ACID BASE BALANCE
BY
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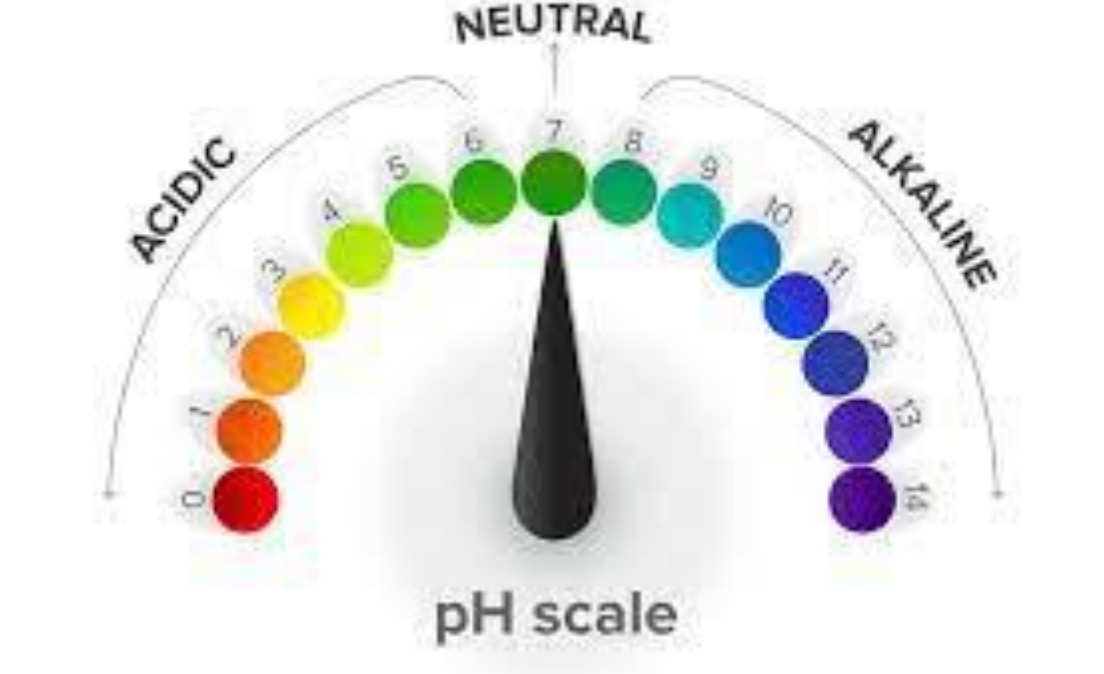
لارم تكون الحماية ضد ال acidosis لانه الجسم بطبيعة الاحوال مثلا بال glycolysis رح تنتج احماض ف لازم اسوي حماية ضدها



* لحا اذ بها بالي
ممكن تعطيني
acid او base

Maintenance of blood pH

! acidosis is more dangerous

- The normal pH of the blood is maintained in the narrow range of 7.35- 7.45 (slightly alkaline).

If the range is interrupted it may cause neither acidosis or alkalosis

- The body has developed three lines of defense to regulate the body's acid-base balance

Bicarbonate to carbonic acid 20:1 > alkaliside

- 1- Blood buffers

Weak acid with strong base

Carbonic acid
Bicarbonate > alkaline

As a buffer there should be alkaline more than acid due to the defence mechanism.

- 2- Respiratory mechanism
- 3- Renal mechanism
- Blood buffers:
- A buffer may be defined as a solution of a weak acid & its salt with a strongbase

Blood contains three buffer systems

base / alkali

- Bicarbonate buffer

bicarbonate % > Carbonic acid x20, since i want to treat acidosis

- Phosphate buffer
- Protein buffer
- Bicarbonate buffer system:
- Sodium bicarbonate & carbonic acid ($NaHCO_3$- H_2CO_3) is the most predominant buffer system of ECF.
- Carbonic acid dissociates into hydrogen and bicarbonate ions.

$$H_2CO_3 \longleftrightarrow H^+ + HCO^-_3$$

- The blood pH 7.4, the ratio of bicarbonate to carbonic acid is 20: 1

Acidosis can be due to the decrease in carbonic acid and increase bicarbonate base

- The bicarbonate concentration is much higher (20 times) than carbonic acid in the blood.
- This is referred to as alkali reserve. (مخزون)

another name for buffer system

عندي كتير base بطلعه ما بكون في كتير acid

Respiratory mechanism for pH regulation

- A rapid mechanism.

But can't be used in long term

- This is achieved by regulating the concentration of carbonic acid (H_2CO_3) in the blood.

hyper → ↑ basic

hypo → ↑ acidic

↑ in acidosis so, hyper to fix & avoid its dissolving

In the RBC the mechanism is anaerobic due to the absence of mitochondria

The large volumes of CO_2 produced by the cellular metabolic activity. All of this CO_2 is eliminated from the body in the expired air via the lungs

$$H_2CO_3 \xrightarrow{\text{Carbonic anhydrase}} CO_2 + H_2O$$

The respiratory centre is highly sensitive to changes in the pH of blood.

Decrease in blood pH causes hyperventilation to blow off co_2 & reducing the H_2CO_3 concentration

- Respiratory control of blood pH is rapid but only a short term regulatory process, since hyperventilation cannot proceed for long.

Hemoglobin as a buffer

- Hemoglobin binds to H^+ ions & helps to transport CO_2 as HCO_3^- with a minimum change in pH.
- In the lungs, hemoglobin combines with O_2, H^+ ions are removed which combine with HCO_3^- to form H_2CO_3 & is dissociates to release CO_2 to be exhaled.

Generation of HCO_3 by RBC

- Due to lack of aerobic metabolic pathways, RBC produce very little CO_2.
- The plasma CO_2 diffuses into RBC along the concentration gradient, it combines with water to form H_2CO_3 by Carbonic anhydrase.
- In RBC, H_2CO_3 dissociates to produce H^+ & HCO_3^-
- The H^+ ions are buffered by Hemoglobin.
- As the concentration of HCO_3^- increases in the RBC, it diffuses into plasma along with concentration gradient, in exchange for Cl^- ions, to maintain electrical neutrality.

High

Low

higher in plasma

dissolves it

CA dissociation

low

High

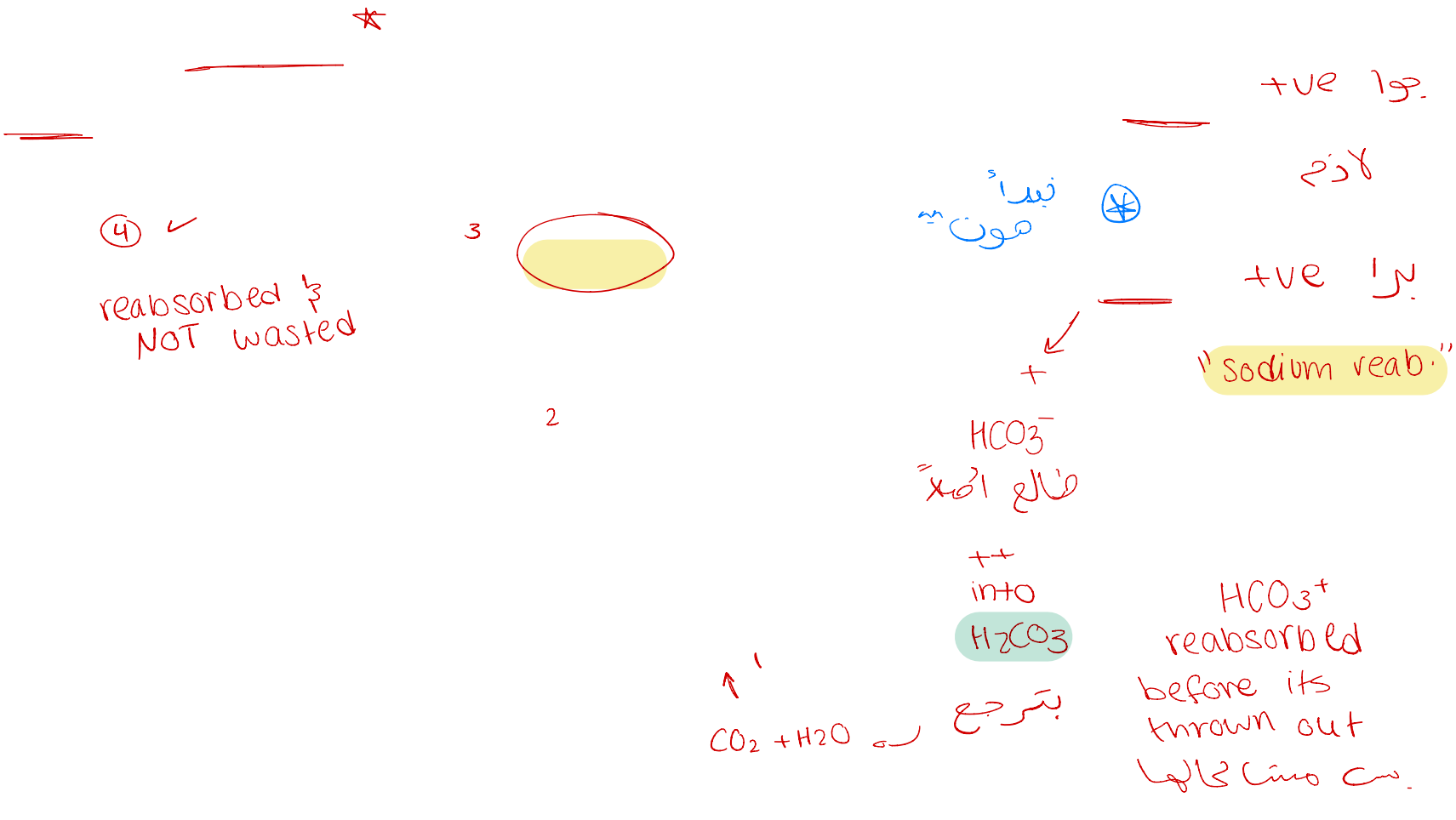
-ve out

2 Y

-ve in

Excretion of H^+ ions

- Kidney is the only route through which the H^+ can be eliminated from the body.
- H^+ excretion occurs in the proximal convoluted tubules & is coupled with generation of HCO_3-.
- Carbonic anhydrase catalyses the production of carbonic acid (H_2CO_3) from CO_2 & H_2O in renal tubular cells.
- H_2CO_3 then dissociates to H^+ & HCO_3-
- H^+ ions are secreted into tubular lumen in exchange for Na^+
- Na^+ in association with HCO_3^- is reabsorbed into blood


+ve
+ve
"sodium reab."
+
HCO_3^-
++
into
H_2CO_3
$CO_2 + H_2O$
HCO_3^+
reabsorbed
before its
thrown out
reabsorbed
NOT wasted
4
3
2

Reabsorption of Bicarbonate

- This mechanism is responsible to conserve blood HCO_3^-, with simultaneous excretion of H^+ ions.
- Bicarbonate freely diffuses from plasma into tubular lumen.
- HCO_3^- combines with H^+, secreted by tubular cells, to form H_2CO_3.
- H_2CO_3 is then cleaved to form CO_2 and H_2O.
- As the CO_2 concentration builds up in the lumen, it diffuses into the tubular cells along the concentration gradient.

- In the tubular cell, CO_2 again combines with H_2O to form H_2CO_3 which then dissociates into H^+ & HCO_3^-
- The H^+ is secreted into the lumen in exchange for Na^+.
- The HCO_3^- is reabsorbed into plasma in association with Na^+.
- Reabsorption of HCO_3^- is a cyclic process without net excretion (1) of H^+ or generation (2) of new HCO_3^-

alkalining urine until it matches blood PH

base

! how much [sodium hydroxide] we add to urine to match its PH = 7.4 to bloods

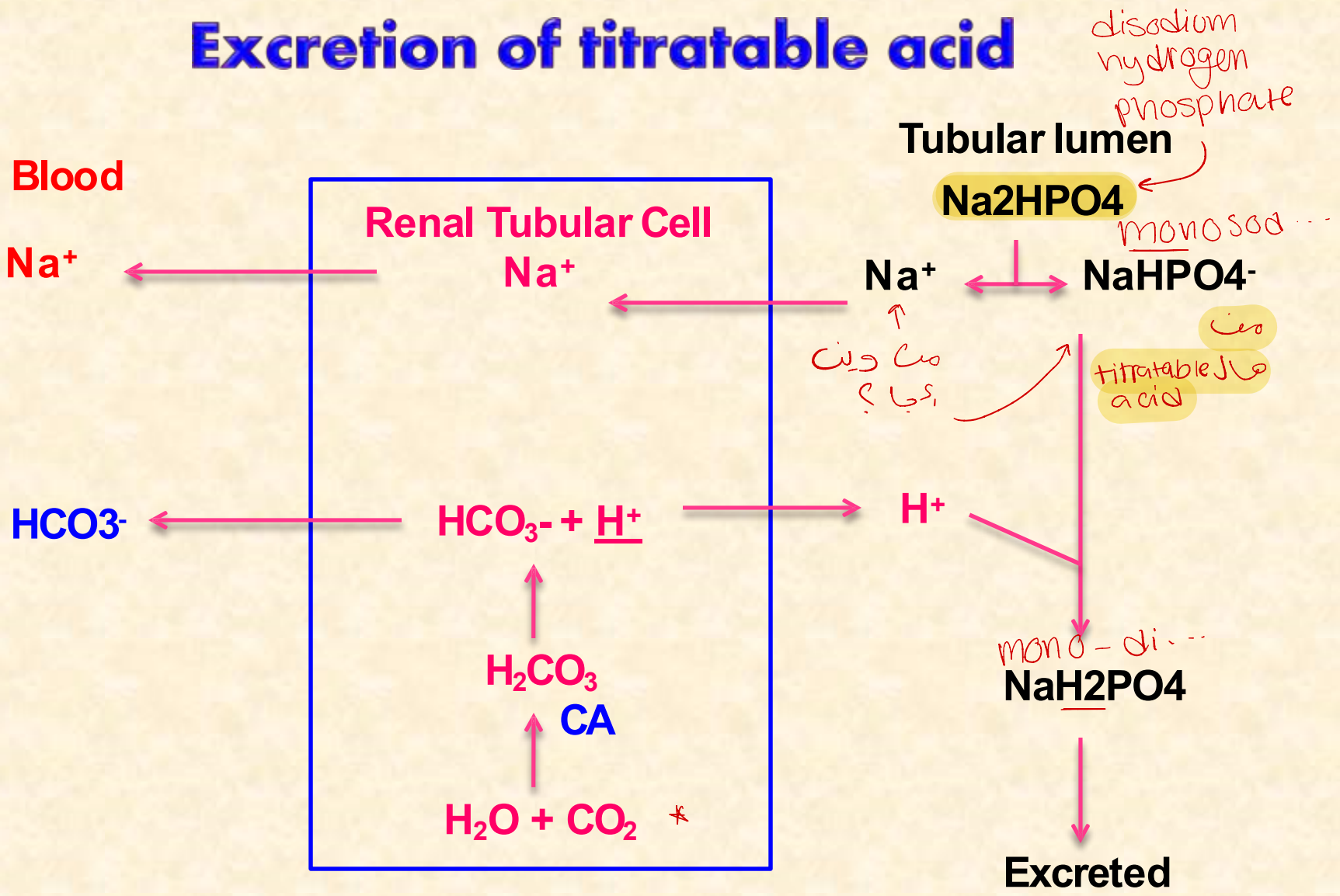
PH = 7.35 - 7.45

- H^+ ions are secreted into the tubular lumen in exchange for Na^+ ion.
- This Na^+ is obtained from the base, disodium hydrogen phosphate (Na_2HPO_4).
- This combines with H^+ to produce the acid, sodium dihydrogen phosphate (NaH2PO4), in which form the major quantity of titratable acid in urine is present.
- Tubular fluid moves down the renal tubules,

more and more H^+ ions are added, resulting in the acidification of

urine. Causes a fall in the pH of urine as low as 4.5.

Excretion of titratable acid

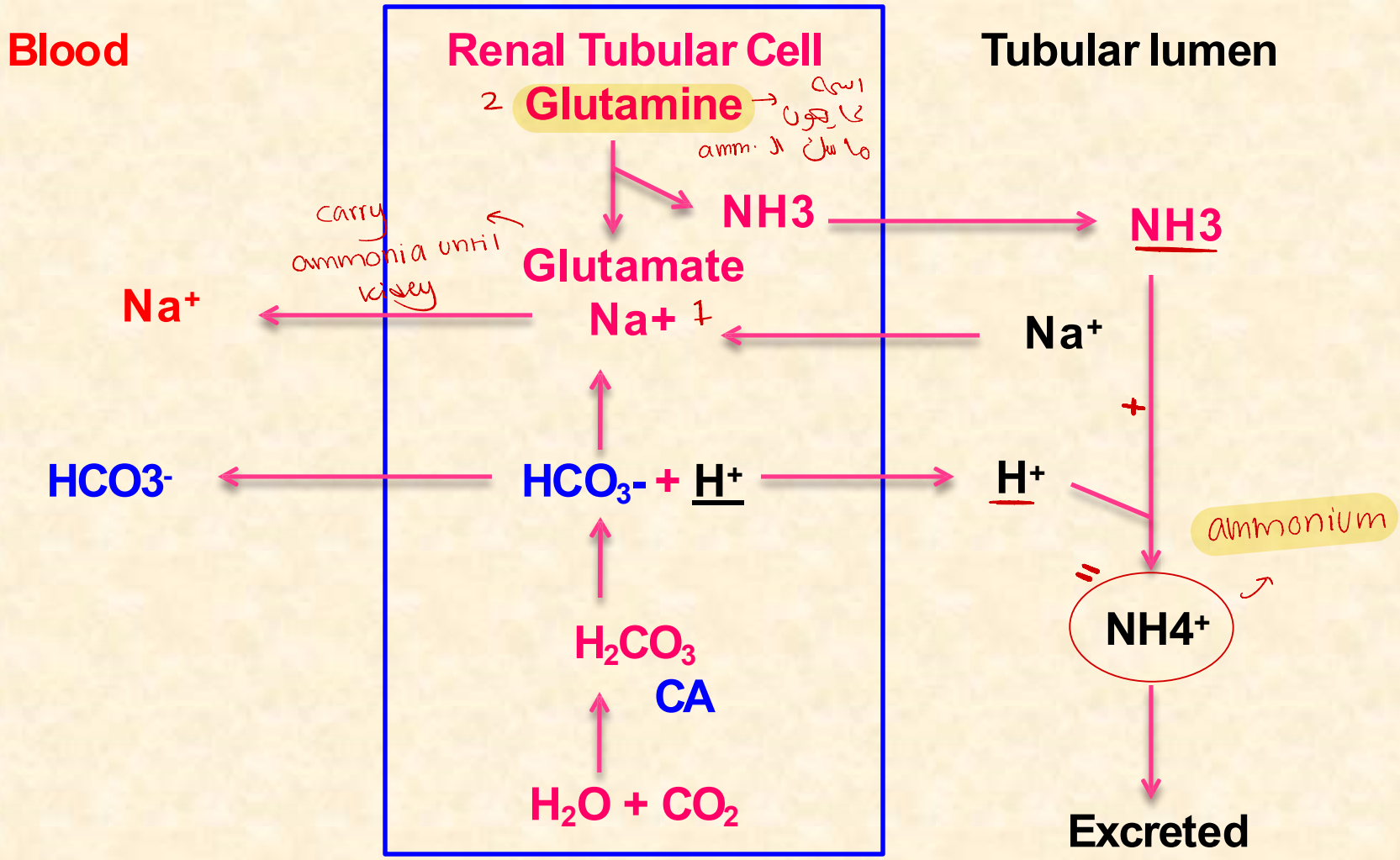


Excretion of ammonium ions

- The H^+ ion combines with NH3 to form ammonium ion ($NH4^+$).
- The renal tubular cells deaminate glutamine to glutamate and NH3 by the action of enzyme glutaminase.
- The liberated NH3 diffuses into the tubular lumen where it combines with H^+ to form $NH4^+$.
- Ammonium ions cannot diffuse back into tubular cells and excreted into urine.

Ammonia is toxic
One of the ways in excreting it is by urine

Excretion of ammonium ions



Acidosis

Blood PH tend to ↓

1820
صار خلل

Results from formation of **excessive acids**

More than the capacity of the body to eliminate them

↑ carbonic
↓ bicarb

carbonic ← حامض
acid

Respiratory acidosis

Metabolic acidosis

Respiratory acidosis

Q. cases.

hypoventilation الأسباب *

↑CO2 (CO2 RETENTION) due to

- Bronchial asthma
- Chronic bronchitis
- Emphysema
- Pneumonia
- Respiratory centre inhibition
- Asphexia

If lung is abnormal kidney will fix the case

↑CO2 → ↑ blood H2CO3

Respiratory acidosis

↑CO2 → ↑ blood H_2CO_3

→ HCO_3^- not changed

→ ↓ HCO_3^-/H_2CO_3 (N=20:1)

→ ↓blood PH

(Uncompensated respiratory acidosis [acidemia])

How to compensate?

Kidney reabsorbs more HCO_3^-

Till normal HCO_3^-/H_2CO_3 (20:1)

→ PH reach 7.4

NOT hypervent. cuz lung is not healthy

Metabolic acidosis

↑ acids or ↓ bases (HCO_3^-) in blood

→ ↓ blood HCO_3^-

blood H_2CO_3 not changed

→ ↓ HCO_3^-/H_2CO_3 (N=20:1)

→ ↓blood PH

(Uncompensated metabolic acidosis [acidemia])

How to compensate?

↓ PH→ ++ chemoreceptors in respiratory centre→ hyperventilation→ loss of CO_2→↓H_2CO_3

Till normal HCO_3^-/H_2CO_3 (20:1)

→ PH reach 7.4 (Compensated metabolic acidosis)

Causes of Metabolic acidosis

1- ↑blood acids

Lactic acidosis
Uncontrolled Diabetes inscp that will cause increase in ketone bodies

↑production

- ↑ lactic acid in muscular exercise
- ↑ ketone bodies in Ketosis due to Diabetes mellitus
- ↑ acids from metabolism of different food stuffs (diet) as pyruvic , lactic, phosphoric and nucleic acids.

↓excretion

- failure of excretion by the kidney in chronic renal failure

Causes of Metabolic acidosis

1- ↑ base loss

- **Diarrhea: Intestinal juices are alkaline being rich in Na^+ & K^+ bicarbonate**
- **Vomiting: due to low intestinal obstruction**
- **Hyperkalemia:**

***↑renal tubular reabsorption of Na^+ in exchange with K^+**

→ stop of Na^+/ H^+ exchange

*** Na^+ reabsorption will be in the form of NaCl not NaHCO3 > $HCO3^-$ will be excreted in the form of KHCO3 in urine.**

$HCO3^-$ loss in urine → metabolic acidosis (Alkaline urine)

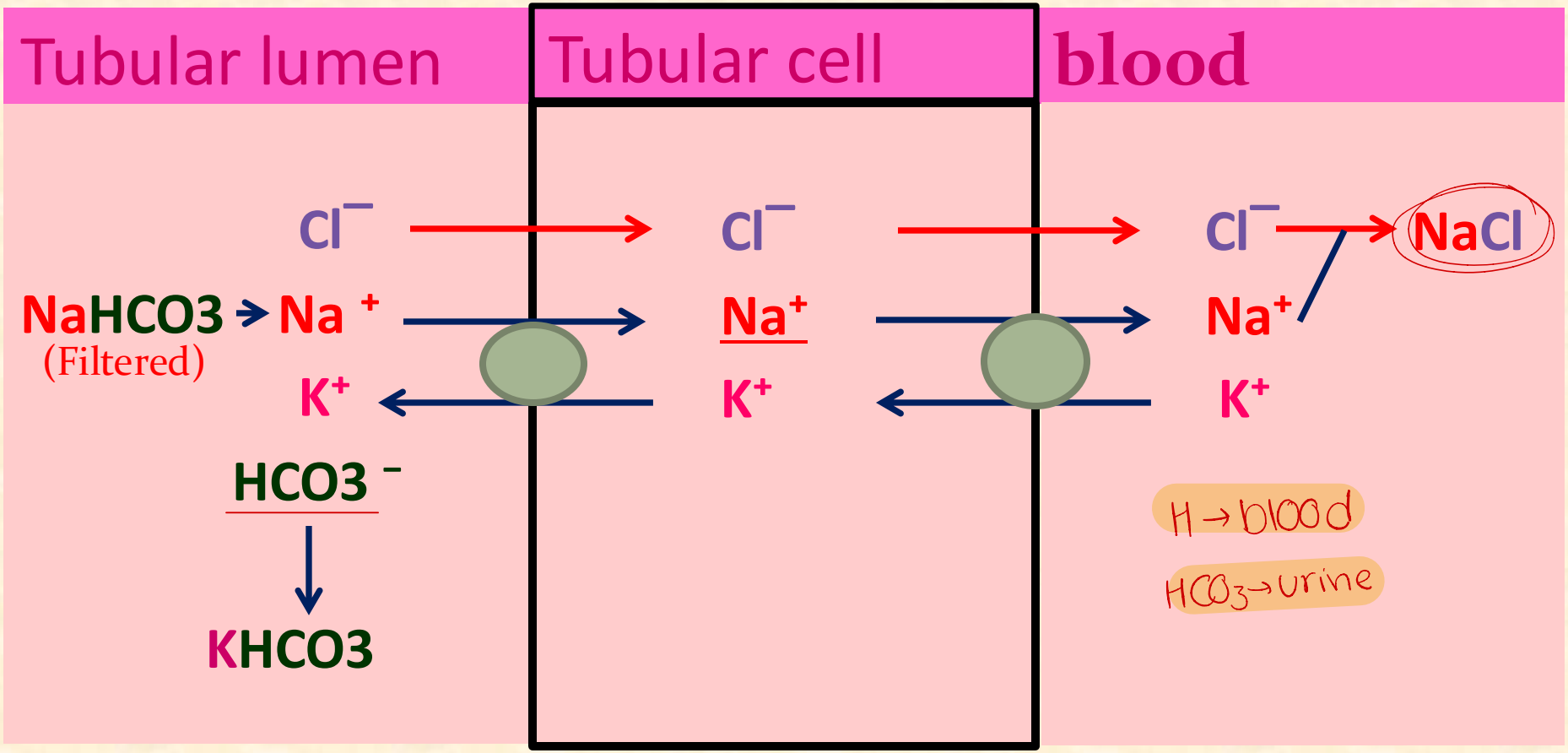
↑ Cl in blood→ hyperchloremic acidosis (Acidic blood)

The alkaline urine& acidic blood is called paradoxical acidosis

معكوس

Causes of Metabolic acidosis

1- ↑blood acids



Alkalosis

Blood PH tend to ↑

Results from formation of excessive bases

More than the capacity of the body to neutralize & eliminate them

hypERvent

Respiratory alkalosis

Metabolic alkalosis

Respiratory alkalosis

hyperVent أسباب ال

↑ CO2 loss due to

- fever
- encephalitis
- high altitude
- late stages of salicylate poisoning (aspirin)
- hystrical hyperventilation → following emotional trauma

↓CO2 → ↓ blood H2CO3

Respiratory alkalosis

↓CO2 → ↓ blood H2CO3

→ HCO_3^- not changed

→ ↑ HCO_3^-/H2CO3 (N=20:1)

→ ↑ blood PH

(Uncompensated respiratory alkalosis [alkalemia])

How to compensate?

-- of renal tubular reabsorption of HCO_3^-

Kidney excretes more HCO_3^-

Till normal HCO_3^-/H2CO3 (20:1)

→ PH reach 7.4

(Compensated respiratory alkalosis)

Urine will be alkaline because of ↑ secretion of K^+ & HCO_3^- in urine

Metabolic alkalosis

↑ bases or ↓ acids in blood

↑ blood HCO_3^-

blood H_2CO_3 not changed

→ ↑ HCO_3^-/H_2CO_3 (N=20:1)

→ ↑blood PH

(Uncompensated metabolic alkalosis [acidemia])

How to compensate?

↑ PH→ - - - chemoreceptors in respiratory centre→ hypoventilation→ CO_2 retention →↑H_2CO_3

Till normal HCO_3^-/H_2CO_3 (20:1)

→PH reach 7.4 (Compensated metabolic alkalosis)

Causes of Metabolic alkalosis

1- ↑absorption of bases

- Intake of high vegetable and fruit diet: They contain Bicarbonate salts and citrate salts. Citrate salts will be transformed into bicarbonate salts by krebs cycle
- Intake of drugs containing bicarbonate & citrate salts (drugs used for treatment of hyperacidity & peptic ulcer)

Causes of Metabolic alkalosis

2- ↑loss of acids

- Prolonged suction of gastric juice → after treating suicidal attempt after drug overdose
- Vomiting due to high intestinal obstruction ✱ الفرق مهم!
- Hypokalemia:
  - *↓renal tubular reabsorption of Na^+ in exchange with K^+
    → instead there is Na^+/ H^+ exchange
  - * Na^+ reabsorption will be in the form of NaHCO3 not NaCl →
    # Cl^- loss in urine in the form of NH4Cl→ hypochloremia and acidic urine

H out
Na in
HCO_3 in

↑ NaHCO3 in blood→ alkalosis(alkaline blood)

The acidic urine& alkaline blood is called paradoxical alkalosis

- Cushing syndrome: →Na& water retention & K excretion→ hypokalemia