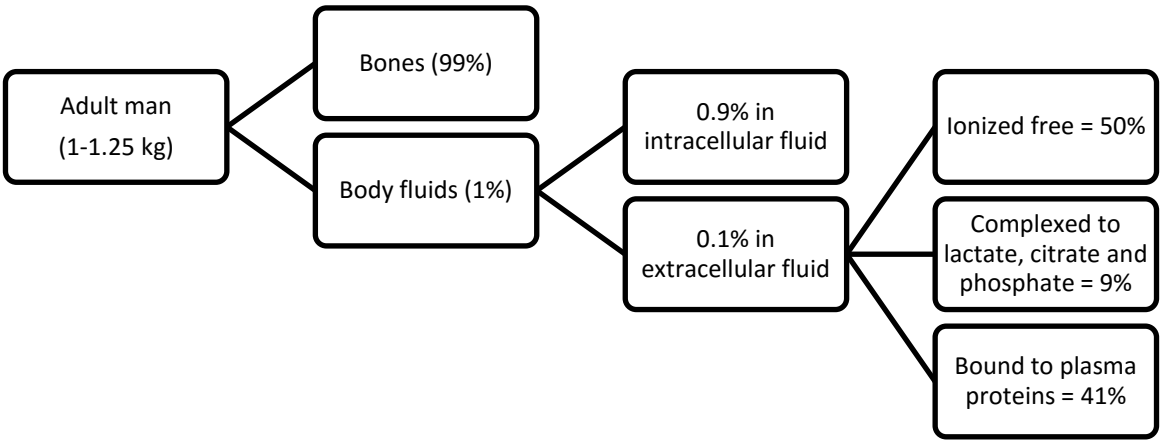
Unit V – Problem 12 – Physiology: Calcium Homeostasis

- **Calcium distribution:**

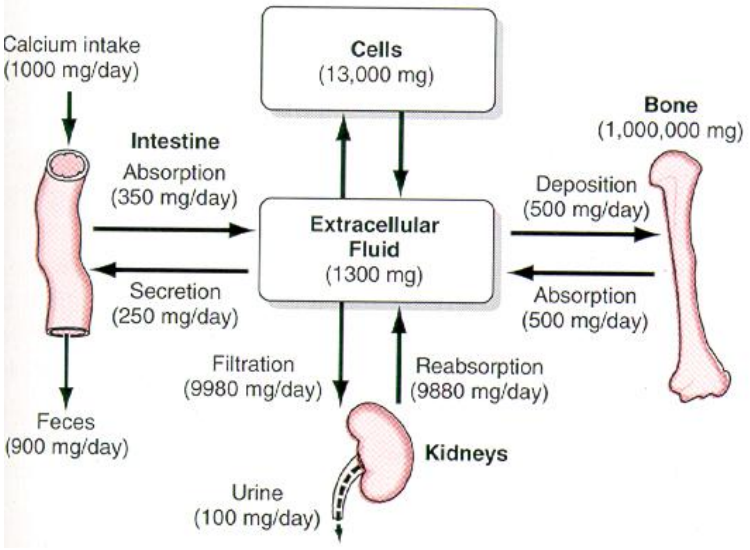


- Ionized calcium is the one which is important for the functions of the body.
- The amount of total calcium differs with the level of serum albumin.
- **Corrected calcium concentration estimates the total concentration as if the albumin concentration is normal (usually taken as 40 g/L):**
  - ✓ Corrected [Ca] = measured total [Ca] + {0.02 x (40-albumin g/L)}
- **As the pH of the body increases, calcium will get bound to serum proteins leading to hypocalcemia that results in tetany!**

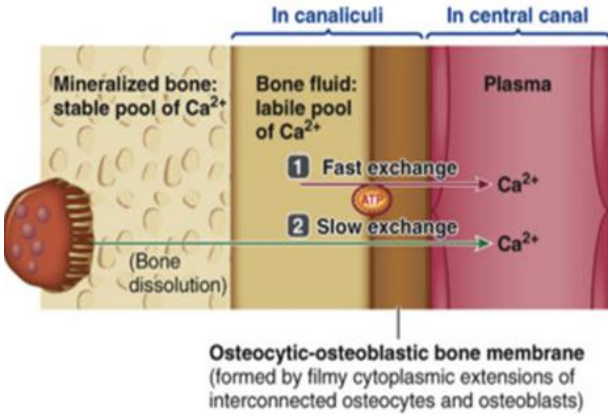
- **Calcium imbalances:**

Hypercalcemia	Hypocalcemia
Seen with: acidosis and hyperparathyroidism	Seen with: diarrhea, pregnancy, alkalosis, lactation and hypoparathyroidism
↓ membrane Na^+ permeability and inhibits depolarization	↑ membrane Na^+ permeability, causing nervous and muscular systems to be abnormally excitable
Characterized by: muscular weakness, depressed reflexes and cardiac arrhythmias	Characterized by: tetanus, laryngospasm and death!

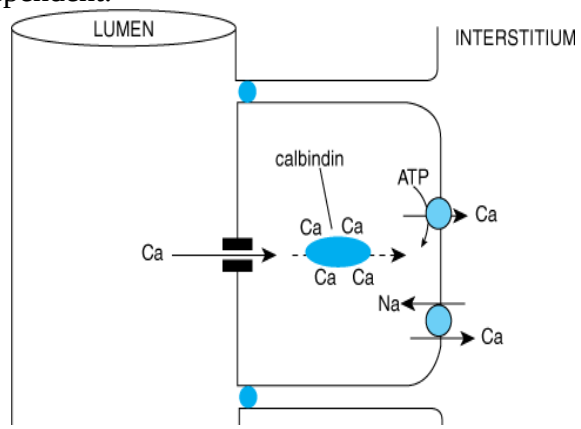
- **Regulation of calcium metabolism:**
  - **Calcium homeostasis**: the hormonal regulation of serum ionized calcium through regulating calcium exchange at the gut, kidney and bone:
    - ✓ Rapid transfer between extracellular fluid and other tissues of the body → maintains a constant free plasma [Ca].
  - **Calcium balance**: is the state of the calcium body stores, primarily in bones, which are largely a function of dietary intake, intestinal absorption, renal excretion and bone remodeling.



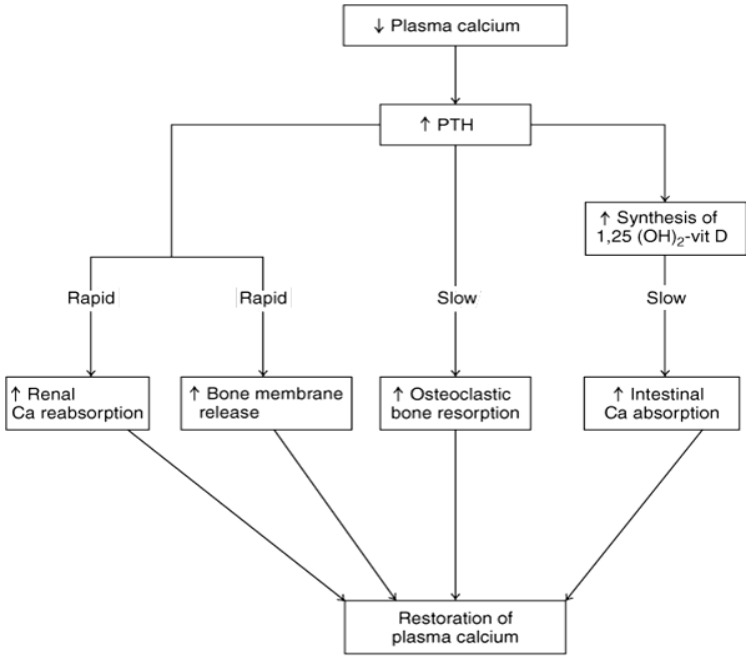
- **Bones and regulation of extracellular fluid calcium:**
  - **Short-term exchange is represented by the calcium-buffering system**: calcium is removed from the labile pool in the bone fluid into the plasma by parathyroid hormone-activated calcium-pumps located in the osteocytic-osteoblastic bone membrane.
  - **Long-term exchange is represented by the use of bone calcium stores on a slower time scale**: calcium is moved from the stable pool in mineralized bone into the plasma through parathyroid hormone-induced dissolution of the bone by osteoclasts.



- **Effector sites for calcium balance-GI tract:**
  - Hormonal control of this absorptive process is the major mean of homeostatically regulating total-body calcium balance.
  - This is vitamin-D dependent.



- **Effector sites for calcium balance-kidneys:**
  - In proximal convoluted tubule, calcium reabsorption is largely passive and paracellular.
  - In thick ascending limb of loop of Henle, calcium reabsorption is dependent on sodium reabsorption and it under hormonal control.
  - In distal convoluted tubule, calcium reabsorption is active and transcellular and is under hormonal control of parathyroid hormone.
- **Parathyroid hormone:**
  - **Source**: chief cells of parathyroid glands.
  - **Function:**
    - ✓ ↑ bone resorption of Ca^{2+} and PO_4^{3-}
    - ✓ ↑ kidney reabsorption of Ca^{2+} in distal convoluted tubule (DCT).
    - ✓ ↓ reabsorption of PO_4^{3-} in proximal convoluted tubule (PCT).
    - ✓ ↑ 1,25-$(OH)_2D_3$ (calcitriol) production by stimulating kidney 1α-hydroxylase enzyme.
  - **Regulation:**
    - ✓ ↓ serum Ca^{2+} → ↑ parathyroid hormone secretion.
    - ✓ ↓ serum Mg^{2+} → ↑ parathyroid hormone secretion.
    - ✓ ↓↓ serum Mg^{2+} → ↓ parathyroid hormone secretion.



- **Vitamin D (cholecalciferol):**
  - **Source**: D_3 from sun exposure in skin. D_2 ingested from plants. Both converted to 25-OH in the liver and to 1,25-$(OH)_2$ (active form) in kidneys by the enzyme 1α-hydroxylase.
  - **Function:**
    - ✓ ↑ absorption of dietary Ca^{2+} and PO_4^{3-}
    - ✓ ↑ bone resorption → ↑ Ca^{2+} and PO_4^{3-}
  - **Regulation:**
    - ✓ ↑ parathyroid hormone, ↓Ca^{2+}, ↓PO_4^{3-} cause ↑1,25-$(OH)_2$ production.
  - **Deficiency of vitamin D:**
    - ✓ It causes rickets in children (مرض الكُساح) and osteomalacia in adults (تليُّن العظام)
    - ✓ Deficiency is caused by: malabsorption, ↓ exposure to sunlight, poor diet and chronic kidney failure.
- **Regulation of plasma phosphate:**