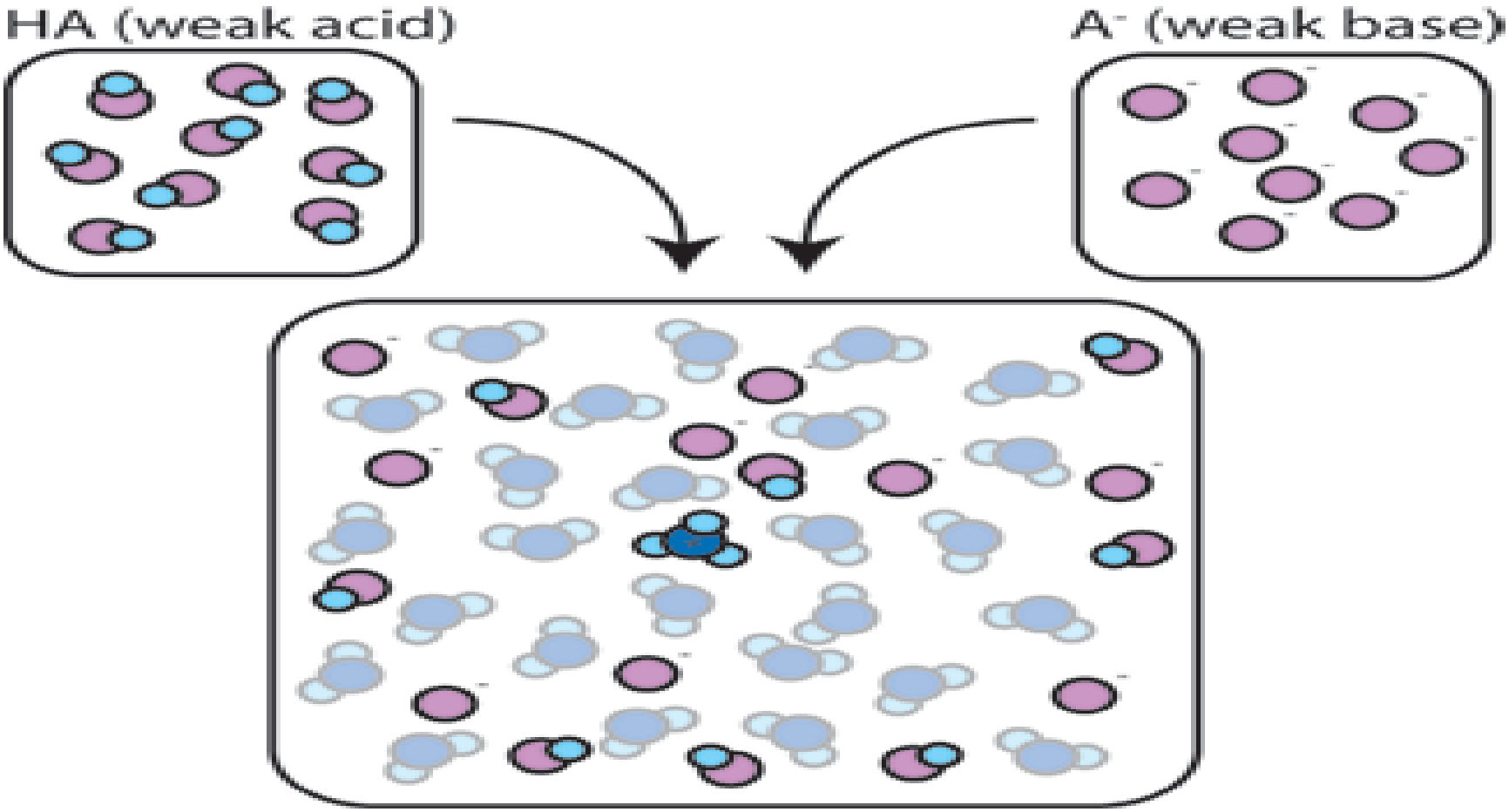
Acids–bases and buffers



Acid release H+ into solution while **base** remove H+ from solution.

Acid and Base grouped as strong or weak.

Buffer resist changes in PH

When H+ added, buffer removes it.

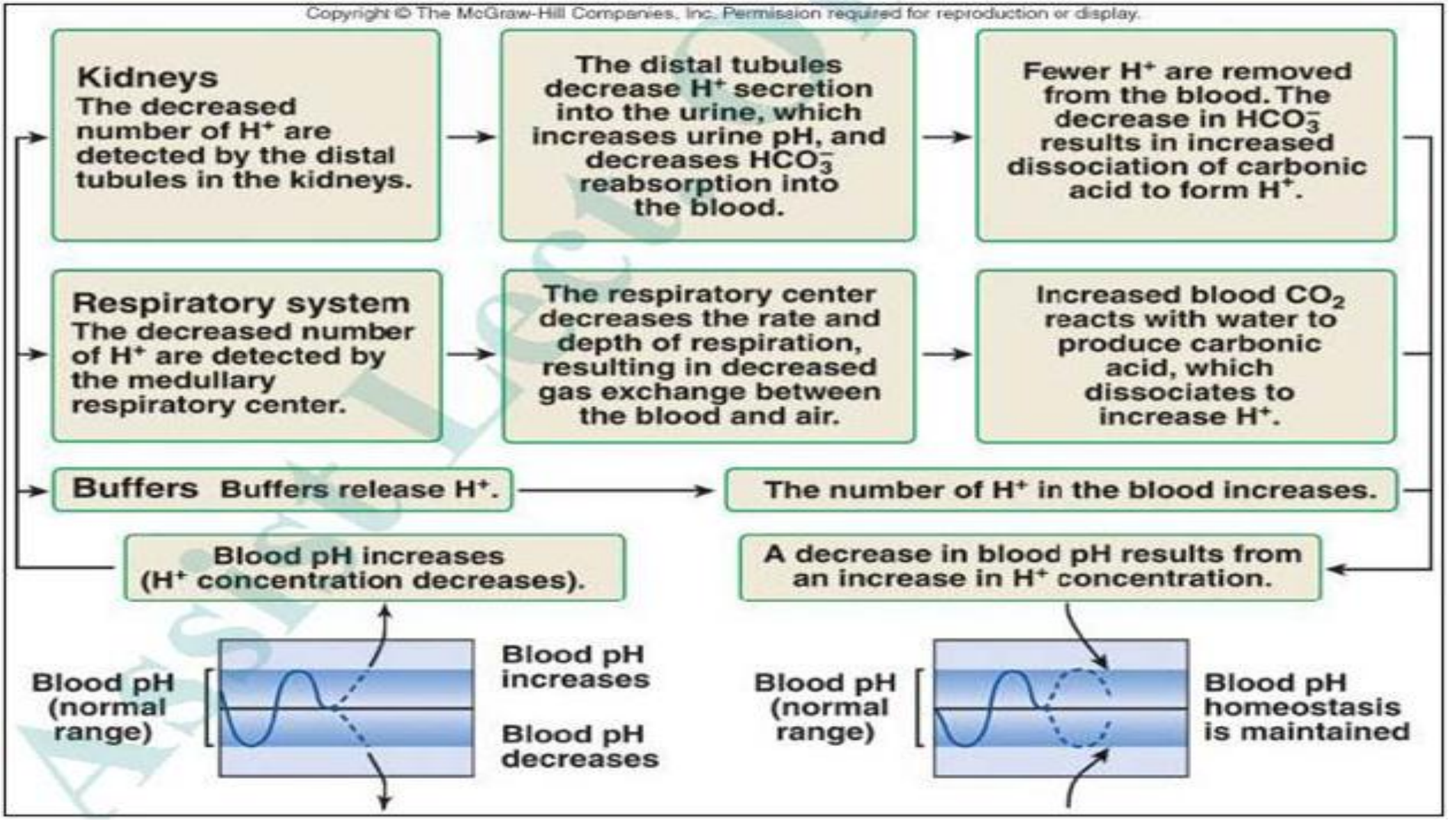
When H+ removed, buffer replaces it.

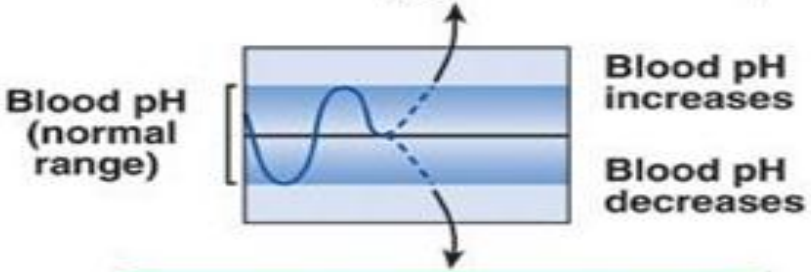
Types of buffer systems:

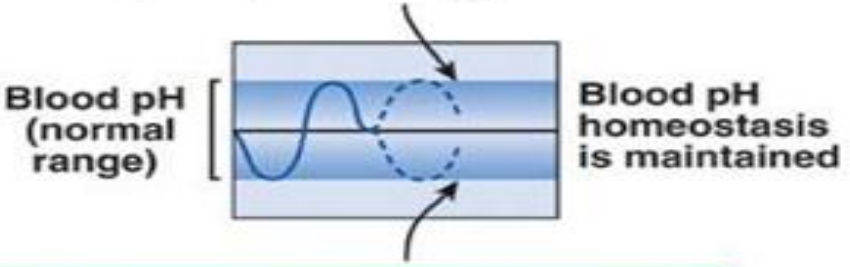
Carbonic acid/bicarbonate.

- Protein.
- Phosphate.

Regulation of Acid–Base balance







Blood pH decreases (H^+ ion concentration increases).

An increase in blood pH results from a decrease in H^+ concentration.

Buffers Buffers bind H^+. → The number of H^+ in the blood decreases.

Respiratory system
The increased number of H^+ are detected by the medullary respiratory center. → The respiratory center increases the rate and depth of respiration, resulting in increased gas exchange between the blood and air. → As blood CO_2 decreases, H^+ and HCO_3^- combine to form carbonic acid, which becomes CO_2 and water.

Kidneys
The increased number of H^+ are detected by the distal tubules in the kidneys. → The distal tubules increase H^+ secretion into the urine, which decreases urine pH, and increases HCO_3^- reabsorption into the blood. → More H^+ are removed from the blood. The increased number of HCO_3^- in the blood remove H^+ from the blood by combining with H^+ to form carbonic acid.

Buffer system

1-protein Buffer system: they provide approximately ¾ of the buffer capacity of the body. Hemoglobin in red blood cells is an important intracellular protein. The greatest buffering capacity is a protein rich with histidine amino acids,

2-bicarbonate buffer system: it plays an exceptionally important role in controlling the physiological PH of extracellular fluid.

3- phosphate buffer system: it is an important intracellular buffer system.

Respiratory Regulation of Acid-Base Balance

Respiratory regulation of pH is achieved through carbonic acid/bicarbonate buffer system

- As carbon dioxide levels **increase**, pH decreases
- As carbon dioxide levels **decrease**, pH increases

Carbon dioxide levels and pH affect respiratory centers

Hypoventilation increases blood carbon dioxide levels

Hyperventilation decreases blood carbon dioxide levels.

Renal Regulation of Acid–Base Balance

- Secretion of H^+ into filtrate and reabsorption of HCO_3^- into ECF cause extracellular pH to increase
  HCO_3^- in filtrate reabsorbed.
- Rate of H^+ secretion increases as body fluid pH decreases or as aldosterone levels increase.
- Secretion of H^+ inhibited when urine pH falls below 4.5.

Acidosis and Alkalosis

Acidosis: pH body fluids below 7.35.

Respiratory: caused by inadequate ventilation

Metabolic: Result from all conditions other than respiratory that decrease PH

Alkalosis: pH body fluids above 7.45.

Respiratory: caused by hyperventilation

Metabolic: Result from all conditions other than respiratory that increase PH

Acidosis is a condition in which there is too much acid in the body fluids. It is the opposite of alkalosis.

Alkalosis (a condition in which there is too much base in the body fluids). Normal PH range:**7.35-7.45** with normal being **7.4**

pH <7.4 is called **acidosis**. There are only two ways for acidosis to occur: 1-low HCO3 (Metabolic Acidosis)

2-High PaCO2 (Respiratory Acidosis)

pH>7.4 is defined as **alkalosis**. Again, there are only two ways alkalosis can happen 1-High HCO3 (Metabolic Alkalosis)

2-Low PaCO2 (Respiratory Alkalosis)

Disorder	pH	pCO_2	HCO_3^-	Clinical examples
Respiratory and metabolic acidosis	Very low	↑	Lower than expected	Cardiopulmonary arrest, cerebrovascular accident and renal failure
Respiratory and metabolic alkalosis	Very high	↓	Higher than expected	Congestive cardiac failure and vomiting, diuretic therapy and liver failure
Metabolic acidosis and respiratory alkalosis	≈7.45	Lower than expected	↓	Salicylate overdose, septic shock, sepsis and renal failure
Metabolic alkalosis and respiratory acidosis	≈7.45	Higher than expected	↑	Diuretic therapy or vomiting and emphysema
Metabolic acidosis and metabolic alkalosis	≈7.45	→	→	Lactic acidosis or diabetic ketoacidosis and vomiting
Triple disorder: mixed metabolic acidosis and alkalosis *plus* respiratory alkalosis or acidosis	Variable	Variable	Variable	Renal failure, vomiting and congestive cardiac failure

Acidosis

- Principal effect of acidosis is depression of the CNS through ↓ in synaptic transmission.
- Generalized weakness
- Deranged CNS function the greatest threat
- Severe acidosis causes
- Disorientation
- coma
- death

Signs and Symptoms of Respiratory Acidosis

- Breathlessness
- Restlessness
- Lethargy and disorientation
- Tremors, convulsions, coma
- Respiratory rate rapid, then gradually depressed
- Skin warm and flushed due to vasodilation caused by excess CO_2

Treatment of Respiratory Acidosis

- Restore ventilation
- IV lactate solution
- Treat underlying dysfunction or disease

Metabolic Acidosis

- **Bicarbonate deficit**–blood concentrations of bicarb. drop below 22mEq/L
- **Causes:**
- Loss of bicarbonate through diarrhea or renal dysfunction
- Accumulation of acids (lactic acid or ketones)
- Failure of kidneys to excrete H+

Symptoms of Metabolic Acidosis

- Headache, lethargy
- Nausea, vomiting, diarrhea
- Coma
- Death

Treatment of Metabolic Acidosis

- IV lactate solution
- Treat underlying dysfunction or disease

Alkalosis

- Alkalosis causes over excitability of the central and peripheral nervous systems.
- Numbness
- Lightheadedness
- It can cause :
- Nervousness ,muscle spasms or tetany ,Convulsions
- Loss of consciousness and Death

Respiratory Alkalosis

- Carbonic acid deficit
- pCO_2 less than 35 mm Hg (hypocapnea)
- Most common acid-base imbalance
- Primary cause is hyperventilation
- **Conditions that stimulate respiratory center:**
- Oxygen deficiency at high altitudes ,Pulmonary disease and Congestive heart failure – caused by hypoxia ,Acute anxiety
- Fever, anemia ,Early salicylate intoxication
- Cirrhosis ,Gram-negative sepsis

Treatment of Respiratory Alkalosis

- Treat underlying cause ,IV Chloride containing solution – chloride ions replace lost bicarbonate ions

Metabolic Alkalosis

- **Bicarbonate excess** – concentration in blood is greater than 26 mEq/L
- **Causes**: :Excess vomiting = loss of stomach acid ,Excessive use of alkaline drugs ,Certain diuretics (loop diuretics and thiazides)
- Endocrine disorders ,Heavy ingestion of antacids ,Severe dehydration

Symptoms of Metabolic Alkalosis

- Respiration slow and shallow
- Hyperactive reflexes ; tetany
- Often related to depletion of electrolytes
- Atrial tachycardia ,Dysrhythmias

Treatment of Metabolic Alkalosis

- Electrolytes to replace those lost
- IV chloride containing solution
- Treat underlying disorder

INTERPRETATION OF ABG

ACID BASE	Ph	$PaCO_2$	HCO_3
NORMAL	7.35	35-45	22-26
RESP. ACIDOSIS	⇩	⇧	NORMAL
RESP. ALKALOSIS	⇧	⇩	NORMAL
METABOLIC ACIDOSIS	⇩	NORMAL	⇩
METABOLIC ALKALOSIS	⇧	NORMAL	⇧

Questions

- A person was admitted in a coma. Analysis of the arterial blood gave the following, values: PCO2 16 mm Hg, HCO3-5 mmol/l and pH 7.1.

What is the underlying acid-base disorder?

a) Metabolic Acidosis

b) Metabolic Alkalosis

c) Respiratory Acidosis

d) Respiratory Alkalosis

- In a man undergoing surgery, it was necessary to aspirate the contents of the upper gastrointestinal tract. After surgery, the following values were obtained from an arterial blood sample: pH 7.55, PCO_2 52 mm Hg and HCO_3-40mmol/l.

What is the underlying disorder?

a) Metabolic Acidosis

b) Metabolic Alkalosis

c) Respiratory Acidosis

d) Respiratory Alkalosis