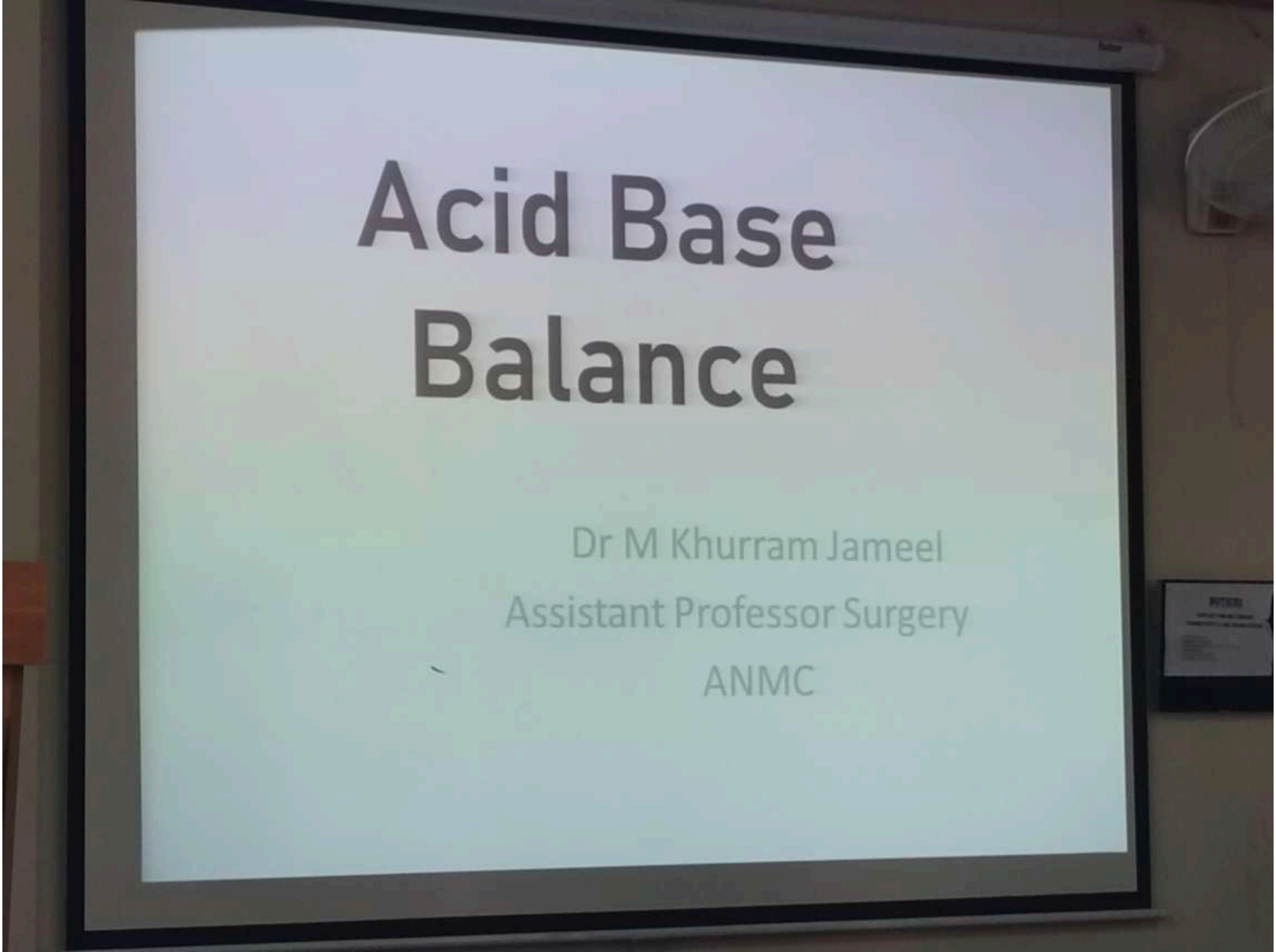
Acid Base
Balance
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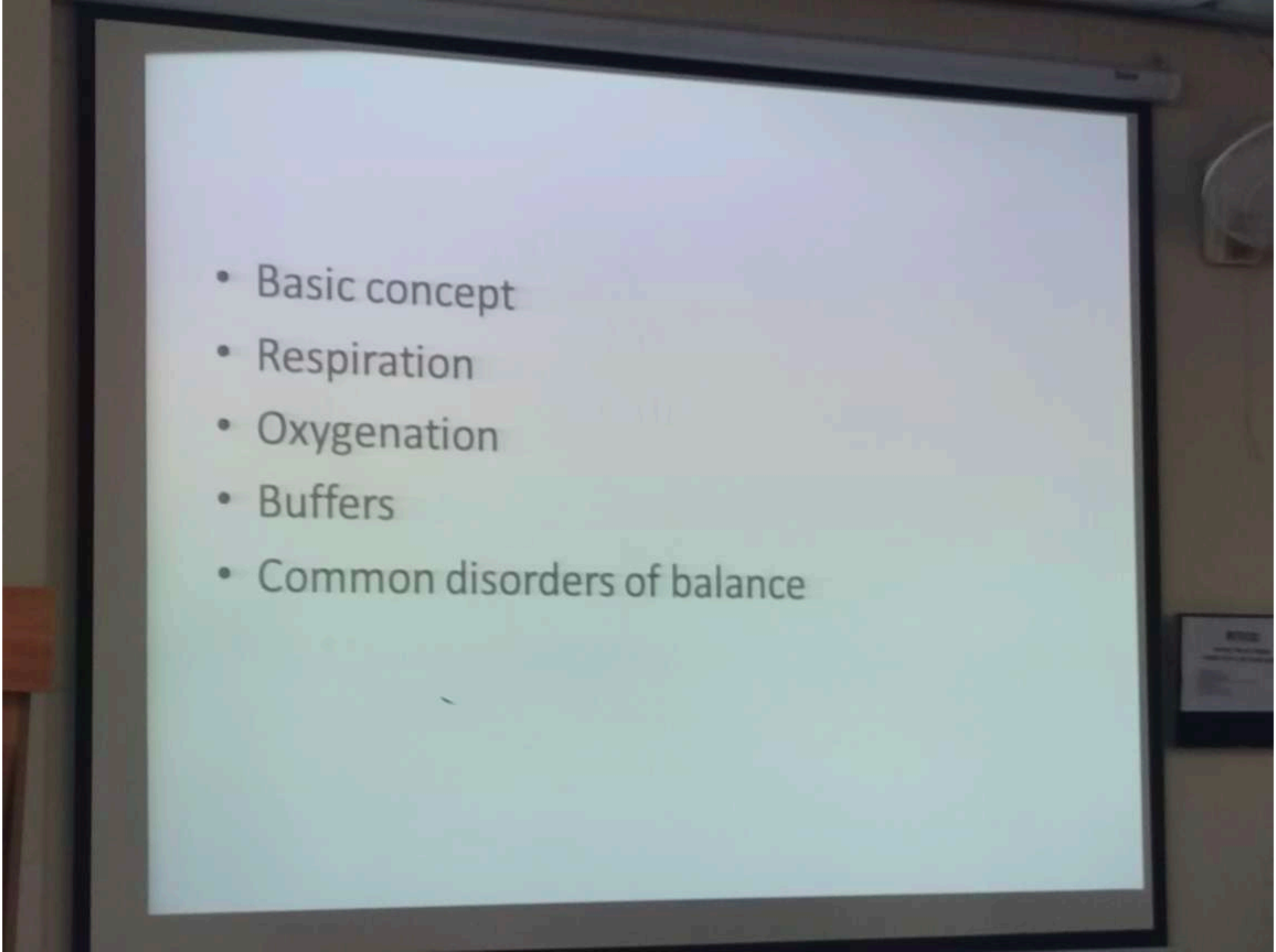

• Basic concept
• Respiration
• Oxygenation
• Buffers
• Common disorders of balance

ABGs

Request No: / Date: / Time:			Units	Arterial Ref Range
BLOOD GASES				
Temperature	37.0		Deg. C	
pH	**7.10L**			7.35-7.45
pCO2	35		mmHg	35-45
HCO3 (Std)	**11L**		mmol/L	22.0-30.0
Base Excess	**-17.4L**		mmol/L	-3.0/3.0
pO2	**169H**		mmHg	75-100
O2 Sat	99		%	95-100
ELECTROLYTES (Whole Blood)				
Potassium	**3.2L**		mmol/L	3.5-5.5
Sodium	**146H**		mmol/L	135-145
Chloride	**129H**		mmol/L	95-110
iCa++	**0.89L**		mmol/L	1.12-1.30
Glucose	7.4		mmol/L	3.6-7.7
Lactate	**4.9H**		mmol/L	0.2-1.8

Acid-Base balance

- **Acids:**
- **Acid is a substance whose dissociation in water releases hydrogen ions (H^+)**
- **Addition of an acid to a solution, increases concentration of free H^+ in the solution.**
- **Produces more acidic solution & decrease in pH**

- $HCL \longrightarrow H^+ + Cl^-$
- **Bases:**
- A base releases hydroxyl ions (OH^-) in aqueous solution & decreases its H^+ concentration by accepting or by binding with free H^+.
- This results in increase in pH of the solution.
- $NaOH \longrightarrow Na^+ + OH^-$
- The OH^-, accepts H^+ & results in the formation of water.

Maintenance of blood pH

- The normal pH of the blood is maintained in the narrow range of 7.35 - 7.45 (slightly alkaline).
- The body has developed three lines of defense to regulate the body's acid-base balance.

- Blood buffers
- Respiratory mechanism
- Renal mechanism
- Blood buffers:
- A buffer may be defined as a solution of a weak acid & its salt with a strong base.

- The buffer resists the change in the pH by the addition of acid or alkali & the buffering capacity is dependent on the absolute concentration of salt & acid.
- The buffer cannot remove H^+ ions from the body but it temporarily acts as a shock absorbant to reduce free H^+ ions.

Blood contains three buffer systems

- Bicarbonate buffer
- Phosphate buffer
- Protein buffer
- Bicarbonate buffer system:
- Sodium bicarbonate & carbonic acid ($NaHCO_3$-H_2CO_3) is the most predominant buffer system of ECF (plasma).

- Carbonic acid dissociates into hydrogen and bicarbonate ions.

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

- By the law of mass action

$$Ka = \frac{(H^+)(HCO_3^-)}{H_2CO_3} \qquad \text{------(1)}$$

- Ka=Dissociation constant of H_2CO_3

Phosphate buffer system

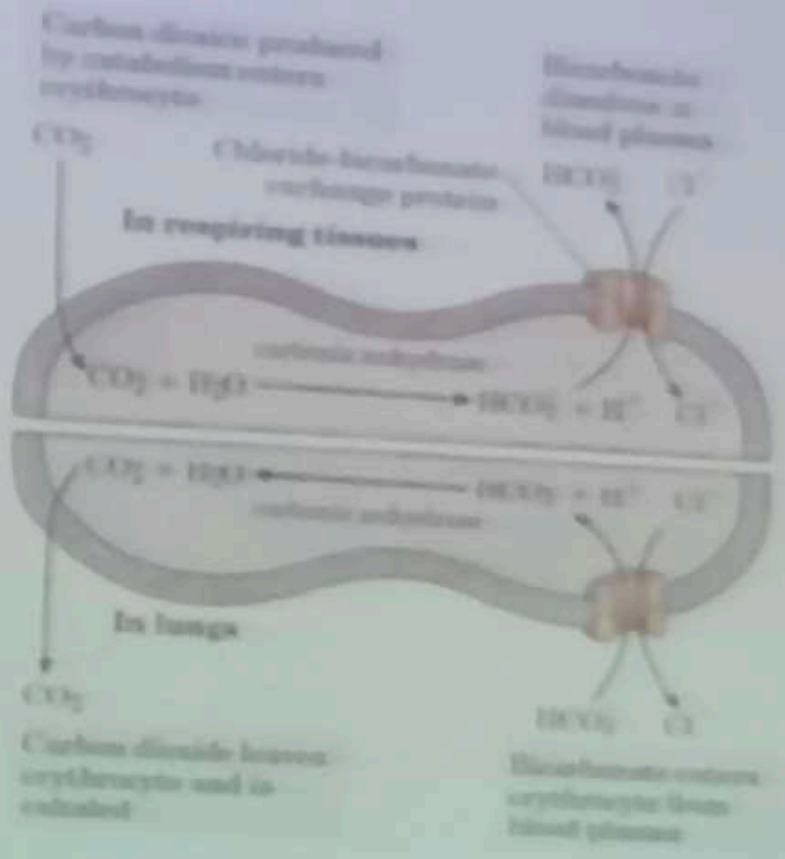
- Sodium dihydrogen phosphate and disodium hydrogen phosphate (NaH_2PO_4, Na_2HPO_4) constitute the phosphate buffer
- It is mostly an Intracellular buffer.

Protein buffer system

- The plasma proteins & hemoglobin, constitute the protein buffer.
- The buffering capacity of proteins is dependent on the pK of ionizable groups of amino acids.
- The imidazole group of histidine (pK=6.7) is the most effective contributor of protein buffer.

Respiratory Buffer Systems

- CO_2 is produced by cellular respiration.
- CO_2 is converted to bicarbonate by carbonic anhydrase.
- results in LOWER pH in respiring tissues.
- CO_2 is exhaled in lungs.



Respiratory mechanism for pH regulation

- Respiratory system provides a rapid mechanism for the maintenance of acid-base balance.
- This is achieved by regulating the concentration of carbonic acid (H_2CO_3) in the blood.

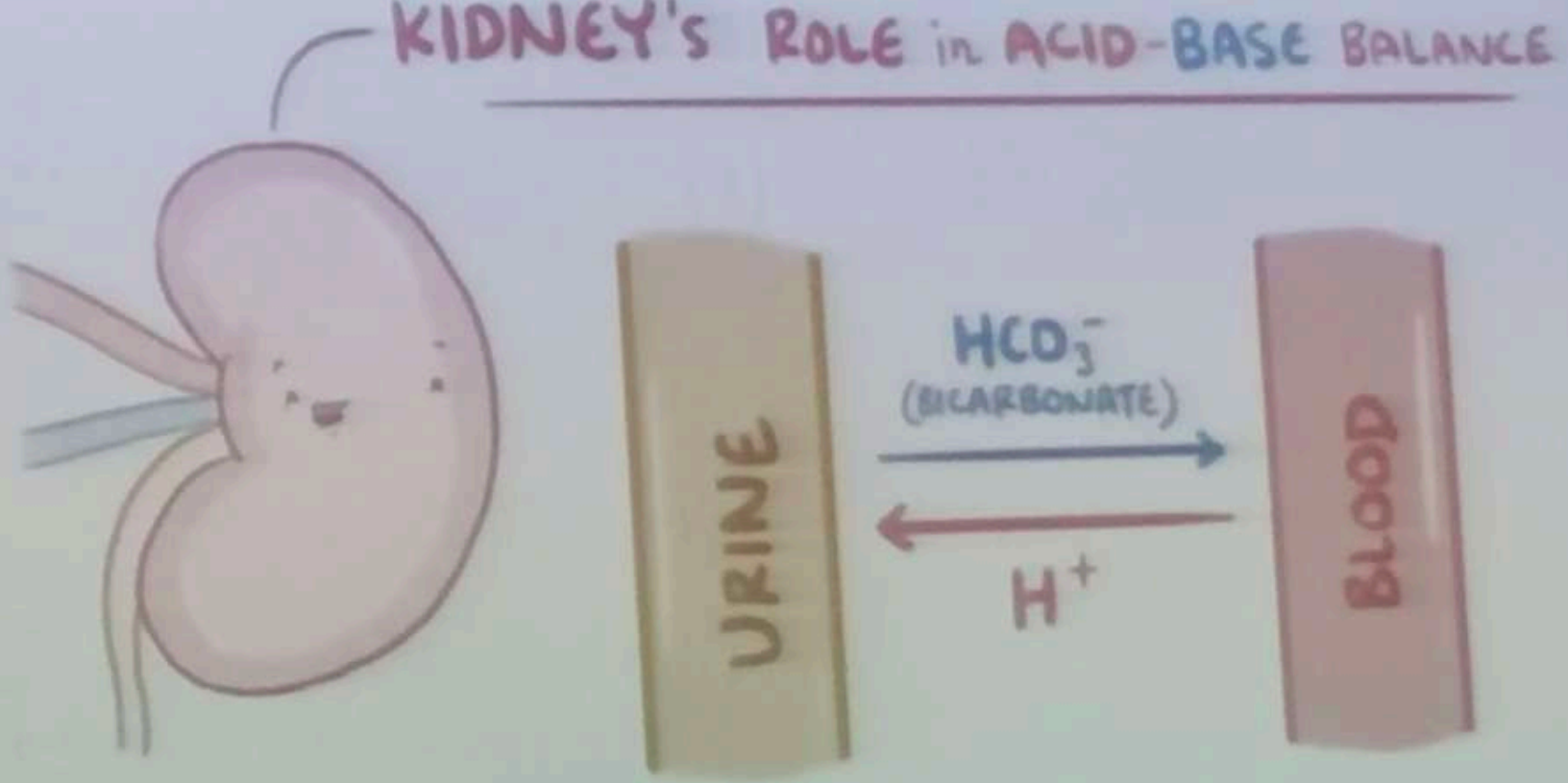
- The large volumes of CO_2 produced by the cellular metabolic activity endanger the acid-base equilibrium of the body
- All of this CO_2 is eliminated from the body in the expired air via the lungs

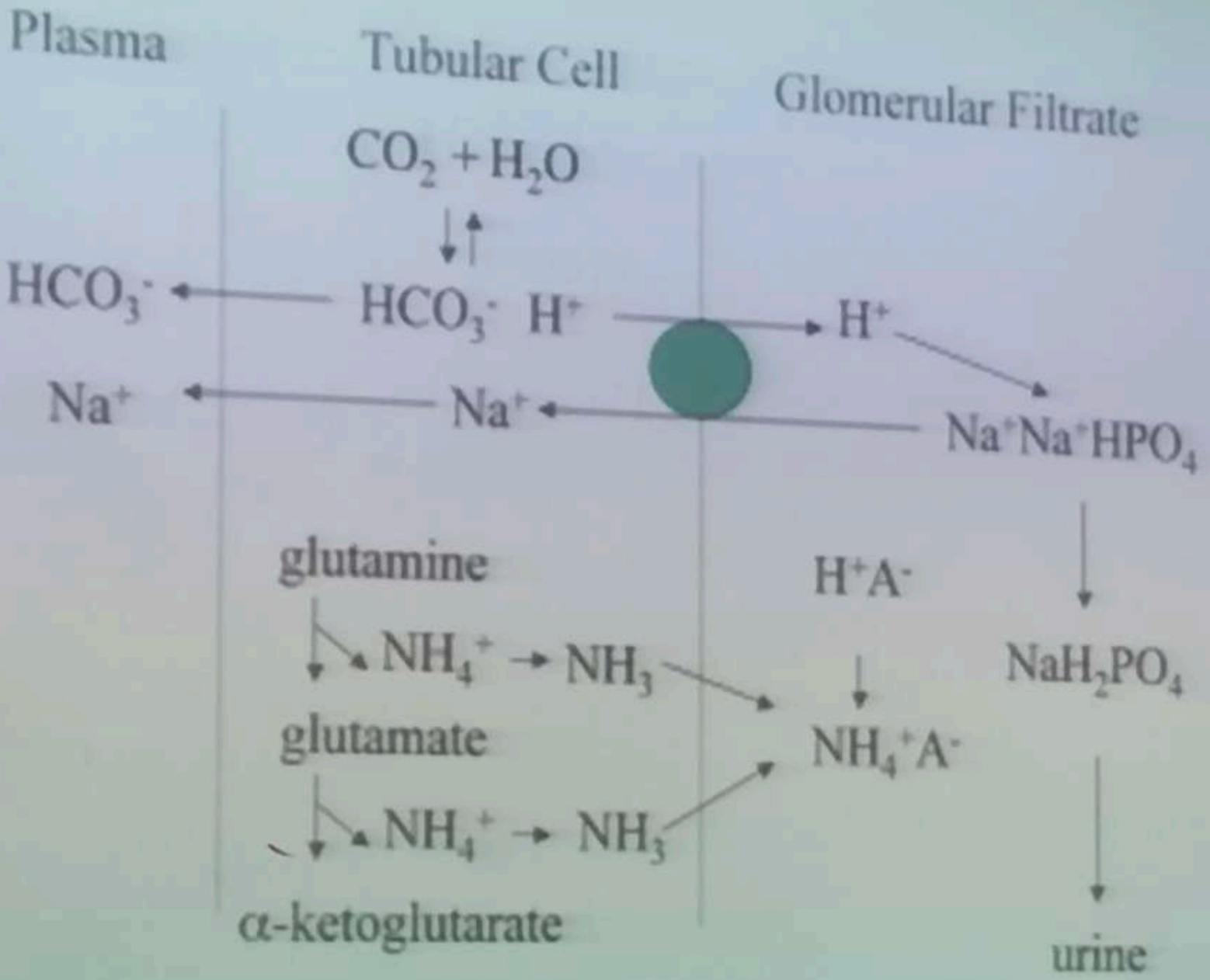
$$H_2CO_3 \xrightarrow{\text{Carbonic anhydrase}} CO_2 + H_2O$$

- The rate of respiration is controlled by a respiratory centre, located in the medulla of the brain
- This 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.

- H^+ ions are eliminated as H_2O
- Respiratory control of blood pH is rapid but only a short term regulatory process, since hyperventilation cannot proceed for long.

Renal Buffer System



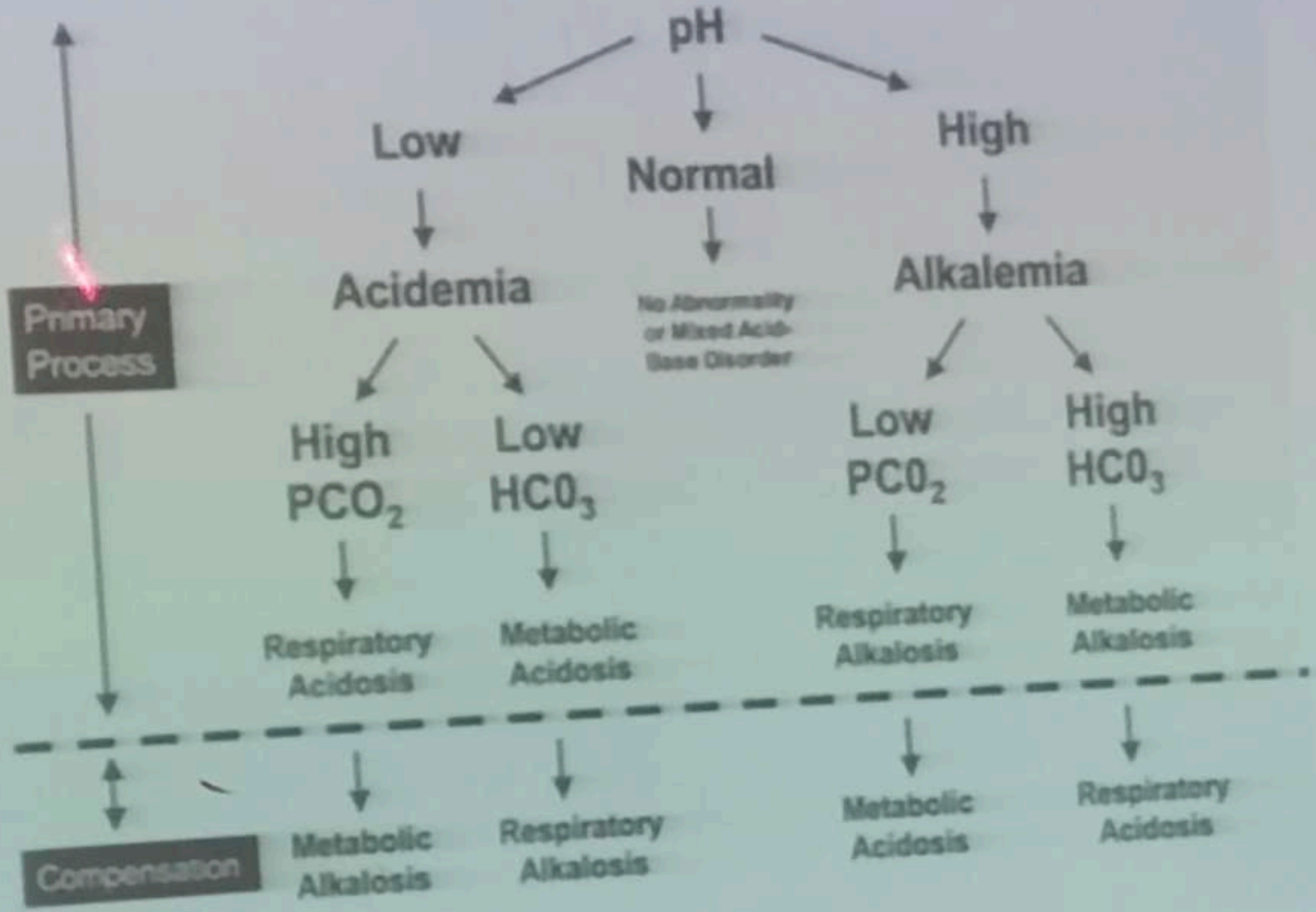

Plasma
Tubular Cell
Glomerular Filtrate
$CO_2 + H_2O$
HCO_3^-
HCO_3^- H^+
H^+
Na^+
Na^+
$Na^+Na^+HPO_4$
glutamine
H^+A^-
NH_4^+
NH_3
NaH_2PO_4
glutamate
$NH_4^+A^-$
NH_4^+
NH_3
α-ketoglutarate
urine

Disorders of acid-base balance

- The acid-base disorders are mainly two types
- Acidosis-a decline in blood pH.
- Metabolic acidosis-due to a decrease in bicarbonate
- Respiratory acidosis-Due to an increase in carbonic acid.

- Alkalosis-a rise in blood pH.
- Metabolic alkalosis-due to an increase in bicarbonate.
- Respiratory alkalosis-due to a decrease in carbonic acid.

ARTERIAL BLOOD GAS INTERPRETATION



BLOOD GAS INTERPRETATION

OPTION #1) TIC-TAC-TOE METHOD

↙ line up your "board" like this

Variables	ACIDOSIS	NORMAL	ALKALOSIS
pH	<7.35	7.35-7.45	>7.45
(RESPIRATORY) $PaCO_2$	>45	35-45	<35
(METABOLIC) HCO_3^-	<22	22-26	>26

the MORE CO_2 you have, the more acidotic you will be

★ ★ ★
pCO_2: ACID
HCO_3^-: BASE

the MORE bicarb you have, the more alkalotic you will be

★ ★ ★ this is a great option for beginners!

STEP #1) For each variable (pH, pCO_2 or HCO_3^-), circle if the value is ACIDOTIC or ALKALOTIC (or normal).

STEP #2) Whichever column has the most circles indicates if the ABG is ACIDOTIC or ALKALOTIC.

STEP #3) To determine whether the ABG is due to a RESPIRATORY or METABOLIC imbalance, look at which variable (pCO_2 or HCO_3^-) is also circled in the same column as your pH.

Causes of acid-base disorders

- **Metabolic acidosis:**
- **Occur due to DM (ketoacidosis).**
- **Lactic acidosis & renal failure.**
- **Respiratory acidosis:**
- **Severe asthama**
- **Cardiac arrest**

- Metabolic alkalosis:
- Vomiting
- Hypokalemia
- Respiratory alkalosis- due to
- Hyperventilation
- Severe anemia

Metabolic acidosis

- Reduction in bicarbonate leads to fall in blood pH.
- This is due to excessive production of organic acids which can combine with $NaHCO_3^-$ and deplete the alkali reserve
- $NaHCO_3^-$ + Organic acid ⟶ Na salts of organic acids + CO_2
- Commonly seen in DM.

Respiratory acidosis

- The primary defect is due to a retention of CO_2 (Increased H_2CO_3)
- Causes for respiratory acidosis are depression of respiratory centre, pulmonary disorders & breathing air with high content of CO_2

Metabolic alkalosis

- This is due to increase in HCO_3^- concentration
- Occur due to excessive vomiting or an excessive intake of sodium bicarbonate for therapeutic purposes.
- Respiratory mechanism initiates compensation by hypoventilation to retain CO_2, this is taken over by renal mechanism which excrete more HCO_3^- and retain H^+

Respiratory alkalosis

- This is due to decrease in H_2CO_3 concentration.
- This is due to prolonged hyperventilation resulting in increased exhalation of CO_2 by the lungs
- Renal mechanism tries to compensate by increasing the urinary excretion of HCO_3^-