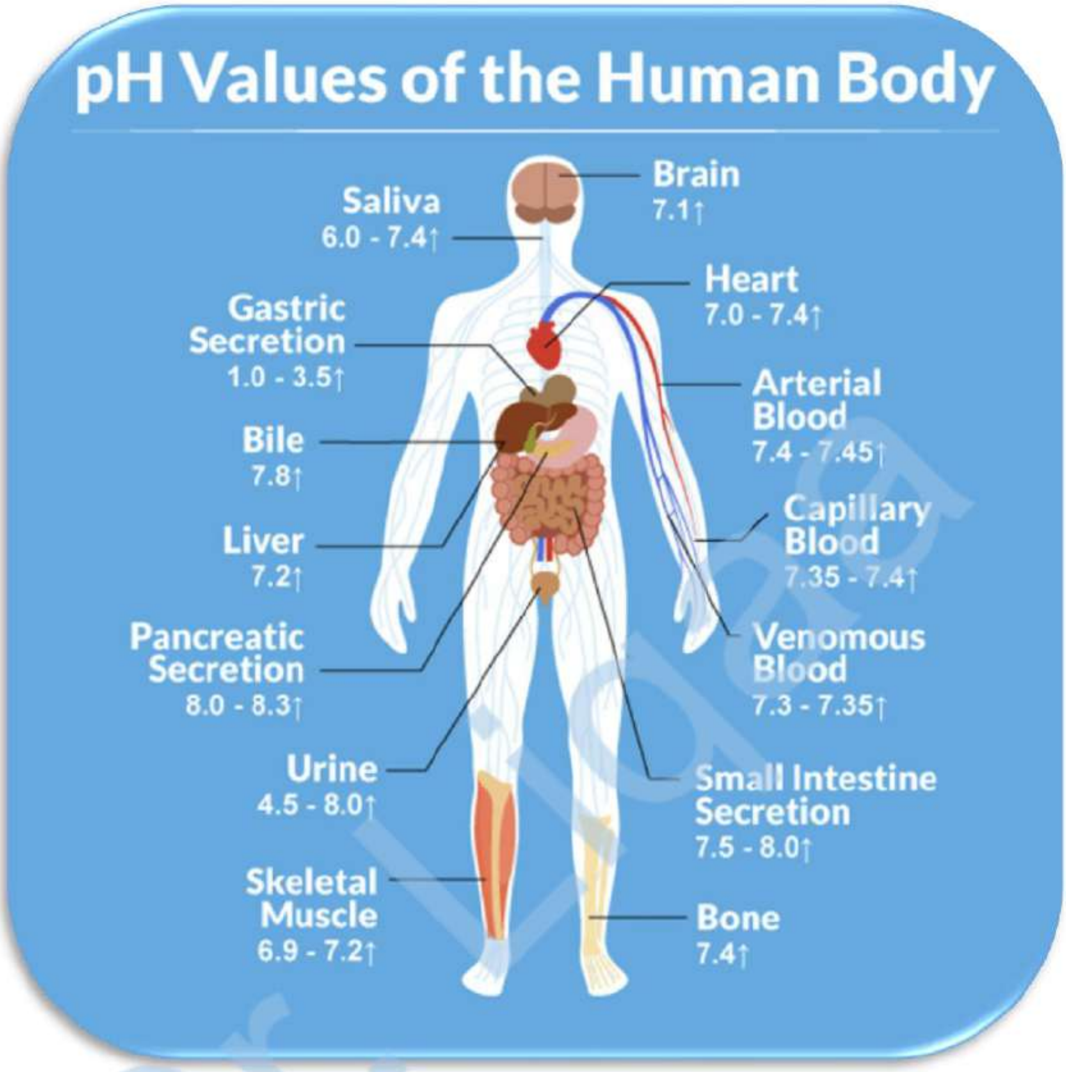


Figure: pH of human body fluids

There are effects that change the pH of body fluids, but the presence of buffer solutions inside the body prevents a change in the pH, for example, the range of pH of the blood ranges between 7.3-7.5 in a healthy state. But when the pH of the blood crosses the above range, a condition called acidosis, or alkalosis, occurs alerting an abnormal condition. It is difficult to keep the pH of a solution constant without containing another buffer solution. The effects of carbon dioxide in the air make the solution acidic, and glassware that are basic-made make the solution basic.

The benefit of buffer solutions is to reduce changes in the pH of a solution when exposed to an acid or base. A buffer solution is a mixture of a weak acid and its salt derived from a strong base.

Buffer solutions of blood

The pH value of the blood is equivalent to 7.4. Any increase in pH results in the so-called alkalosis and vice versa, when a decrease in pH results in a pathological condition called acidosis and therefore the blood contains buffer solutions have the ability to maintain the pH of the blood from any change that may occur to it and these solutions can be summarized as follows:

1. Bicarbonate_carbonic acid buffer

It is an important solution regulating blood plasma. This buffer is involved in resistance to acidic or basic effects that come through blood plasma. In the case of resistance of the regulator to acid, this is done as follows:

$$NaHCO3 + HCl \longrightarrow H2CO3 + NaCl$$

$$H_2CO_3 \leftrightarrow H_2O + CO_2$$

It is noted from the above two steps, that the concentration of hydrogen ion increases when added to the blood coming from the tissues, and results in an increase in the concentration of H2CO3, thus an increase in the dissolved CO2 in the blood, and as a result, the excess of it comes out in the form of exhalation through the lungs.

In the case of resistance of the buffer to the base, it is done as in the two steps below:

$$\underset{\text{carbonic acid}}{H_2CO_3} \rightleftharpoons H^+ + \underset{\text{bicarbonate}}{HCO_3^-}$$

$$H + OH \leftrightarrow H2O$$

In this case, when OH is added to the blood plasma. The concentration of H decreases in the blood, which increases the dissociation of H2CO3 into H and HCO3 and as a result a large amount of CO2 gas in the lung dissolves in the blood plasma to maintain the above balance.

2. Mono and Dihydrogen phosphate buffer

The dihydrogen phosphate ion is a weak acid, it ionizes into a monohydrogen phosphate ion and a hydrogen ion as in the equation:

$$H_2PO_4^-(aq) \rightleftharpoons H^+ + HPO_4^{2-}$$

The PKa value of the acid is equivalent to 6.8. This value is close to the pH of the blood 7.4, so this buffer is good for the blood and when applying the Henderson-Haselbag equation to this buffer at pH 7.4 and PKa 6.8, we get the ratio between H_2PO_4/HPO_4 which is 5.01.

That is, the concentration of the salt HPO_4 is five times the concentration of the acid H_2PO_4, and this indicates that **the buffer phosphate solution is good in acidic systems.**

3. Serum Protein buffer

Serum contains many proteins that contain in their chemical composition amino acids with weak acidity such as glutamic acid and aspartic acid, as well as weak basic amino acids, such as lysine, arginine and histidine. These acids are suitable to be buffer solutions. However, these proteins are weak regulators when compared to the buffers of bicarbonate, phosphate and hemoglobin in the red blood cell.

4. Hemoglobin buffer solution

The erythrocyte (Red blood cell, RBC) contains hemoglobin containing the amino acid histidine. This acid has the ability to accept hydrogen ions in the hemoglobin molecule and the excretion of oxygen, as in the following figure, and it is explain from this figure that in areas containing a high concentration of hydrogen ions, such as those that occur in tissues, where oxygen is released from hemoglobin, while areas where hydrogen concentration is low, such as fine capillaries in the lung, for example, oxygen remains attached to the hemoglobin molecule.

$$HBO2 + H2CO3 \longleftrightarrow HHb + O2 + HCO3$$

Oxyhemoglobin (HBO2) and Deoxygenated hemoglobin (HHB)

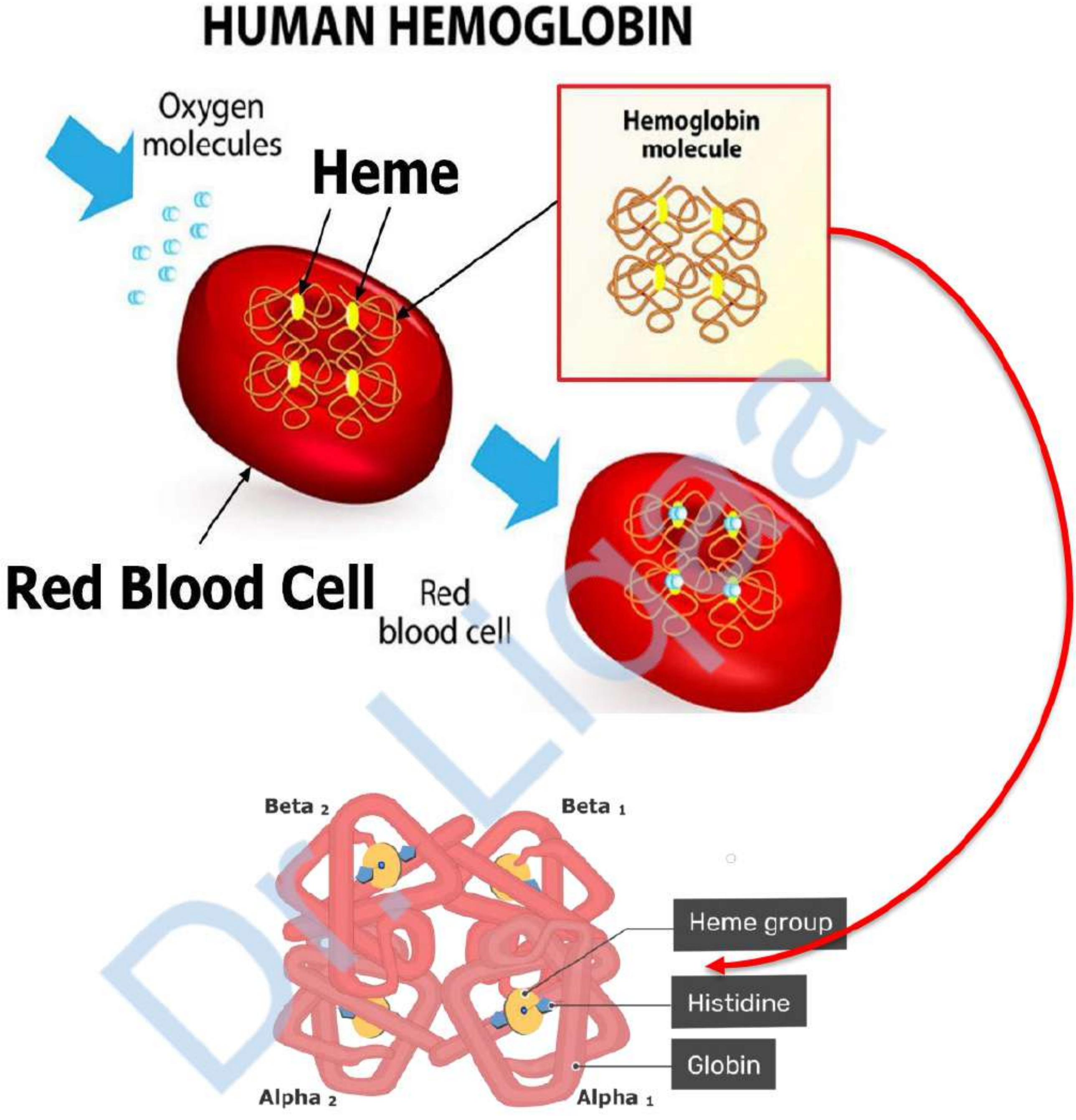


Figure: The structure of hemoglobin

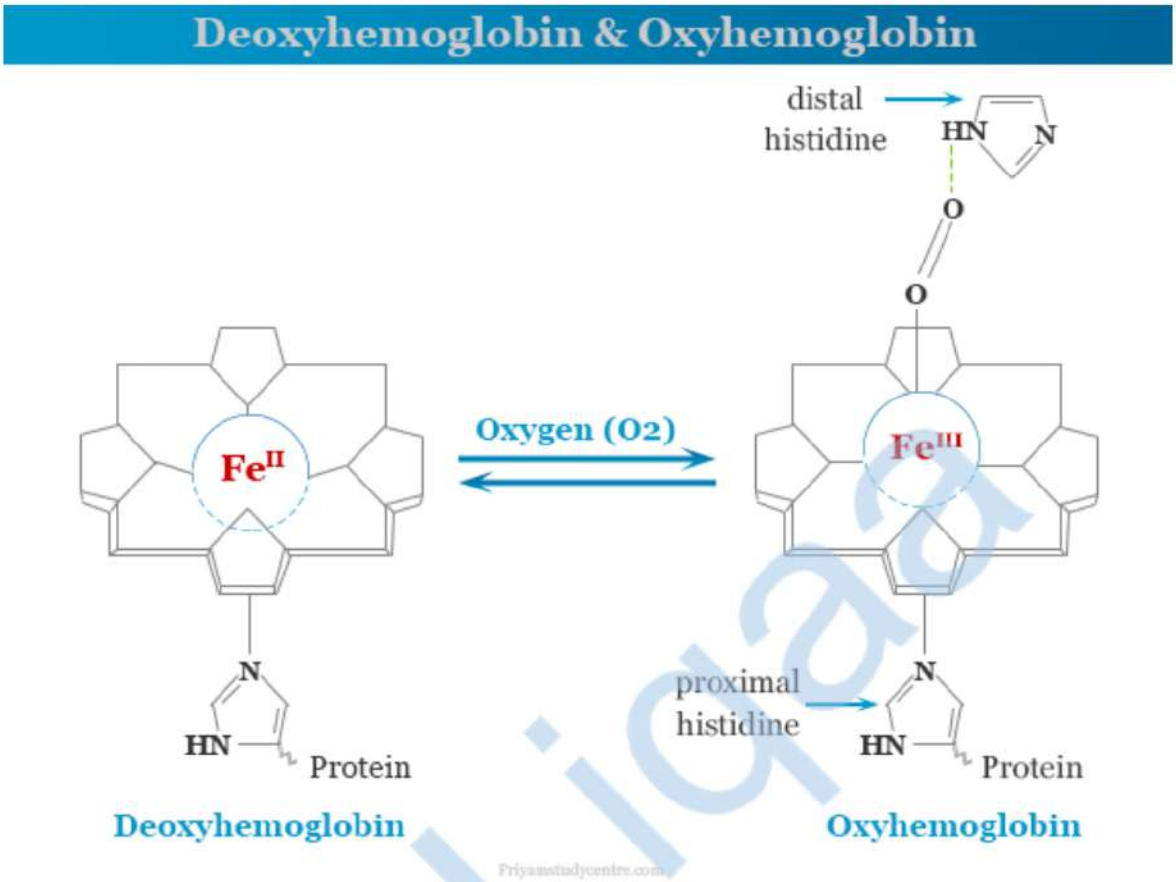


Figure: Deoxyhemoglobin and Oxyhemoglobin