WATER, ELECTROLYTE AND PH BALANCE

BY

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Electrolytes

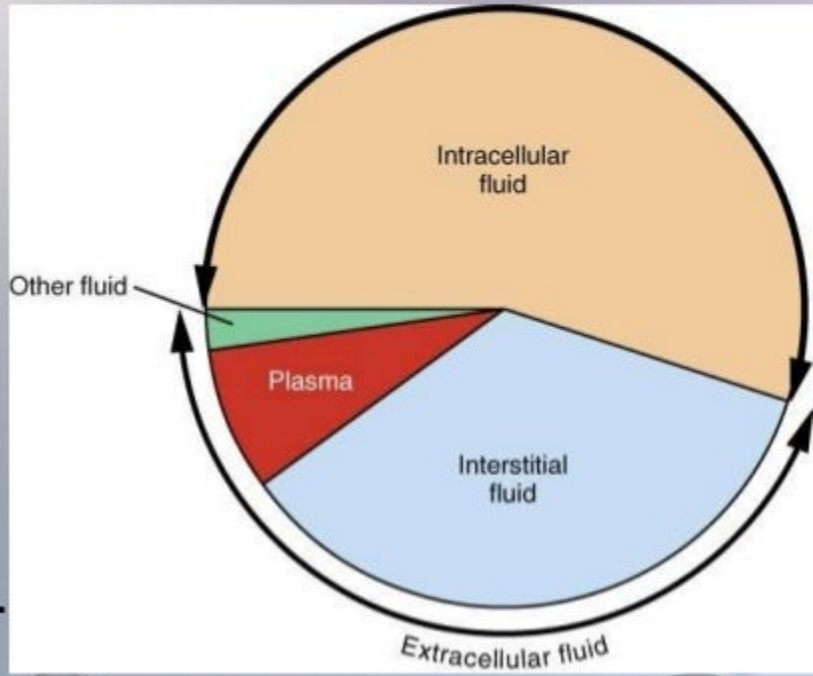
- Electrolytes are minerals found in bodily fluid that carry an electric charge.
- Electrolytes in living system includes Sodium, Potassium, Chloride, Bicarbonate, Calcium, Phosphate, Magnesium, Copper Zinc, Iron, Manganese, Molybdenum And Chromium.
- In terms of body function, six electrolytes are most important: Sodium, Potassium, Chloride, Bicarbonate, Calcium And Phosphate.

Body Fluid:

The total amount of water present in different forms is known as body fluid.

Compartments of body fluid

- Extracellular fluid compartment
- Intracellular fluid compartment



60% of body weight is due to body fluid.

Intracellular Fluid Compartment

- The fluid present inside the cells is called intracellular fluid.
- It includes water and electrolytes within the cell.
- About 40% of total body weight is constitute by intracellular fluid.

Extracellular Fluid Compartment

All the fluids outside the cells are collectively called extracellular fluid. These fluid account for about 20% of the total body weight.

Interstitial fluid: includes fluid between the cells. Eg. Fluid present in connective tissue.

Intra- vascular fluid: includes plasma and lymph

Trans-cellular fluid: includes fluid present in serous and mucous membrane. Eg. Intra-ocular fluid, cerebrospinal fluid, synovial fluid, digestive juices, pleural fluid, pericardial fluid, peritoneal fluid, etc.

Composition Of Body Fluid

- **Water**
- **Solid particles:**

Organic Substances: Glucose, Amino Acids, Lipids, Enzymes, Hormones, Vitamins

Inorganic Substance: Sodium, Potassium, Calcium, Magnesium, Chloride, Bicarbonate, Phosphate, Iron, Sulphate, etc

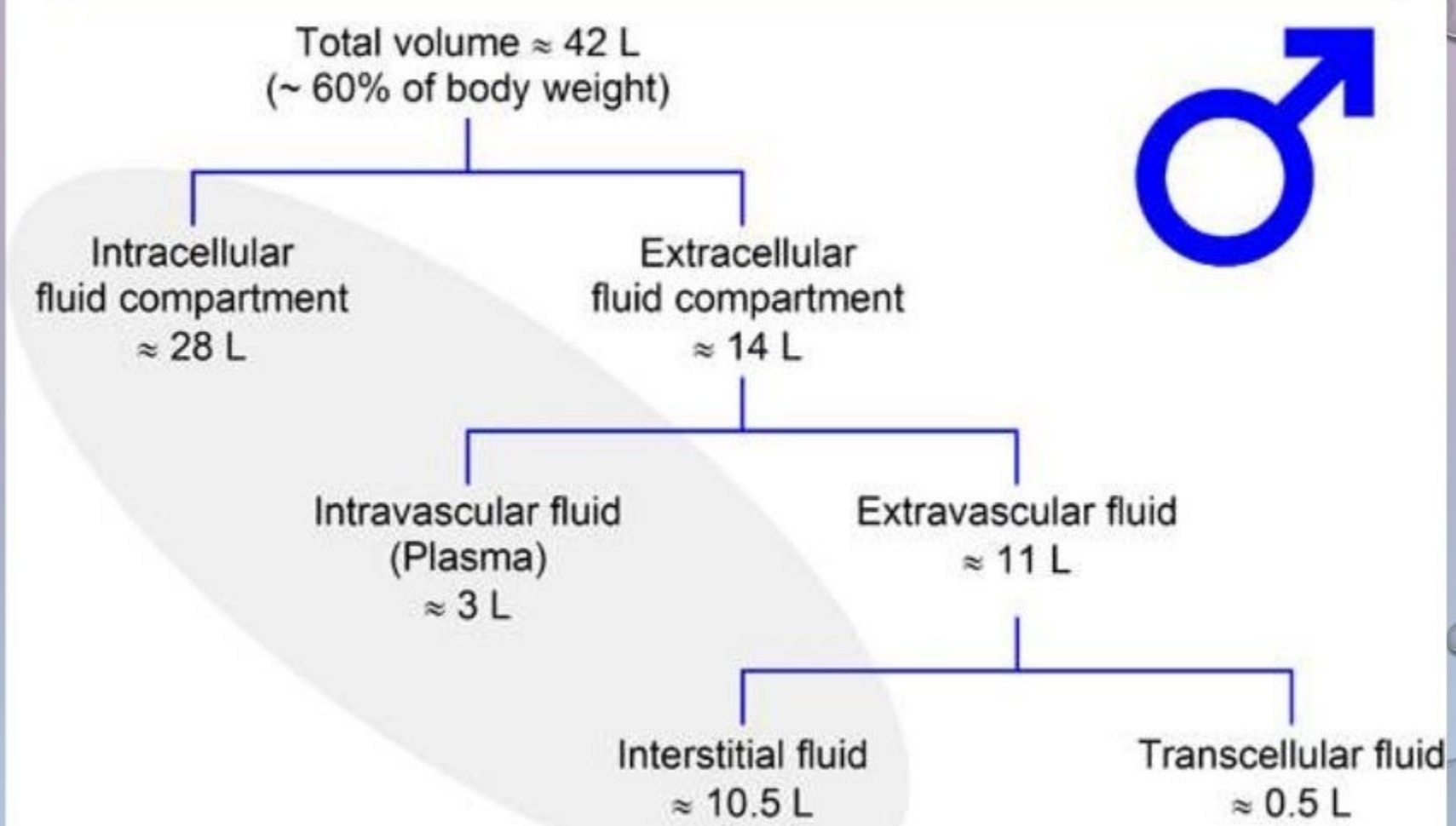
Extracellular Fluid: Sodium, Chloride, Bicarbonate(high Concentration)

Potassium, Calcium, Magnesium, Phosphate, Sulphate (Low Concentration)

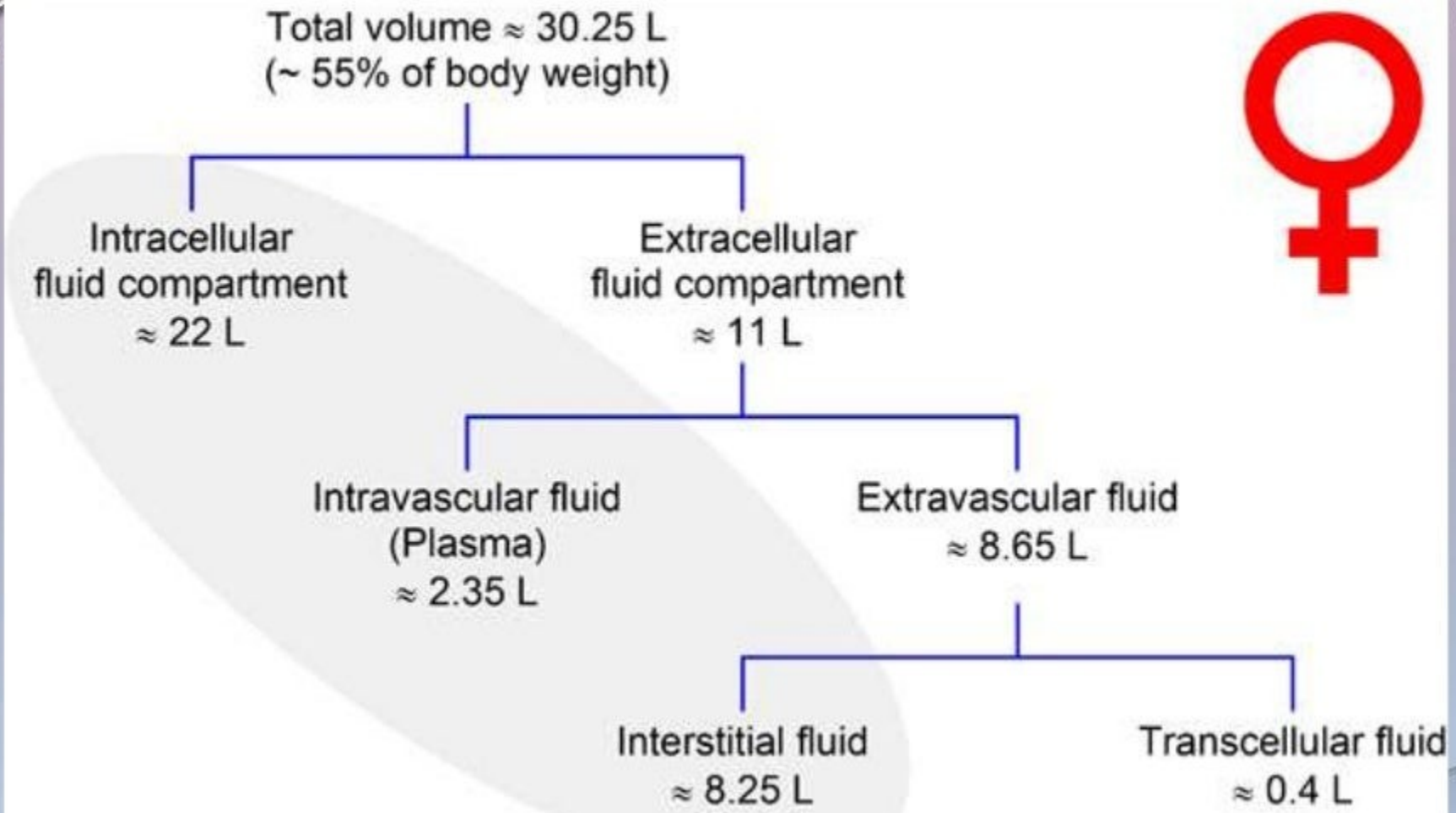
Intracellular Fluid: Sodium, Chloride, Bicarbonate(low Concentration)

Potassium, Calcium, Magnesium, Phosphate, Sulphate (High Concentration)

Body Fluid Compartments of a 70-kg Adult Man



Body Fluid Compartments of a 55-kg Adult Woman



What percentage of body weight is composed of fluid?

I. 40

II. 50

III. 60

IV. 70

Which of the following is not extracellular fluid?

I. Csf

II. Plasma

III. Peritoneal fluid

IV. Water in cell

Interstitial fluid (IF) is _____.

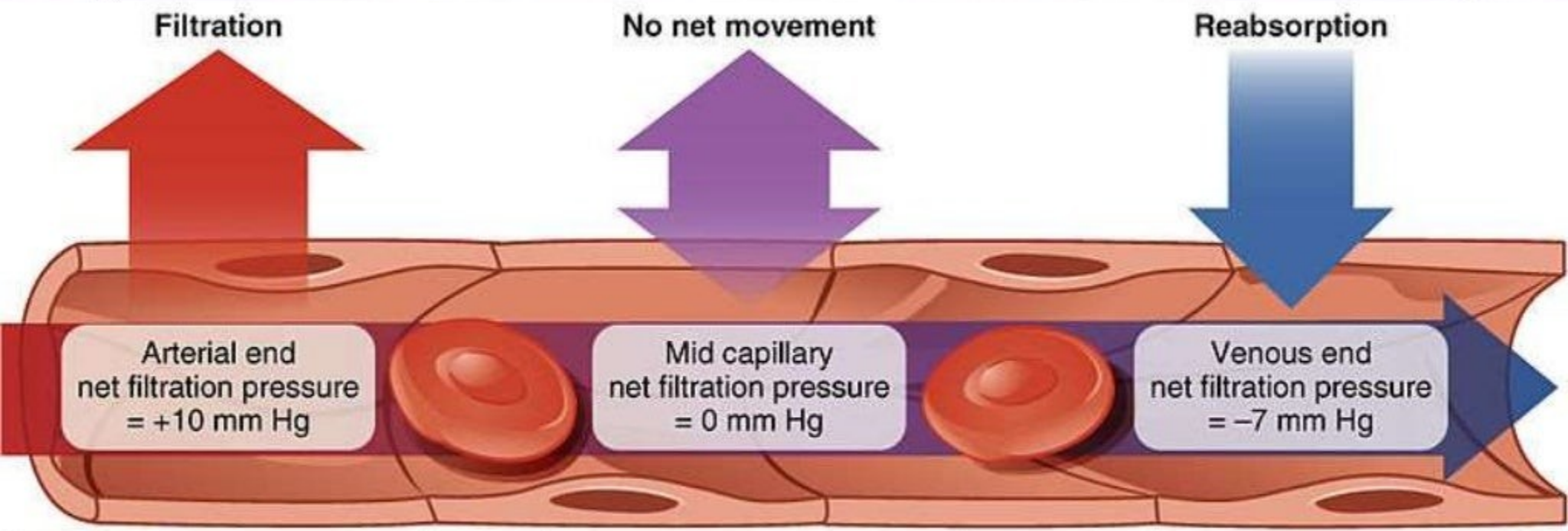
I. The fluid in the cytosol of the cells

II. The fluid component of blood

III. The fluid that bathes all of the body's cells except for blood cells

IV. The intracellular fluids found between membranes

Distribution And Movement Of Fluid Between The Compartments

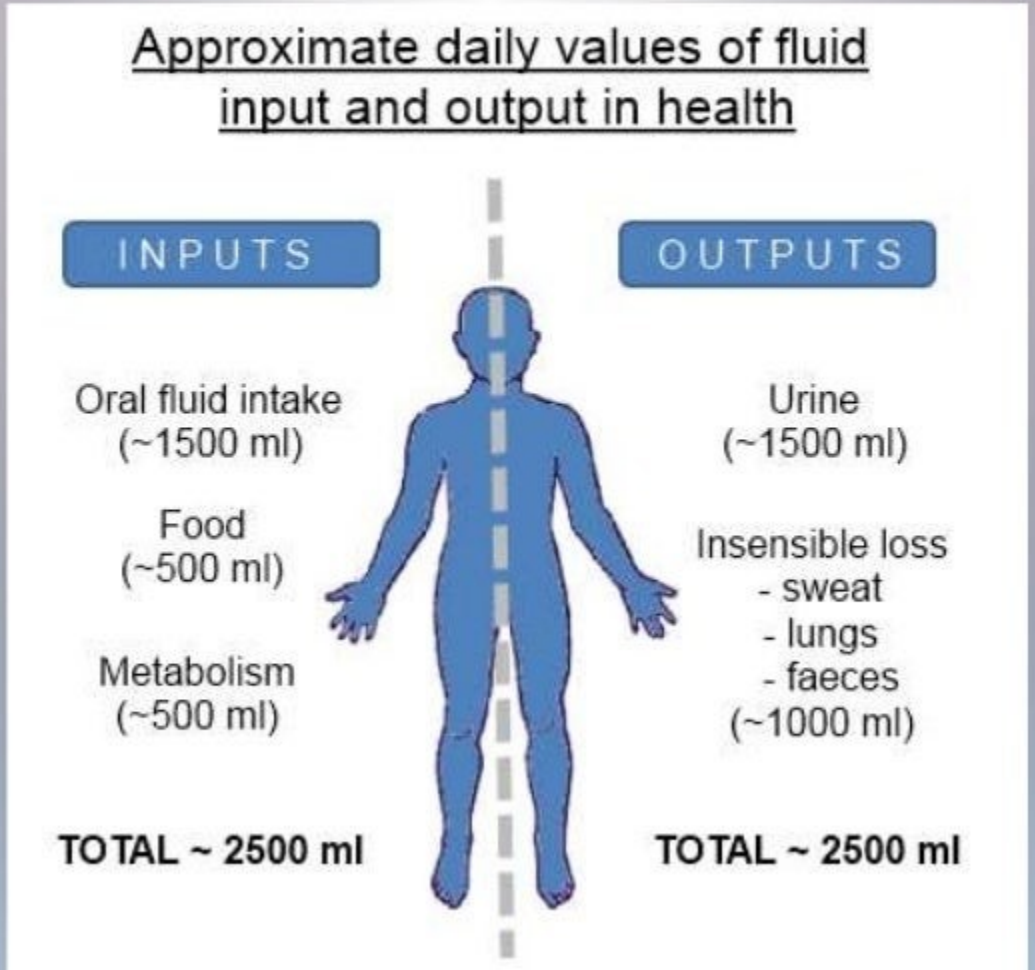


Fluid exits capillary since capillary hydrostatic pressure (35 mm Hg) is greater than blood colloidal osmotic pressure (25 mm Hg)

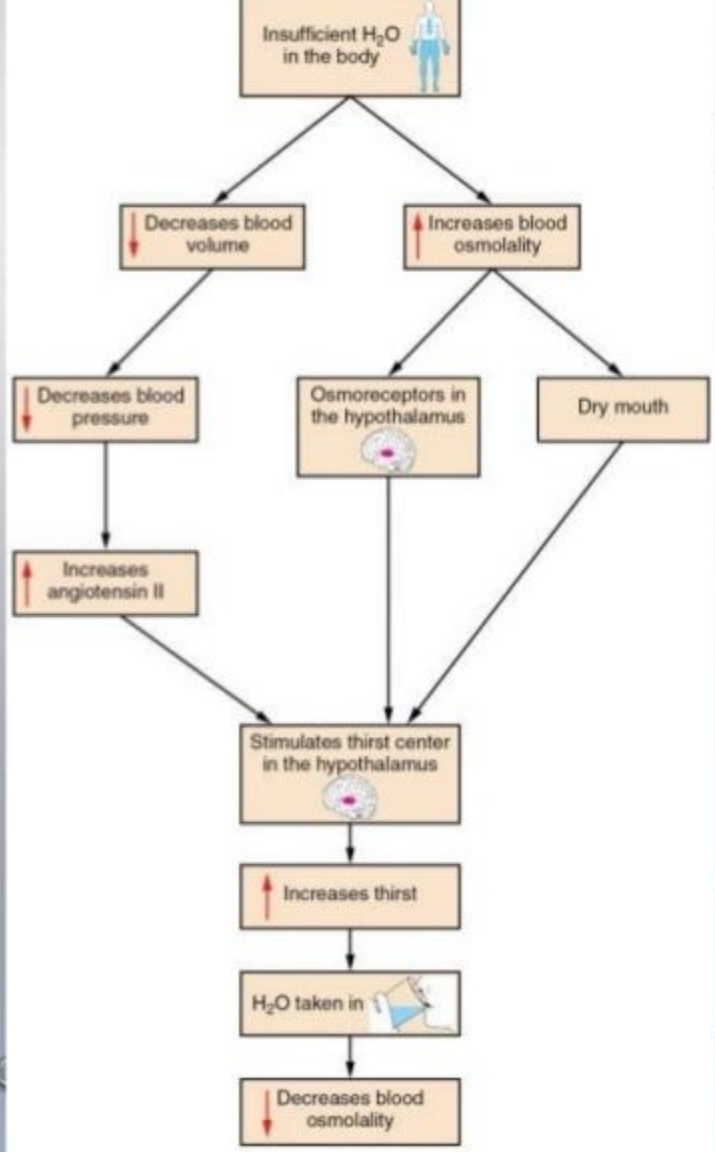
No net movement of fluid since capillary hydrostatic pressure (25 mm Hg) = blood colloidal osmotic pressure (25 mm Hg)

Fluid re-enters capillary since capillary hydrostatic pressure (18 mm Hg) is less than blood colloidal osmotic pressure (25 mm Hg)

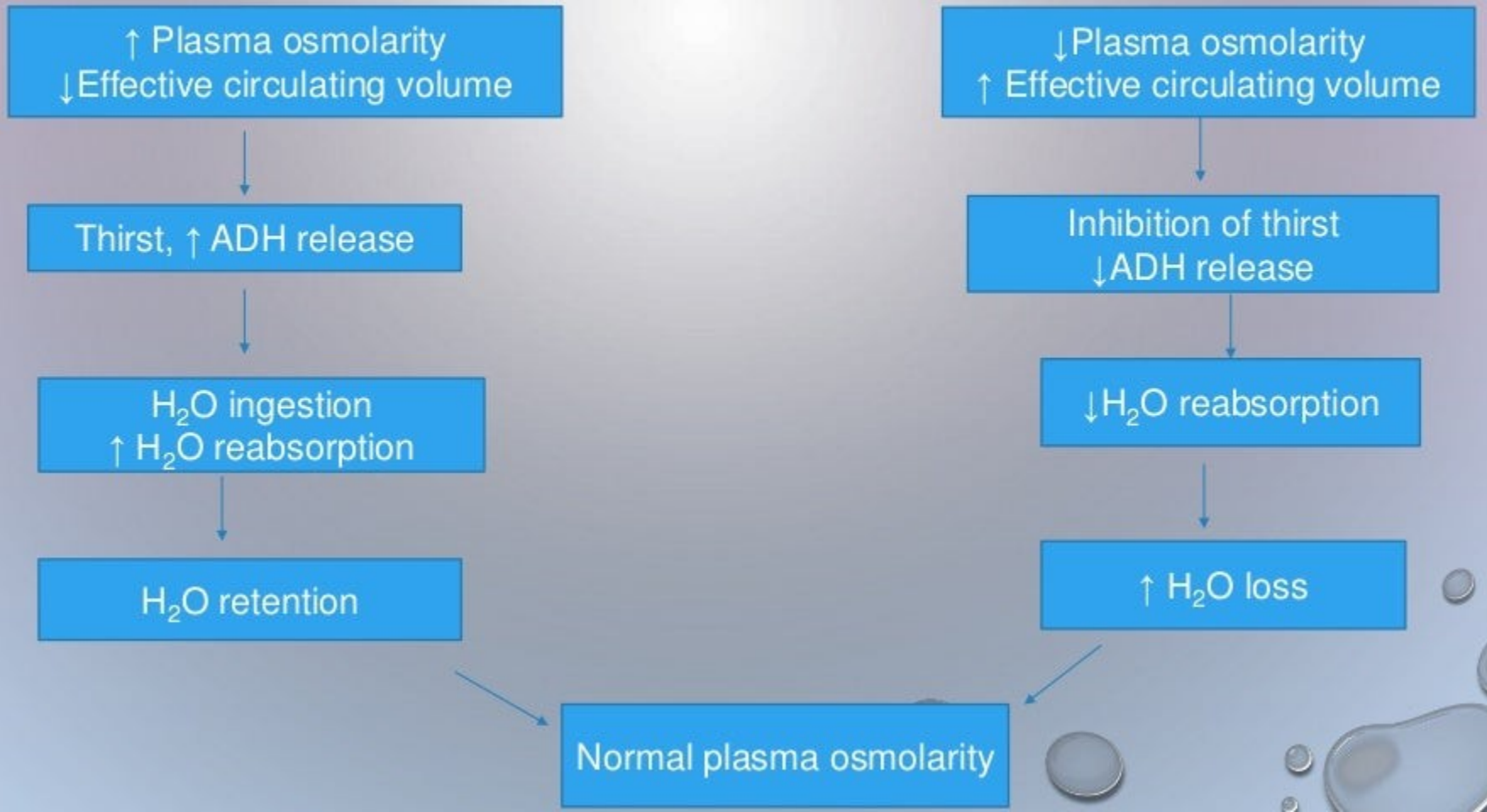
MECHANISM OF WATER BALANCE AND REGULATION



ROLE OF OSMORECEPTOR IN WATER BALANCE



THIRST MECHANISM OF REGULATION OF WATER



MECHANISM OF ELECTROLYTE BALANCE AND REGULATION

Electrolytes are in balance when the concentration of individual electrolytes in the body fluid compartments are normal and remain relatively constant.

The primary regulation of electrolyte balance is through active reabsorption of positive ions.

Electrolyte	ECF (mmol/l)	ICF (mmol/l)	Total in body (mmol)
Sodium	140–155	10–18	3000–4000
Potassium	4.0–5.5	120–145	3000–4000
Calcium	2.2–2.5	2.2–2.5	25 000–27 000
Ionised calcium	0.9–1.3	1×10^{-4}	–
Magnesium	0.7–1.2	15–25	900–1200
Chloride	98–106	2–6	3000–4000
Phosphate	0.7–1.3	8–20	30 000–32 000

Acid and Base:

- Any compound which forms hydrogen ion in solution is acid. Also called proton donor.
- The compound which combines with hydrogen ion in solution is base. Also called proton acceptors.

Buffer:

The solution which have the ability to maintain constant pH despite of addition of strong acid or strong base is called buffer solutions.

It plays an important role in maintaining acid base balance of our body.

Composition Of Buffer System

- Weak acid and its salt with strong base

  CH_3COOH/CH_3COONa buffer system

- Weak base and its salt with strong acid

  NH_4OH/NH_4Cl buffer system

- Weak bivalent acid and its acidic salt

  $H_2CO_3/NaHCO_3$ buffer system

- Two salts of the same polyvalent acid

  $NaHCO_3/Na_2CO_3$ buffer system

Importance Of Buffer System:

1. Metabolic reactions at the tissue level are highly sensitive to pH.
2. H^+ ion changes shapes of proteins including enzymes.
3. H^+ ions are created and destroyed all the time.

Sources of H^+ ions: continuously formed from the breakdown of protein during exercise(lactic acid production), etc.

Acid Base Balance Regulation By Buffer System

The general form of buffer in buffering action is

Buffer + H^+ ⟶ H. Buffer

Types of Buffer:

1. Chemical buffer
    - Bicarbonate buffer
    - Phosphate buffer
    - Protein buffer
2. Pulmonary buffer
3. Renal buffer

Chemical Buffer

The chemical buffering system consists of weak acid and salt of that acid.

Bicarbonate Buffer:

The bicarbonate buffer system consists of carbonic acid and sodium bicarbonate in solution.

When sodium bicarbonate ($NaHCO_3$) comes in contact with a strong acid, such as HCl, carbonic acid (H_2CO_3), which is weak acid, and NaCl are formed. When carbonic acid comes in contact with a strong base, such as NaOH, bicarbonate and water are formed.

$$NaHCO_3 + HCl \longrightarrow H_2CO_3 + NaCl$$

(Sodium bicarbonate) (strong acid) (weak acid) (salt)

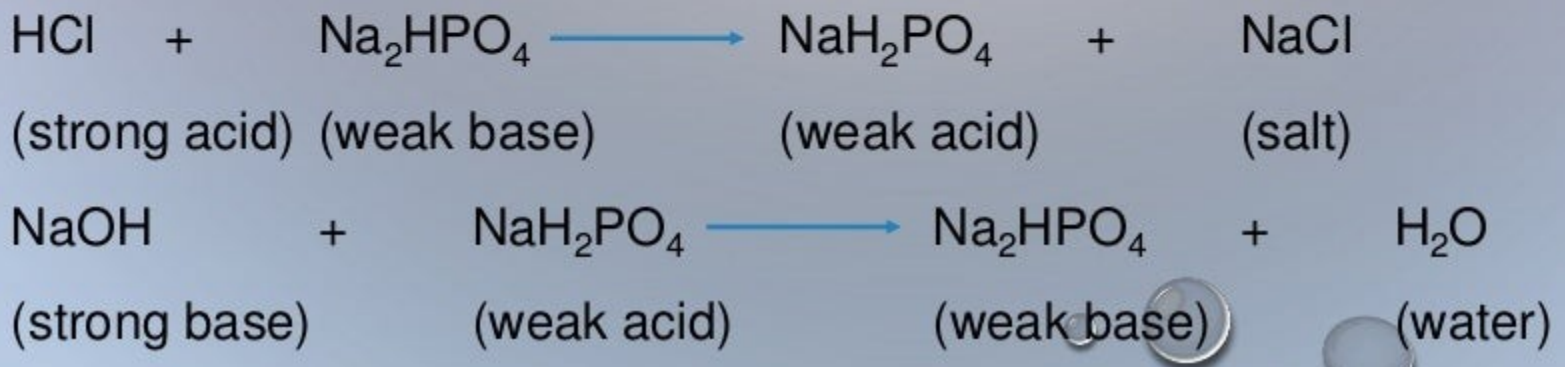
$$H_2CO_3 + NaOH \longrightarrow HCO_3^- + H_2O$$

(Weak acid) (strong base) (bicarbonate) (water)

Phosphate Buffer

The phosphate buffering system consists of phosphoric acid and sodium phosphate. These chemicals act similar to the bicarbonate buffer.

When sodium monohydrogen phosphate (Na_2HPO_4) comes in contact with a strong acid, such as HCl, sodium dihydrogen phosphate(NaH_2PO_4), which is weak acid, and NaCl are formed. When sodium dihydrogen phosphate(NaH_2PO_4) comes in contact with a strong base, such as NaOH, sodium monohydrogen phosphate and water are formed.



Protein Buffer:

The protein present in hemoglobin act as buffering agent. It accepts and donates H^+ and to maintain pH.

Pulmonary Buffer:

Increase CO_2 causes increase in H^+ and decreased pH. Hyperventilation removes excess CO_2 and maintain pH.

Maintains the level of carbonic acid in the blood.

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

(Carbon Dioxide) (Water) (Carbonic Acid)

Renal Buffer:

Kidney excretes excess H^+ to maintain the pH. It controls plasma bicarbonate concentrations.

Steps:

1. Sodium ions are reabsorbed from filtrate in exchange for H^+ by an antiport mechanism in the apical membrane of cells lining the renal tubule
2. The cells produces bicarbonate ions that can be shunted to peritubular capillaries.
3. When CO_2 is available, the reaction is driven to the formation of carbonic acid, which dissociates to form a bicarbonate ion and hydrogen ion.
4. The bicarbonate ion passes into the peritubular capillaries and returns to the blood. The hydrogen ion is secreted into the filtrate, where it can become part of new water molecules and be reabsorbed as such or removed in the urine.

Disorder Of Hydrogen Ion Balance

Acidosis

The condition when the blood pH is below 7.35 is known as acidosis.

Alkalosis

The condition when the blood pH is above 7.45 is known as alkalosis.

The body has three mechanisms by which it attempts to maintain a normal blood pH:

- Buffers
- Removal of CO_2 by lungs
- Removal of H^+ by kidneys.

Respiratory Acidosis

Results when pa CO_2 is above the upper limit of normal(45mmHg)

Causes: Inadequate CO_2 excretion

Excess CO_2 production

Respiratory Alkalosis:

Results when pa CO_2 is less than 34mmHg.

Causes: Excess CO_2 excretion

Metabolic Acidosis

Causes: Excess H^+ production

Ingestion of acid

Inadequate excretion of H^+

Excess loss of bicarbonate

Metabolic Alkalosis

Causes: Excess H^+ loss

Excessive reabsorption of bicarbonate

Ingestion of alkalis

Regulation Of Acid Base Imbalance

1. Rapid chemical buffering
2. Respiratory compensation
3. Renal compensation

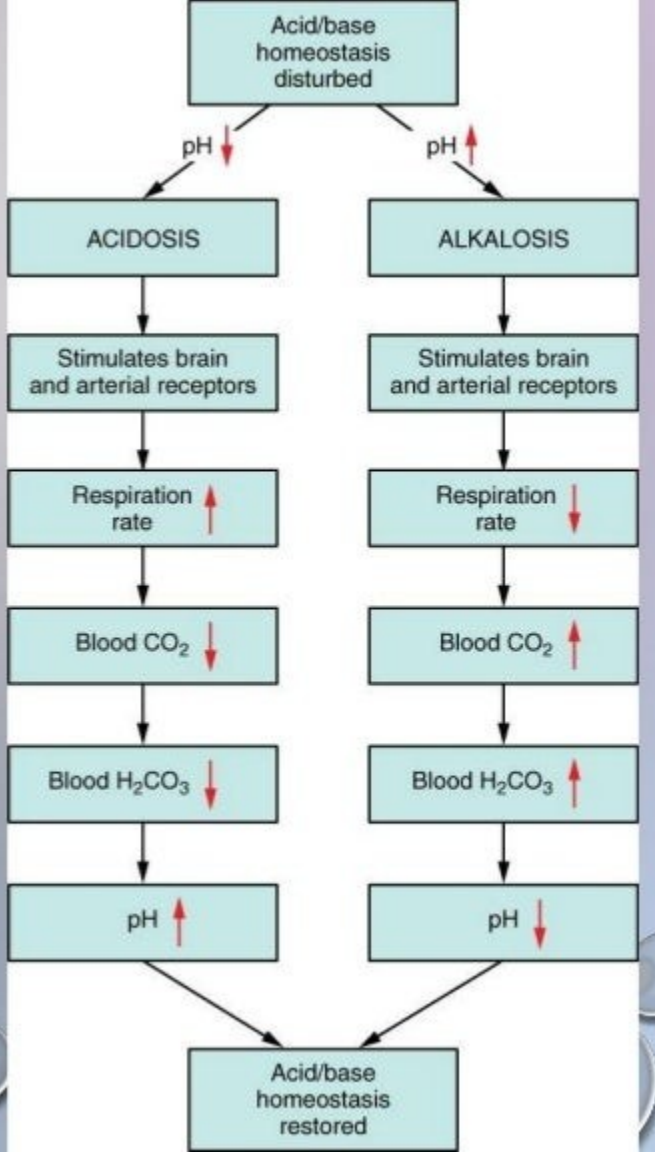
Control of pH:

Lungs: release CO_2

Kidney: excretes H^+ and reabsorbs bicarbonate

GI tract: release bicarbonate

Acid Base Balance By Respiratory Compensation




Thank
you!!