ELECTROLYTES II

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Advance Clinical Biochemistry I (MA 407)

Summer Semester

Lecture Three

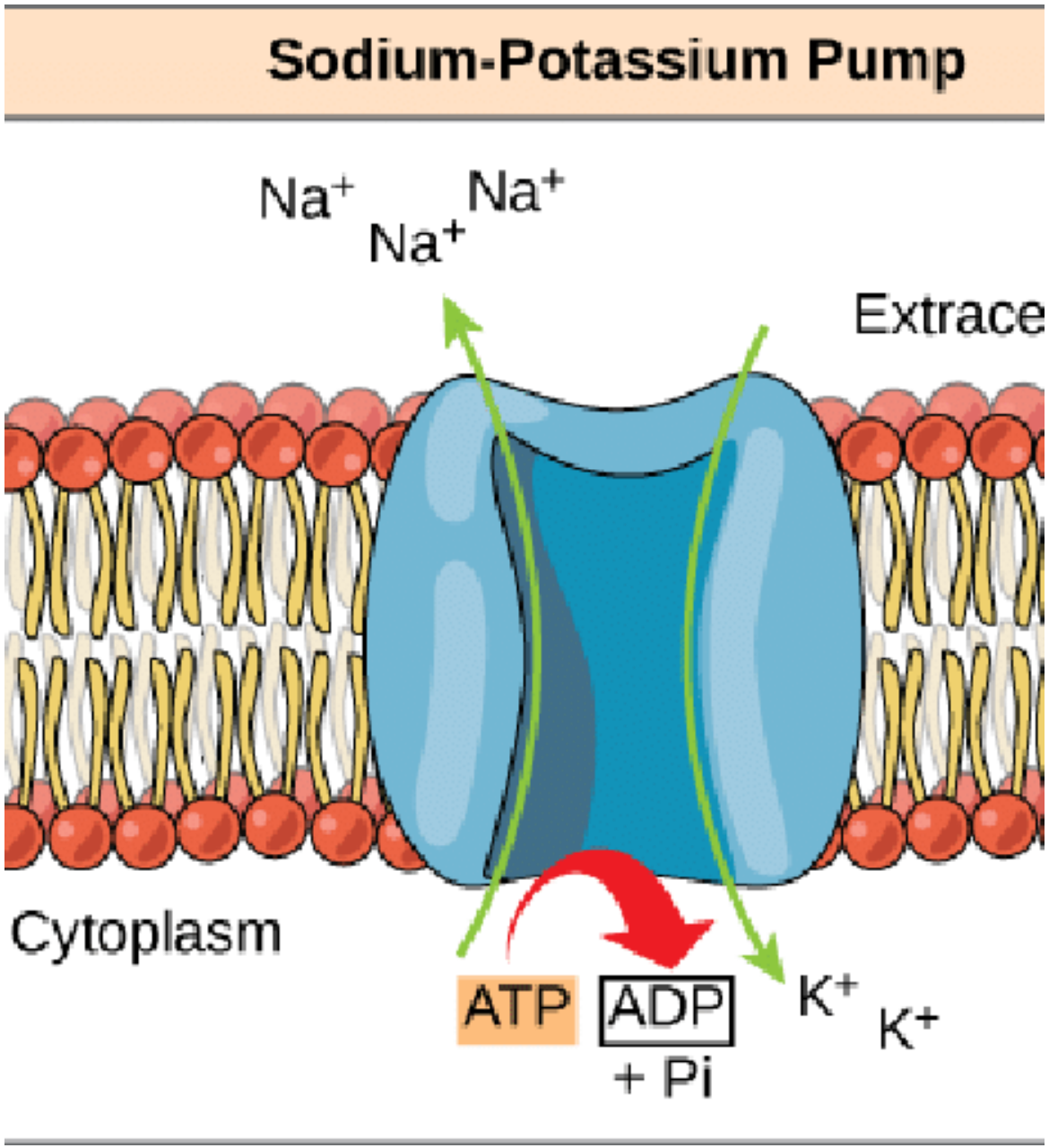
18/08/2025

Outlines

- Potassium
- Calcium
- Bicarbonate
- Magnesium
- Chloride
- Phosphorus

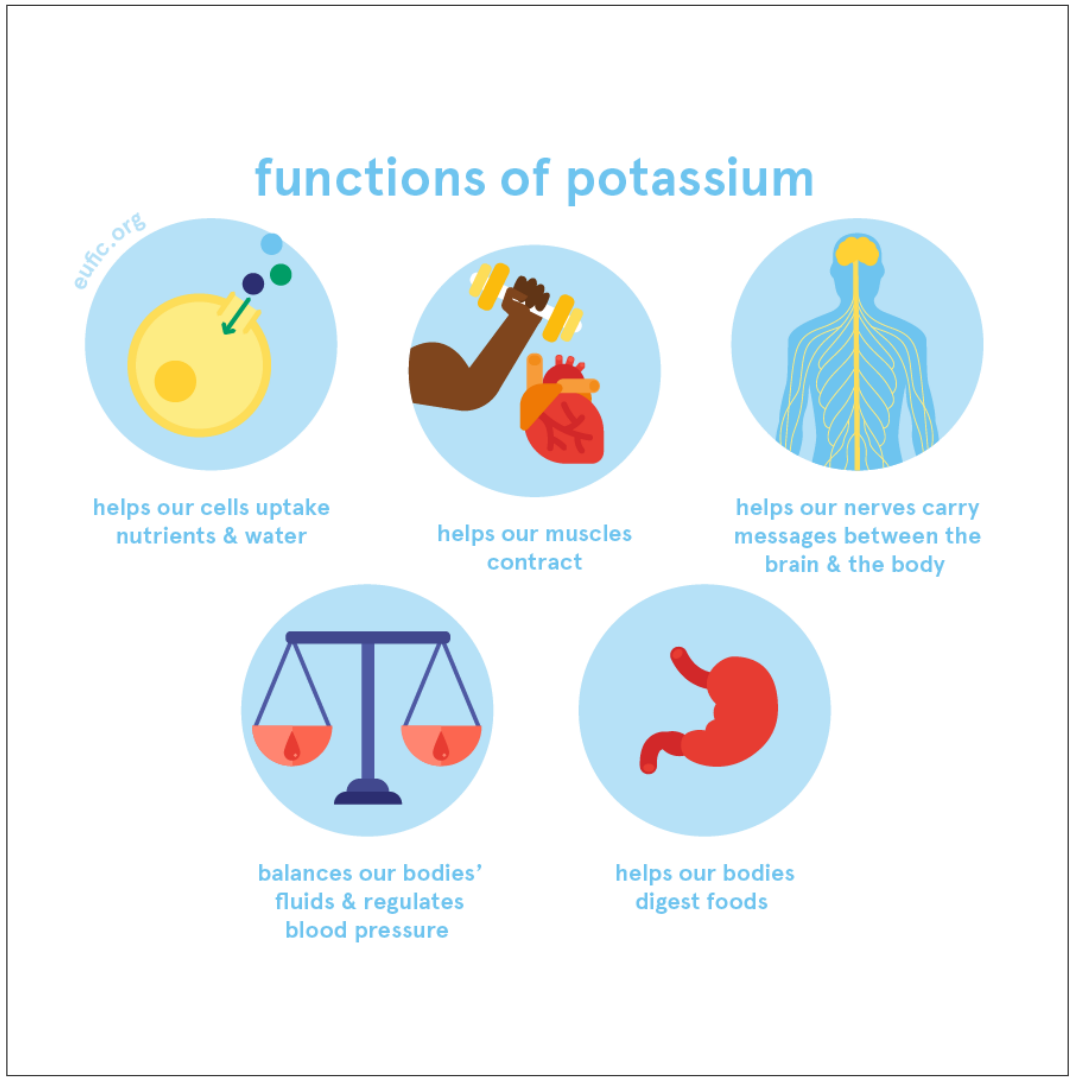
Objectives

- At the end of the lesson, the students should be able to:
- Know the important electrolytes and their distribution.
- Know the precise serum concentrations necessary for proper actions.
- Understand how electrolytes are regulated by kidney
- Know the clinical conditions associated with abnormal serum levels.



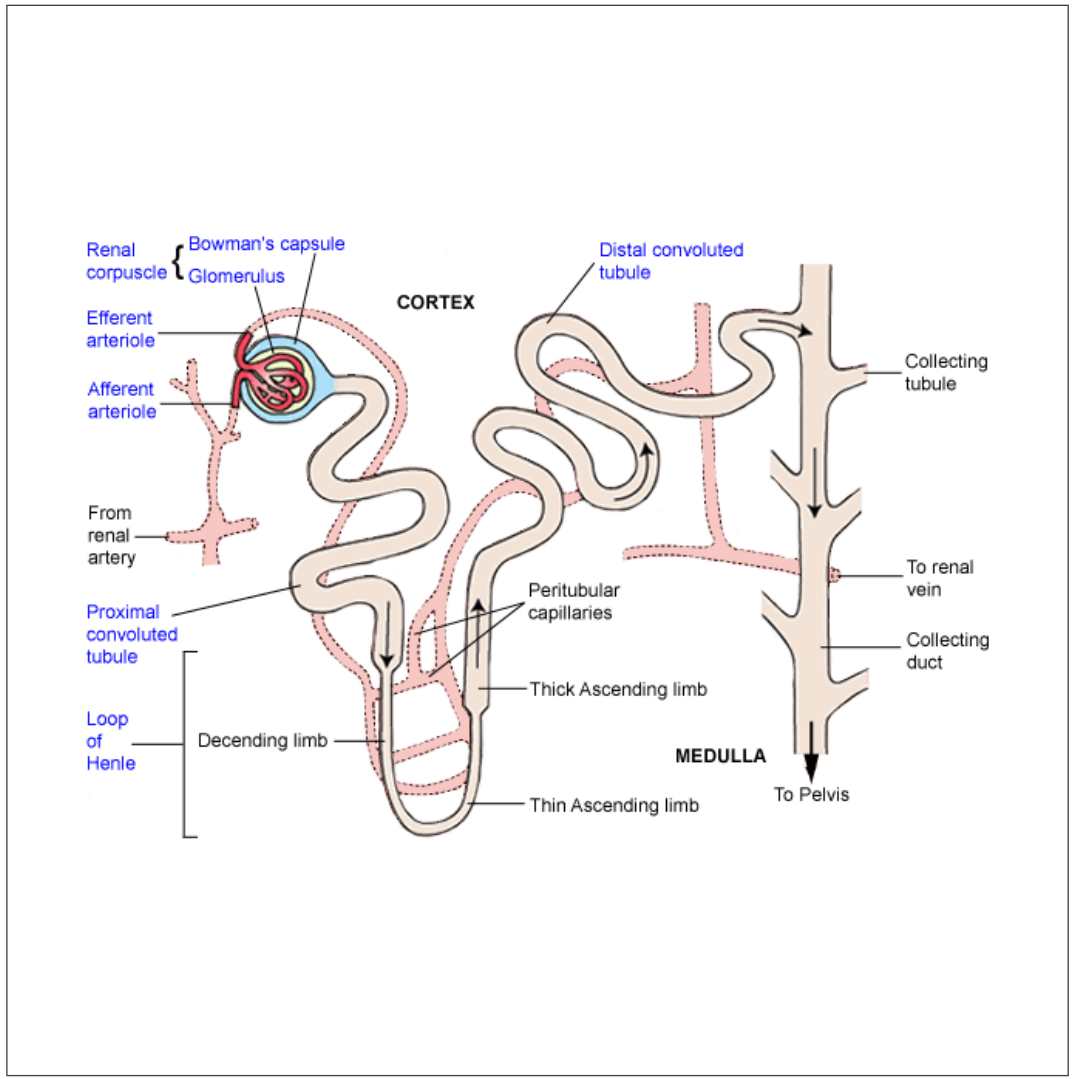
Potassium Ion

- Potassium is mainly an intracellular ion.
- The Na^+-K^+ ATP pump is primarily responsible for regulating the homeostasis of Na^+ and K^+.
- It pumps out sodium in exchange for potassium, which moves into the cells.
- In the kidneys, the filtration of potassium takes place at the glomerulus.



Biochemical Function of Potassium

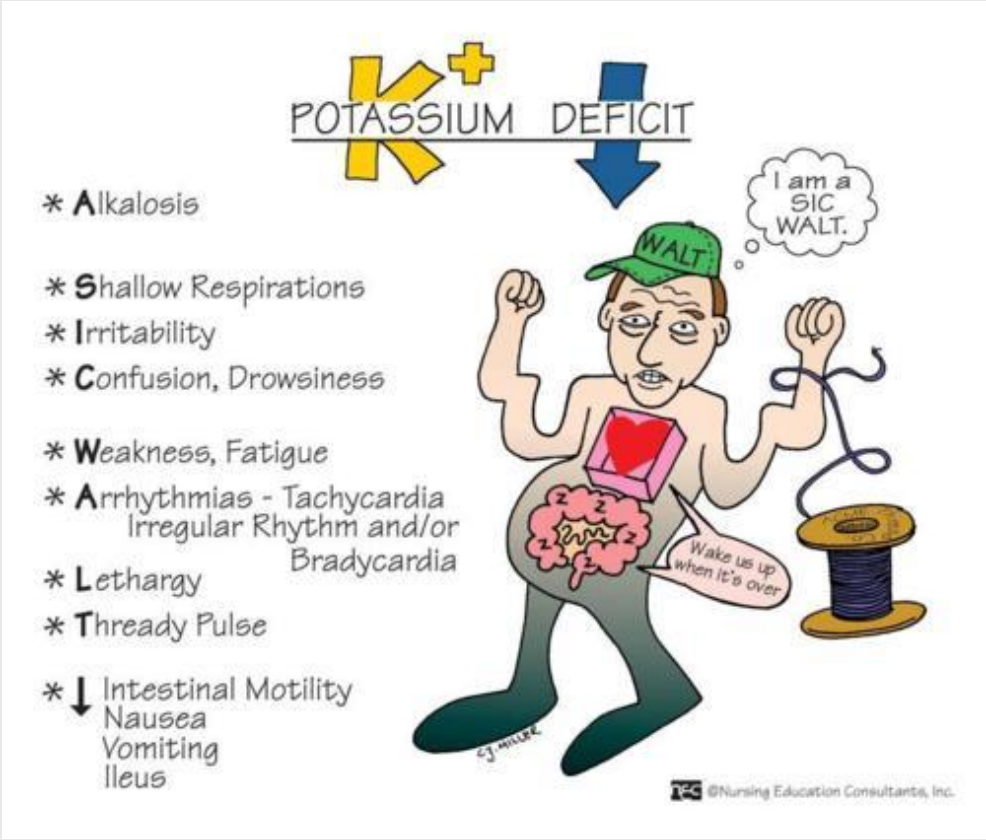
- Potassium's functions are vital for the body in these ways:
- Maintaining electrical gradients.
- Supporting normal muscle and nerve function.
- Regulating fluid, electrolyte, and acid-base balance.



- Potassium reabsorption occurs at the proximal convoluted tubule and ascending loop of Henle.
- Potassium secretion occurs at the distal convoluted tubule, where aldosterone increases the potassium secretion.
- Potassium channels and potassium-chloride cotransporters at the apical tubular membrane also secrete potassium.

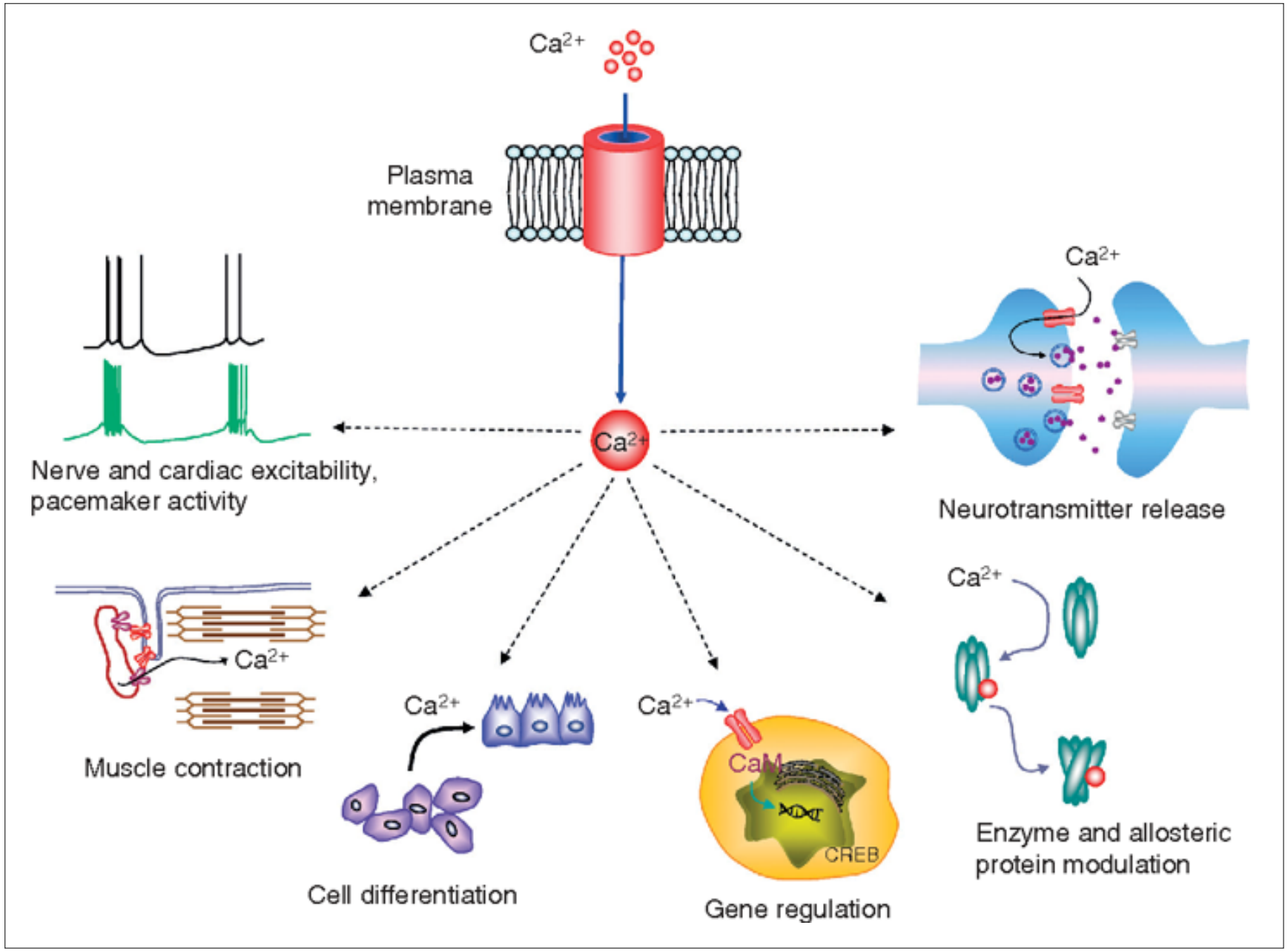
Common clinical Conditions

- Potassium imbalances may result in cardiac arrhythmias.
- Hypokalemia occurs when serum potassium levels are under 3.6 mmol/L.
- The features of hypokalemia include weakness, fatigue, and muscle twitching.
- Hypokalemic paralysis is generalized body weakness that can be either familial or sporadic.



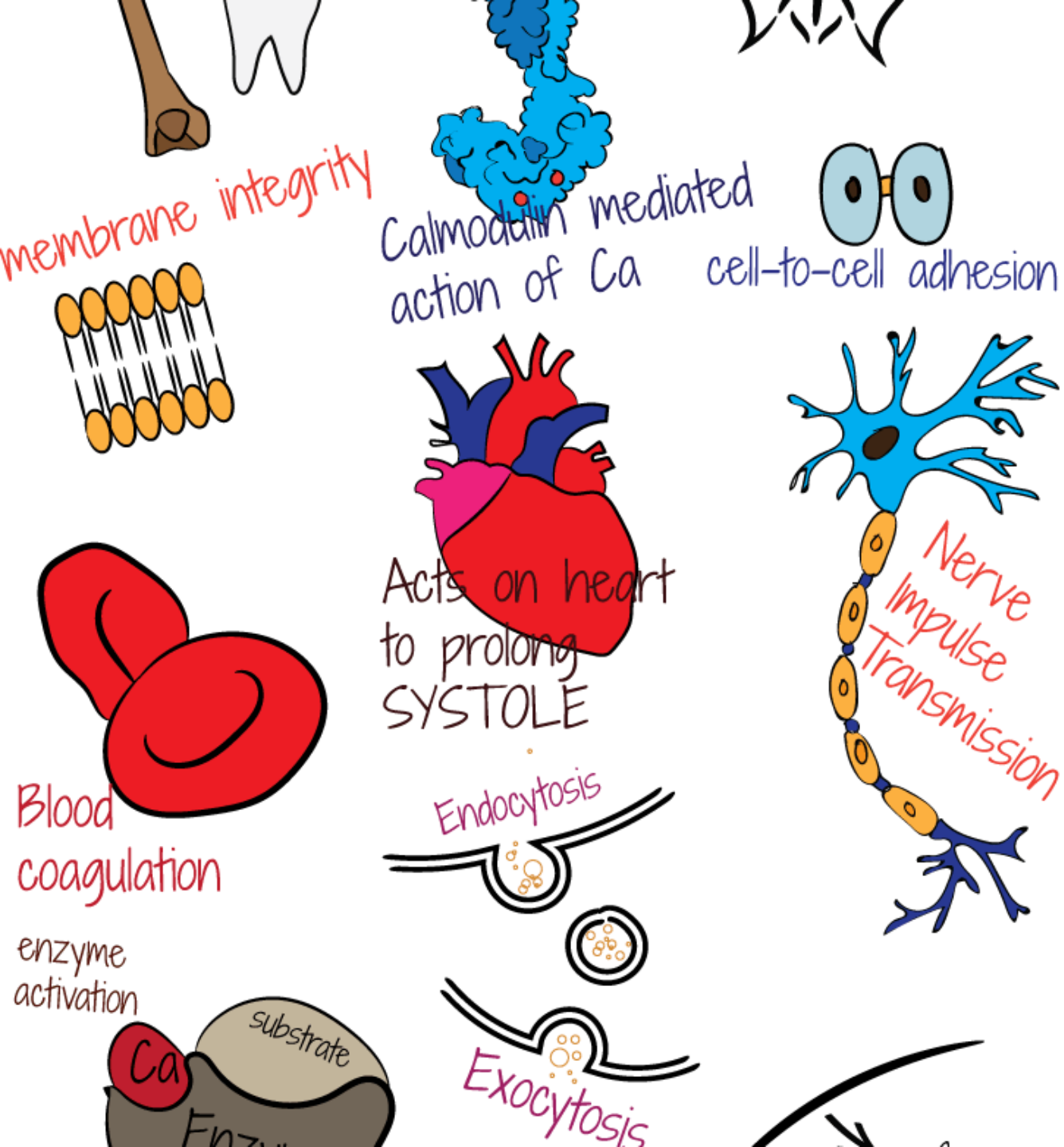
Cont.

- Hyperkalemia occurs when the serum potassium levels are above 5.5 mmol/L, which can result in arrhythmias.
- Muscle cramps, muscle weakness, rhabdomyolysis, and myoglobinuria may present hyperkalemia signs and symptoms.



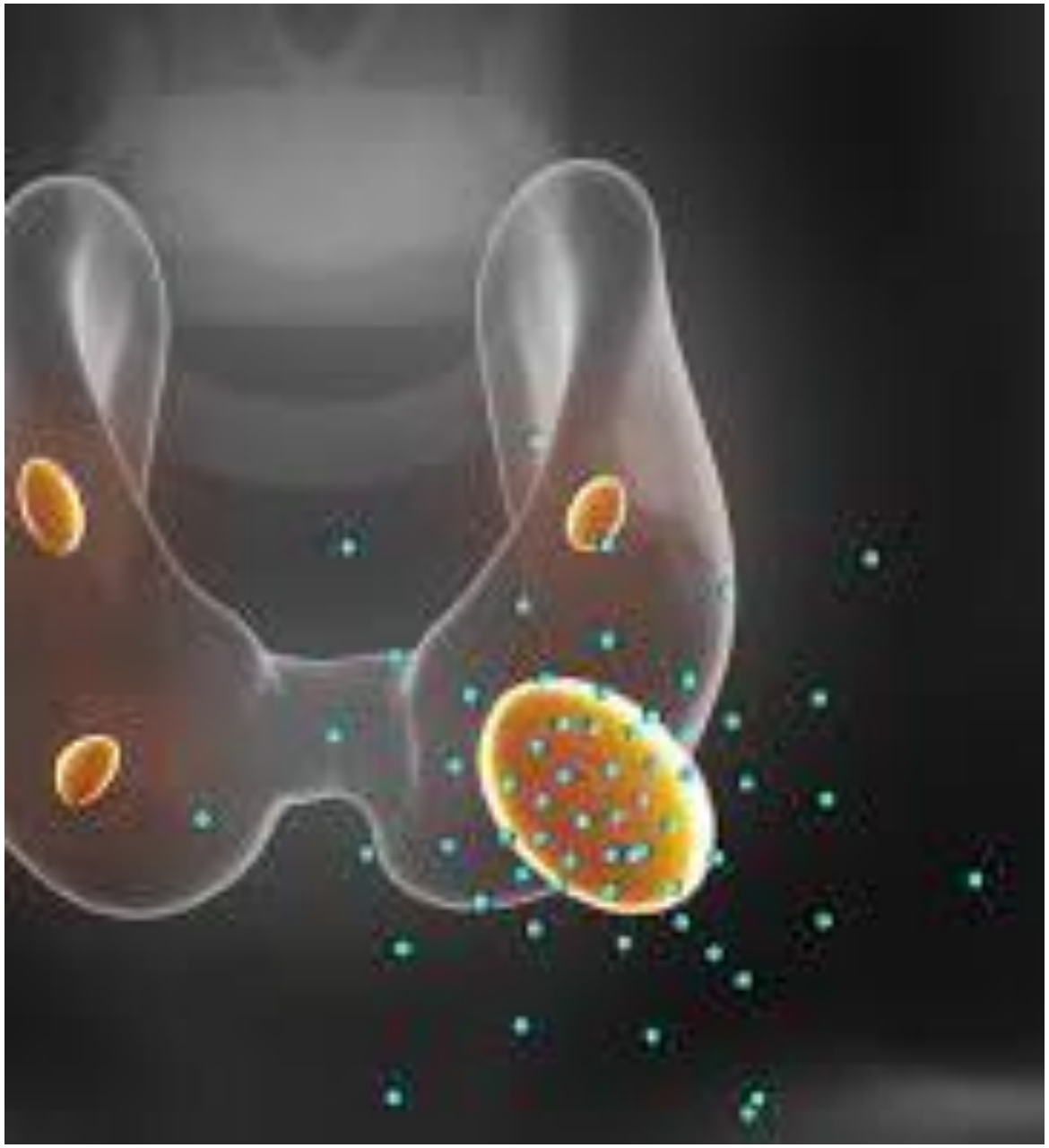
Calcium

- Calcium has a significant physiological role in the body.
- It is involved in skeletal mineralization, contraction of muscles, transmission of nerve impulses, blood clotting, and hormonal secretion.
- The diet is the predominant source of calcium and it is predominately extracellular cation.



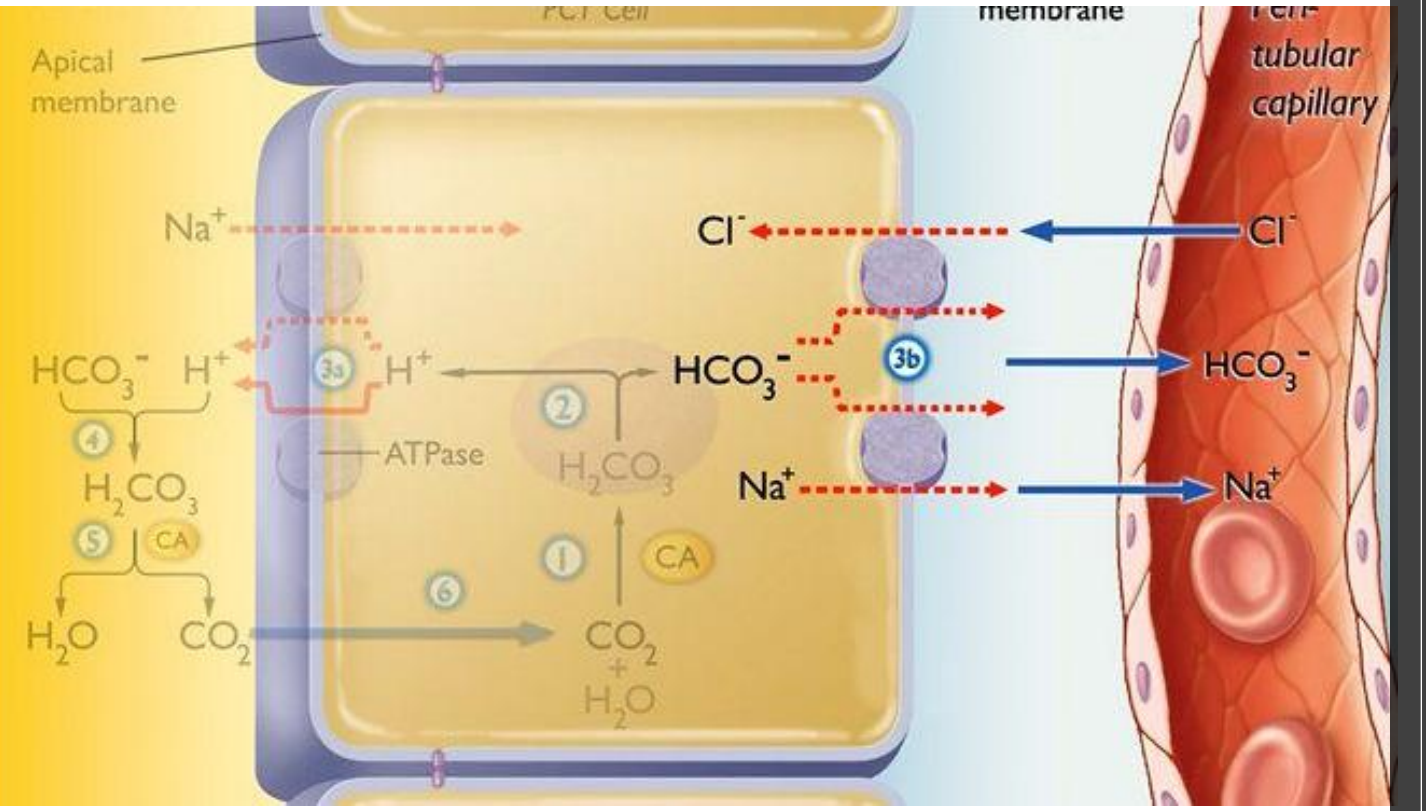
Calcium

- Calcium absorption in the intestine is primarily controlled by the hormonally active form of vitamin D (1,25-dihydroxy vitamin D3).
- Parathyroid hormone also regulates calcium secretion in the distal tubule of the kidneys.
- Calcitonin acts on bone cells to decrease calcium levels in the blood.



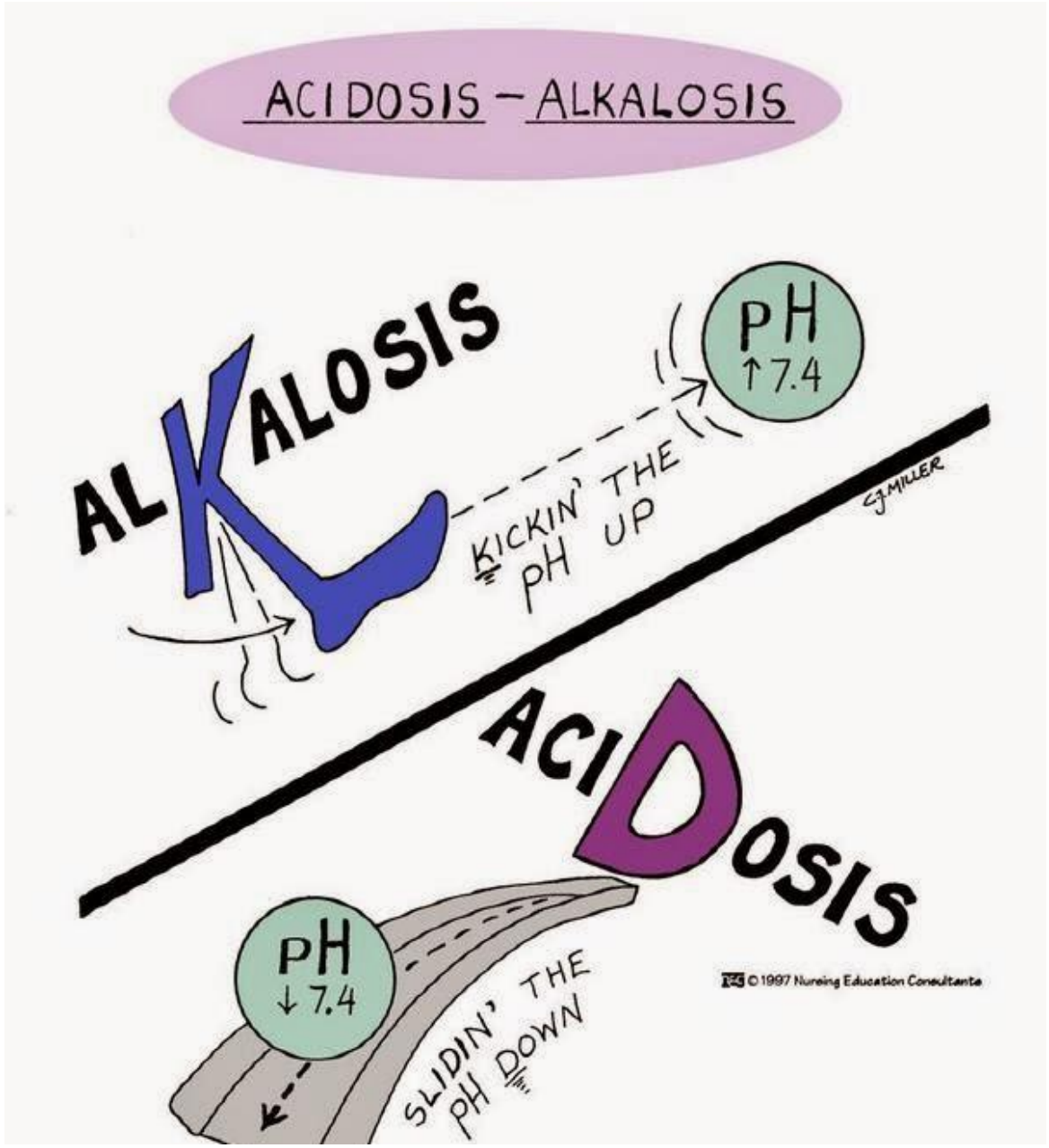
Common clinical Conditions

- Hypocalcemia diagnosis requires checking the serum albumin level to correct for total calcium.
- Hypocalcemia is diagnosed when serum calcium is <8.8 mg/dL, as in vitamin D deficiency or hypoparathyroidism.
- Hypercalcemia is when serum calcium level is > 10.7 mg/dL, as seen with primary hyperparathyroidism.
- Humoral hypercalcemia presents in malignancy, primarily due to PTHrP secretion.



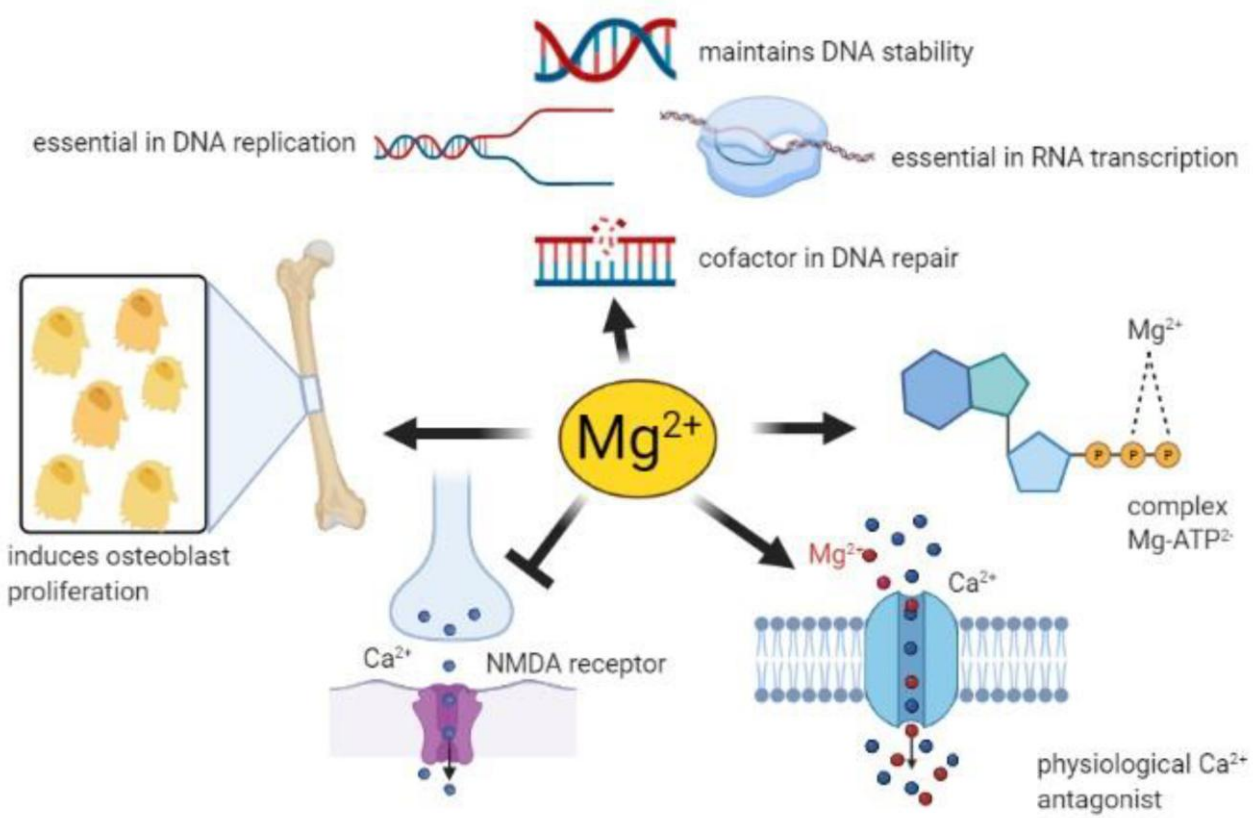
Bicarbonate

- The acid-base status of the blood drives bicarbonate levels.
- Kidneys regulate bicarbonate levels and maintain acid-base balance.
- Kidneys reabsorb the filtered bicarbonate and generate new bicarbonate by net acid excretion.
- Diarrhea usually results in bicarbonate loss, causing an imbalance in acid-base regulation.



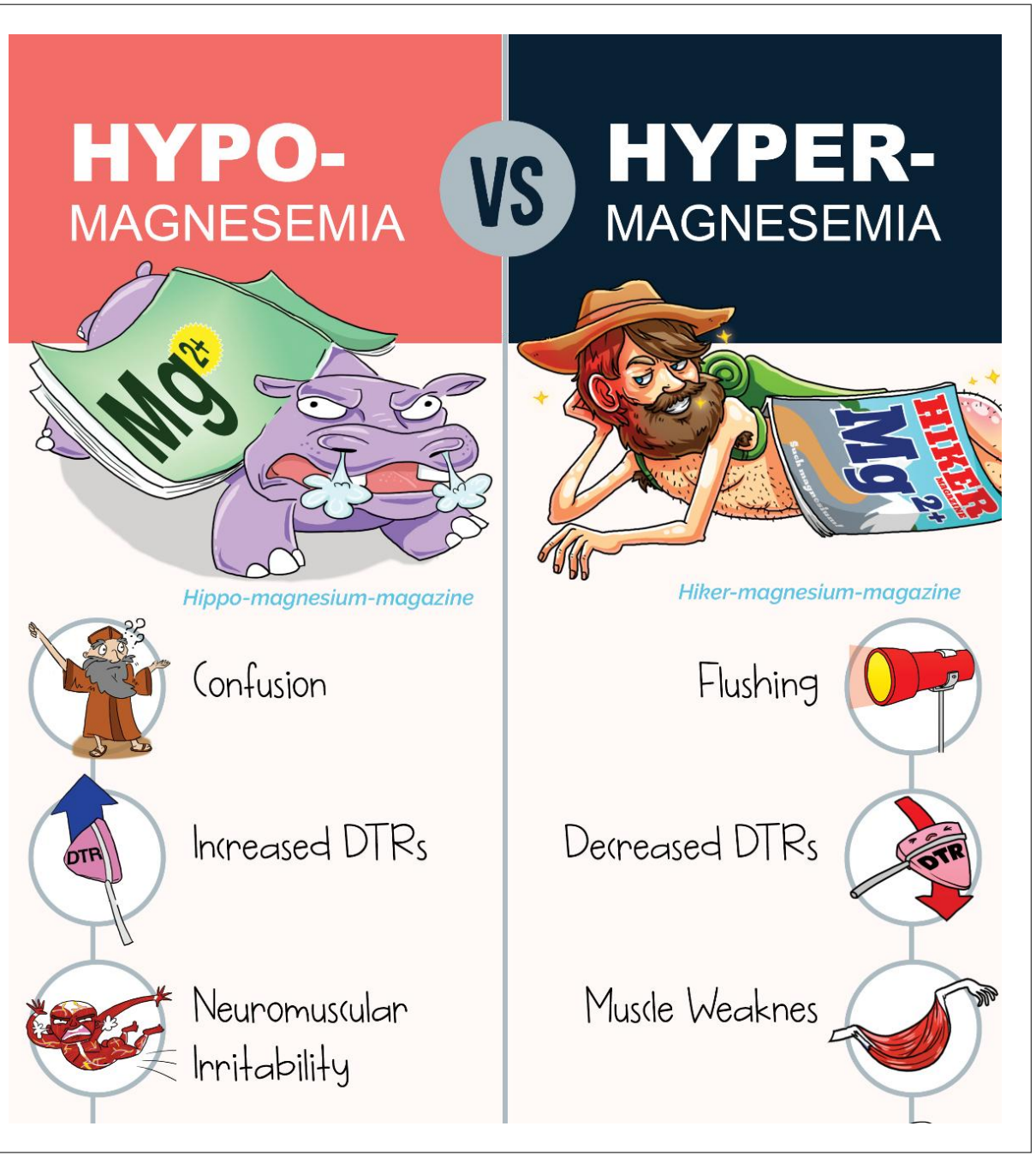
Common clinical conditions

- Many kidney-related disorders can result in imbalanced bicarbonate metabolism leading to excess bicarbonate in the body.
- Low levels of bicarbonate in the blood may cause metabolic acidosis.
- High levels of bicarbonate in the blood may cause metabolic alkalosis.



Magnesium

- Magnesium is an intracellular cation and is supplied to the body via diet (nuts).
- Magnesium is mainly involved in ATP metabolism, proper muscle functioning, neurological functioning, and neurotransmitter release.
- When muscles contract, calcium re-uptake by the calcium-activated ATPase of the sarcoplasmic reticulum is triggered by magnesium.

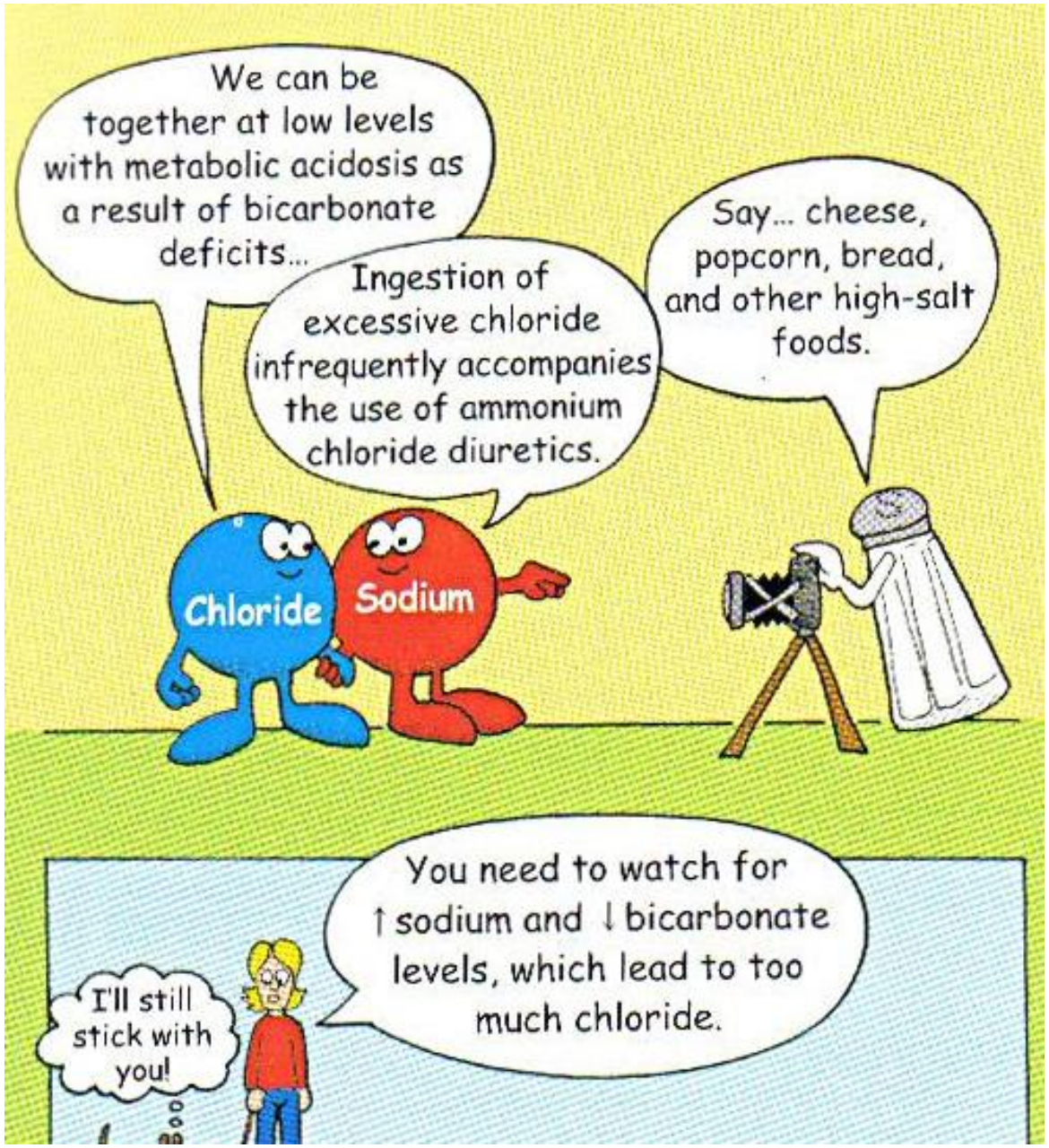


Common clinical condition(s)

- Hypomagnesemia occurs when the serum magnesium levels are less than 1.46 mg/dL.
- Alcoholism, GIT disease conditions, and excessive renal loss may result in hypomagnesemia.
- It commonly presents with ventricular arrhythmias, which include torsades de pointes.
- Hypomagnesemia may also result from the use of certain medications, such as omeprazole.

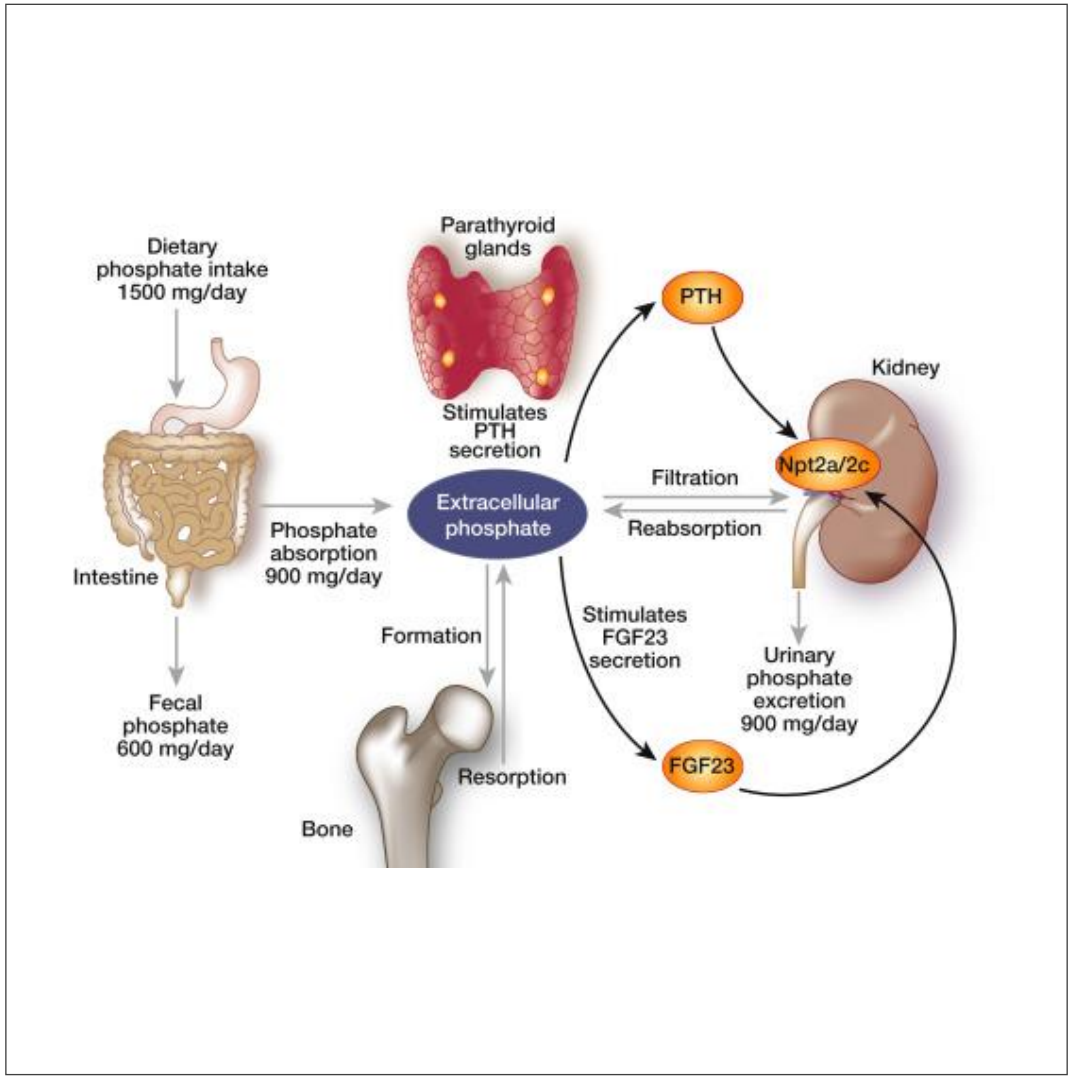
Chloride Ion

- Chloride is an anion found predominantly in the extracellular fluid.
- The kidneys predominantly regulate serum chloride levels.
- Most chloride, filtered by the glomerulus, is reabsorbed by both proximal and distal tubules by active/passive transport.
- Hypochloremia presents in gastrointestinal losses like vomiting or excess water gain like congestive heart failure.



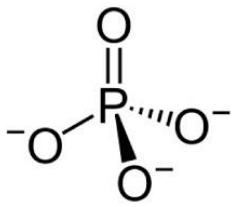
Common clinical condition(s)

- Hyperchloremia, can be caused by severe dehydration, diarrhea, or metabolic problems.
- In that case, the blood becomes too acidic, with eventual kidney disease development.
- A high salt diet can lead to an excessive intake of sodium chloride, which is associated with elevated blood pressure.

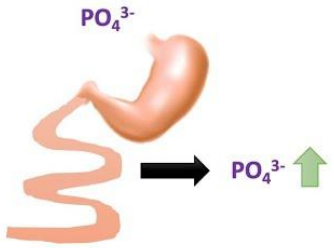


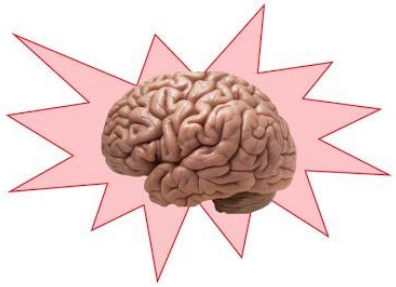
Phosphorus Ion

- Phosphorus is an extracellular fluid cation.
- 85% of the total body phosphorus is in the bones and teeth in the form of hydroxyapatite.
- Other parts of the body (soft tissues) contain the remaining 15%.
- Phosphate plays a crucial role in metabolic pathways.



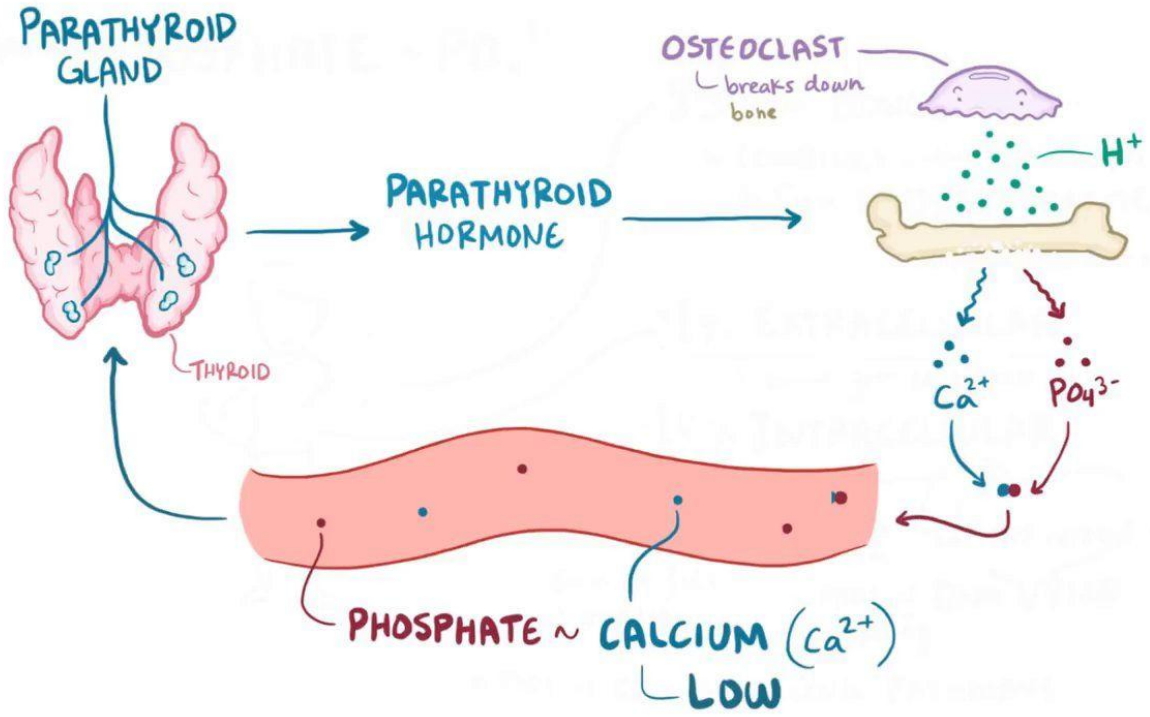
Low Phosphate (Hypophosphatemia)





Phosphorus Ion

- It is a component of many metabolic intermediates and, most importantly, of ATP and nucleotides.
- Phosphate is regulated by Vitamin D_3, PTH, and calcitonin. It is secretion is mainly controlled by the kidney.
- Phosphate imbalance is most commonly due to either impaired dietary intake, GIT disorders, or deranged renal excretion.



Common clinical condition(s)

- Hypophosphatemia is a common condition related to abnormal serum level of phosphorus.
- The condition is caused by malnutrition as in seen in alcoholism.
- The kidneys maintain phosphate levels in the normal range.
- Hyperphosphatemia is uncommon except when kidney GFR falls below 30 ml/min

Summary

- P^{+} (ICF), Ca^{2+} (ECF), Bicarbonate (ECF), Mg^{2+} (ICF), Cl- (ECF) and $HPO^{-2}4$ (ECF).
- Hyponatremia, hypernatremia, and hypomagnesemia can lead to neurological consequences such as seizures.
- Hypokalemia and hyperkalemia, as well as hypocalcemia, may cause cardiac arrhythmias.
- Bicarbonate imbalance can lead to metabolic acidosis or alkalosis.
- Some consequences of potassium, calcium, and magnesium abnormalities are fatigue, lethargy, and muscle weakness.

Take home message

- ✓ Classify the electrolytes based on the cellular fluid distribution..
- ✓ Mention the conditions that result in the high level of (1) Ca^{2+}, (2) Cl^{-}, and (3) Mg^{2+} in the blood.
- ✓ Explain the clinical consequences of serum bicarbonate imbalance.
- ✓ Which of the body tissues contain a larger percentage of phosphorus ion and why?
- ✓ Enumerate the major clinical role of magnesium ion.


Questions
Comments
Feedback