Biochemistry Lecture 5 Notes

Buffers in human body (biological buffers)

- **Carbonic acid-bicarbonate system (blood)**
  Carbonic acid => H_2CO_3
  BiCarbonate ion => HCO_3^-
  Also found in interstitial fluid and intracellular

Now if you are smart you will notice something weird about this buffer which is that it's Parka = 6.1 which means that it's buffering region (5.1 , 7.1) -as we said before (1+PKa/1-PKa) - and if you search about the ideal PH of the blood (where it's supposed to function) is equal to 7.4 which out of the buffering region so how it's still effective? You will know that as we move through these sheets.

- **Dihydrogen phosphate-mono-hydrogen phosphate system(intracellular)**
  Dihydrogen phosphate => $H_2PO_4^-$
  Monohydrogen phosphate => HPO_4^{-2}
  Also found in interstitial fluid

- **ATP, glucose-6-phosphate, bisphsphoglycerate (RBC)**

Ask your self what's the common between these molecules? **They are bounded to one phosphate group or more.** What's special about phosphate groups? **They can bind to H+ and by this the maintain the PH.**

ATP => adenosine Triphosphate (the phosphate groups are attached to the same carbon because Tri not Tris).

Glucose-6-phosphate => glucose bound to one phosphate group on carbon number 6.

Bisphsphoglycerate => glycerate bound to 2 phosphate groups on different carbons (cause bis not bi).

- **Proteins (extracellular and intracellular)**

Why proteins are considered as an buffers ? **cause they are composed of amino acids that can bind to hydrogen at the carboxylic group and amino group on both free end of long protein (while the in between can't -they already making peptide bonds-).**

- **Hemoglobins in blood.**
  Can bind H+ to specific histidine residues Also, can bind to CO_2 (acid, part of buffering System of blood) and form carbamate ion.

Bicarbonate buffer (Carbonic acid-Bicarbonate system)

Imagine if your blood doesn't contain any buffers that resist changes in PH what's going to happen? Simply we are going to die. Why? because when we eat something acidic or basic it's OH- or H+ will diffuse to the blood changing it's PH drastically approximately like the change of PH when we add a Strong acid to water and this change will make most of the proteins dysfunctional and our body will lose the ability to maintain its functions and then we die.

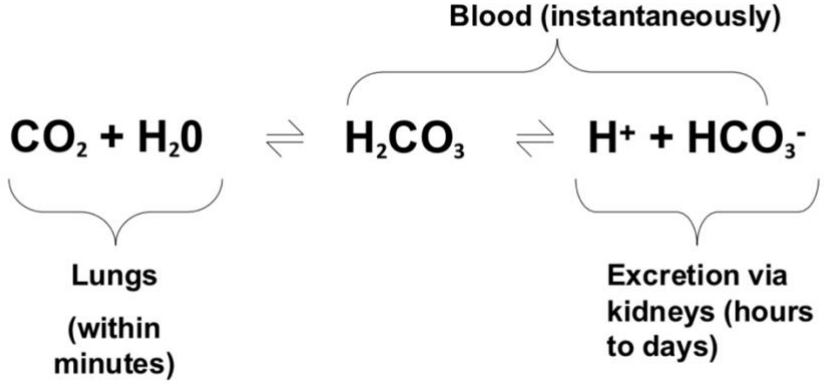
So we have Bicarbonate buffer in the blood to resist changes in the PH and I have already mentioned that there is something special about this buffer, which is even when the blood PH is not within the buffering range of carbonic acid it still can maintain PH of the blood How this can be possible ?!

It can happen due to 3 reasons :

Reasons

- **Relatively high concentration in ECF (24mmol/L)**
  Why? It's components are easy to have, we are having H2O every where in our body and CO2 are easily produced by kerbs cycle and aerobic respiration.
  You may ask why we talk about H2O and CO2 , doesn't Bicarbonate buffer system is composed of H2CO3/ HCO3-

  $H_2O + CO_2 <-> H_2CO_3 <-> HCO_3^- + H^+$ ولك با هبل مهي
- **It's components is maintained by physiological control which make it**
  Through Kidneys and lungs
- **It's an open system (continuously interacting with environment).**



This buffer like any other buffer is falling against constant supplying of H+ or OH- leading to one of two states:

- **Acidosis: PH < 7.35**

- **Alkalosis: PH > 7.45**

Since Bicarbonate buffer is an open system that can be controlled by lungs and kidneys and if there is an issue with one of them it will lead to disturb the equilibrium and change the PH either up or down or in other words either:

- **Acidosis**
- **Respiratory: hypoventilation.** (asthma, emphysema)
- **Metabolic: production of ketone bodies.(starvation)**

Each one of them could be respiratory or metabolic depending on the causing of the change in PH.

- **Alkalosis**
- **Respiratory: hyperventilation.**(anxiety)
- **Metabolic: eating of many salts.**

➢ **Let's explain them one by one:**

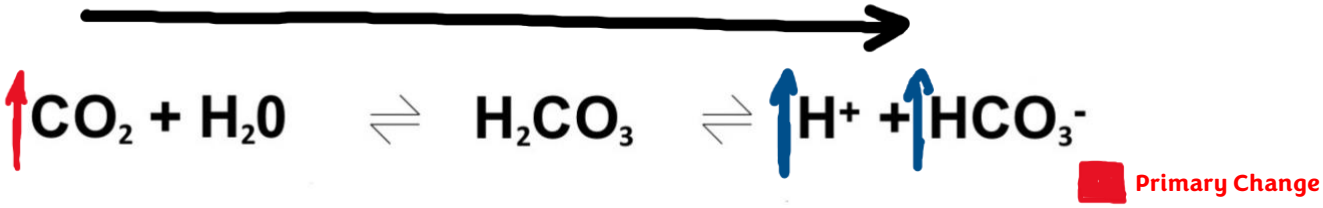
- **Respiratory Acidosis:**
  It can be caused by asthma, emphysema, Choking , Bronchopneumonia and COAD, but what are these? All of them are different pathological conditions happens to the lungs but they have the same result which is increasing [CO2] concentration in the blood.

- Asthma => inflammation of muscles around airways. => الربو

- Emphysema => the air sacs in the lungs (alveoli) become damaged, making it difficult to breathe. => إنتفاخ الرئة

- COAD => chronic obstructive pulmonary or airways disease

- Bronchopneumonia => problem in exhaling leads to increase CO2



When one of the above conditions happens :

1) It will increase [CO2] in blood.
2) Equilibrium will be disrupted.
3) The reaction will be directed forward to restore equilibrium again.
4) The concentration of HCO3- and H+ will increase and this will reduce PH of the blood.
5) Equilibrium is restored.

And this why these case called respiratory acidosis because :

1) PH decreased

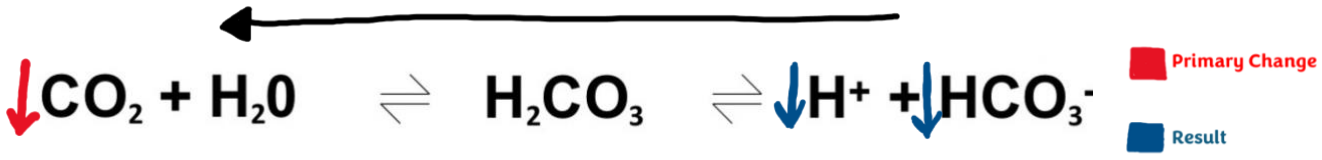
2) the reason of this decrease is the condition happening in the lungs.

- **Respiratory Alkalosis:**

Causes :

1) Hysterical over-breathing => Rapid breathing decrease CO2 levels as it removes faster.
2) Mechanical over-venalition => happens with patients on artificial breathing machines.
3) Raised intercranial pressure => brain try to reduce CO2 in order to decrease the blood flow to it to decrease the intercranial pressure.

These are different conditions but all of them has the same result which is decreasing CO2 levels.



When one of the above conditions happens :

1) It will decrease pCO2 in blood.
2) Equilibrium will be disrupted.
3) The reaction will be directed backward to restore equilibrium again.
4) The concentration of HCO3- and H+ will decrease and this will increase PH of the blood.
5) Equilibrium is restored.

And this why this case called respiratory alkalosis because :

1) PH increase.

2) the reason of this increase is the condition happening in the lungs.

- Metabolic Acidosis:

Causes:

1) Impaired H+ excretion
2) Increased H+ production or ingestion.
3) Loss of HCO3- (starvation ; not eating for a long time)

زي إخوننا في القطاع.. لا تنسوهم من صالح دعائكم!

These are different conditions but all of them has the same result which is increasing H+ concentration in the blood.

When one of the above conditions happens :

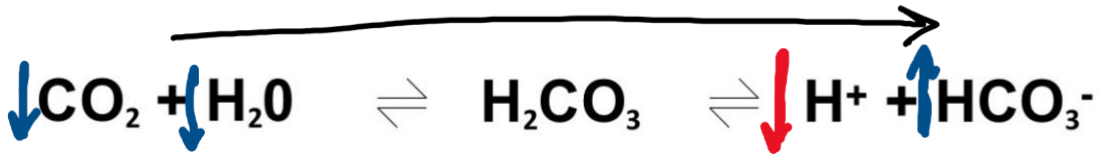
1) **It will increase [H+]in blood and PH decreases**
2) **Equilibrium will be disrupted.**
3) **The reaction will be directed backward to restore equilibrium again.**
4) **The concentration of HCO3- will decrease and H+ will also decrease to maintain PH of the blood.**
5) **Equilibrium is restored.**

- Metabolic alkalosis:

Causes:

4) Loss of H+ in vomit.
5) Alkali ingestion.
6) Potassium deficiency.

These are different conditions but all of them has the same result which is decreasing H+ concentration in the blood.



When one of the above conditions happens :

1) **It will decrease [H+]in blood and PH increases**
2) **Equilibrium will be disrupted.**
3) **The reaction will be directed forward o restore equilibrium again.**
4) **The concentration of HCO3- will increase and H+ will also increase to maintain PH of the blood.**

5) Equilibrium is restored.

Compensation

If the change in PH was done by respiratory: compensation will be by kidney (renal mechanism).

If the change in OH was done by metabolic: compensation will be by respiratory (hypoventilation or hyperventilation).

Compensation could be partial of complete

Complete => PH (after compensation) within normal range [7.35, 7.45].

Partial => PH (after compensation) out of the normal range but relatively close to it.

Complete compensation

	pH	pCO_2	HCO_{3-}
Resp. acidosis	Normal but<7.40	primary change ↑	compensation ↑
Resp. alkalosis	Normal but>7.40	primary change ↓	compensation ↓
Met. Acidosis	Normal but<7.40	compensation ↓	primary change ↓
Met. alkalosis	Normal but>7.40	compensation ↑	primary change ↑

Here pH are within normal range.

Partial Compensation

Here pH values aren't within normal range

	pH	pCO_2	HCO_3^-
Res.Acidosis	down	up primary change	up compensation
Res.Alkalosis	up	Down primary change	Down compensation
Met. Acidosis	down	Down compensation	Down primary change
Met.Alkalosis	up	up compensation	up primary change

The question on this topic will be a case question (clinical like questions).

You will need to memorise ABG (arterial blood gases) so you can know when the question tells you for example pCO2 = 50 you should know it's higher than normal level which is [35, 45].

	ABG	VBG	CBG
pH	7.35-7.45	7.25-7.35	7.35 – 7.45
PCO2 (mmHg)	35-45	41-51	35 – 48
PO2 (mmHg)	80-100	35-40	80-100
HCO3 (mmol/L)	22-26	22-26	22 – 27

الحمد لله