

ROLE OF CALCIUM IN BIOLOGICAL SYSTEMS

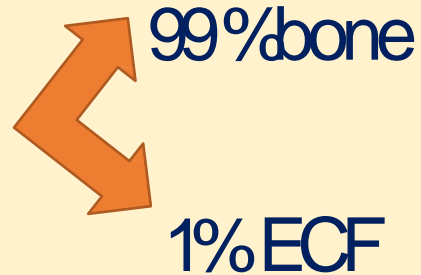
SUBMITTED BY:-
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(Associate prof. In chemistry)

Role of Calcium in Biological Systems

- **Basic Facts :-**
- Calcium was recognized as an element in 1808 by Humphry Davy
- In Latin calx is used for lime.
- Isotopes of calcium with natural abundances ^{40}Ca (96.94%) , ^{44}Ca (2.1%) , ^{42}Ca (0.64%) , ^{43}Ca (0.145%)
- ^{43}Ca has nuclear spin ($I=7/2$).
- ^{45}Ca is a radioactive isotope used in calcium localization and transportation in biological systems.

Calcium Metabolism

□ Body content = (1.0-1.5 kg)



□ Sources: milk (cow -100mg/100ml ,human milk -300mg/100ml), cereals → major source

□ Daily requirement —

Individual	Daily requirement
Adult	500mg
Children	1200 mg
Pregnancy	1500 mg
Oldage	1500mg/day calcium +20 microgram/day vitamin D

Calcium Metabolism-Absorption of Calcium

First & second part of duodeneum

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graph TD; A[First & second part of duodeneum] --> B[Active transport]; B --> C[Carrier protein - calcium dependent ATPase]
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Active transport

Carrier protein - calcium dependent ATPase

Factors affecting Calcium Absorption

Increase calcium absorption

1. Vitamin D → increase in Calbindin → Calcium absorption
2. Parathyroid Hormone
3. acidity-favors calcium absorption
4. Amino acids (Lysine & Arginine)
→ Calcium absorption

Decrease calcium absorption

1. Phytic acid (hexaphosphate Inositol) → fermentation decrease Phytate content
2. Oxalate → present in leafy vegetables
3. Steatorrhoea → fatty acid not absorbed
Calcium fatty acid complex not absorbed
4. High phosphate content → calcium phosphate is not precipitates ,not absorbed

Calcium metabolism

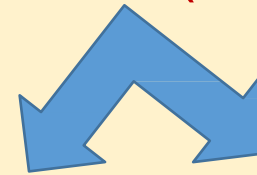
□ optimum Ratio for maximum absorption :

Calcium : phosphorous → (1:2 to 2:1)

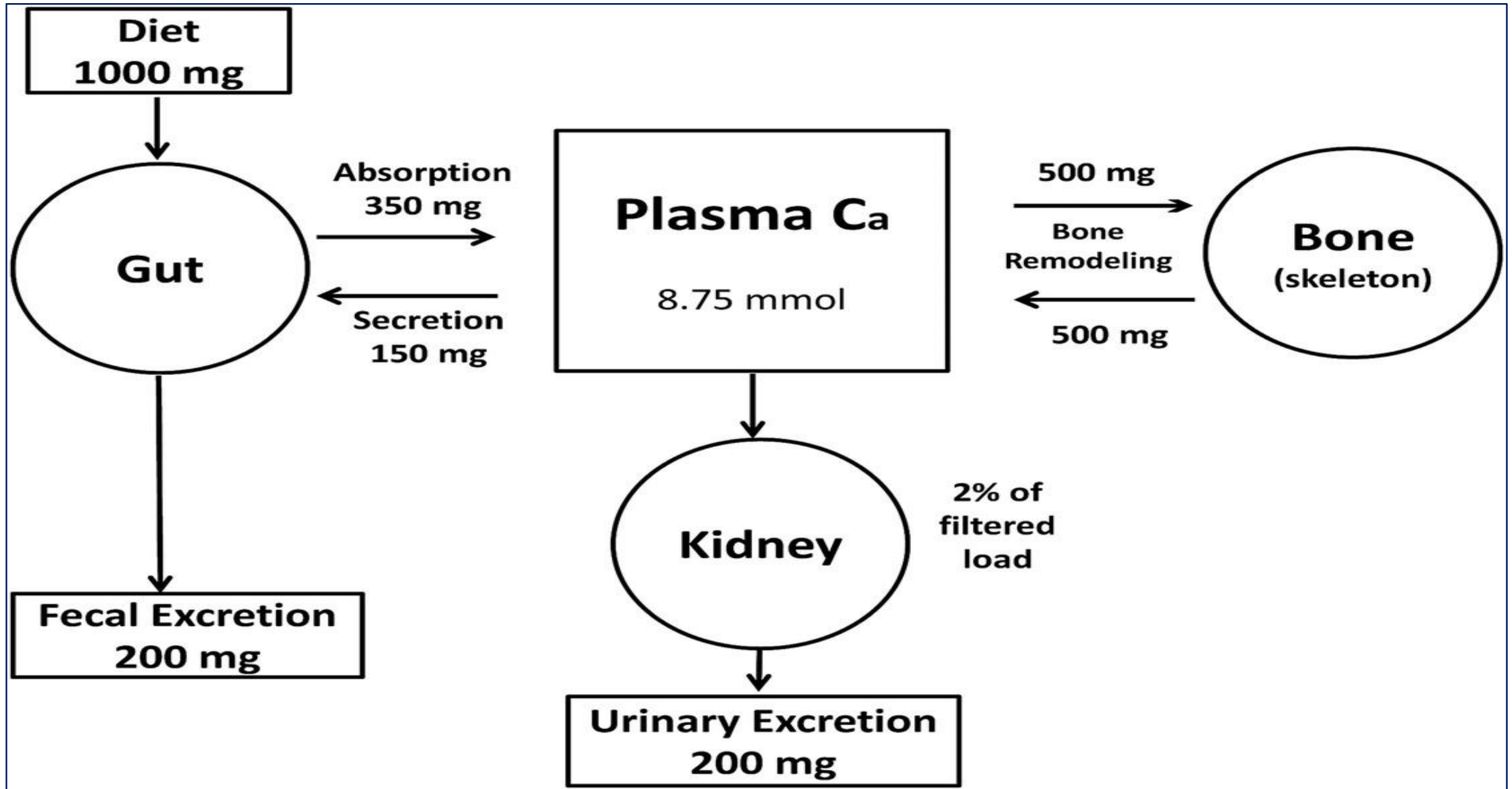
loss of calcium:

stool (400 mg)

Daily intake (500 mg)

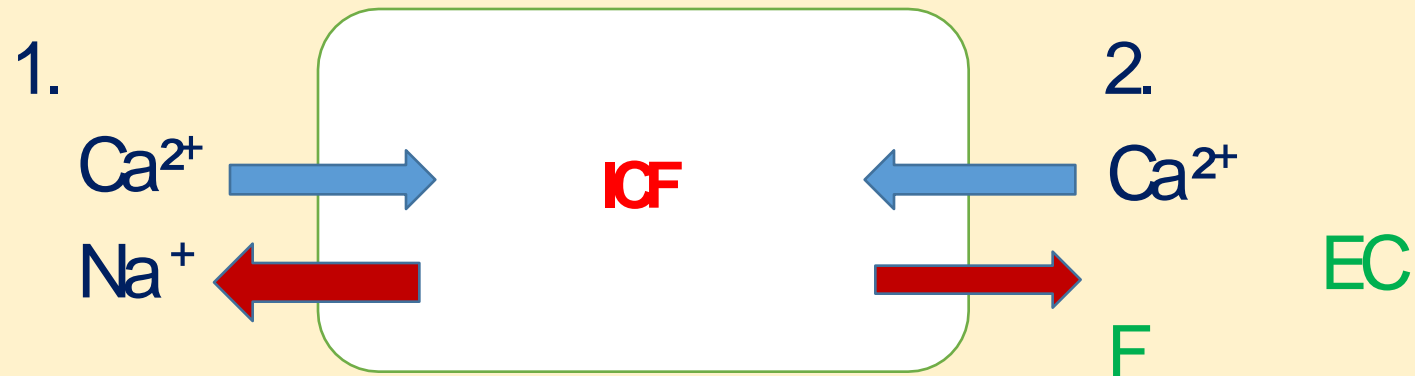


urine (100 mg)

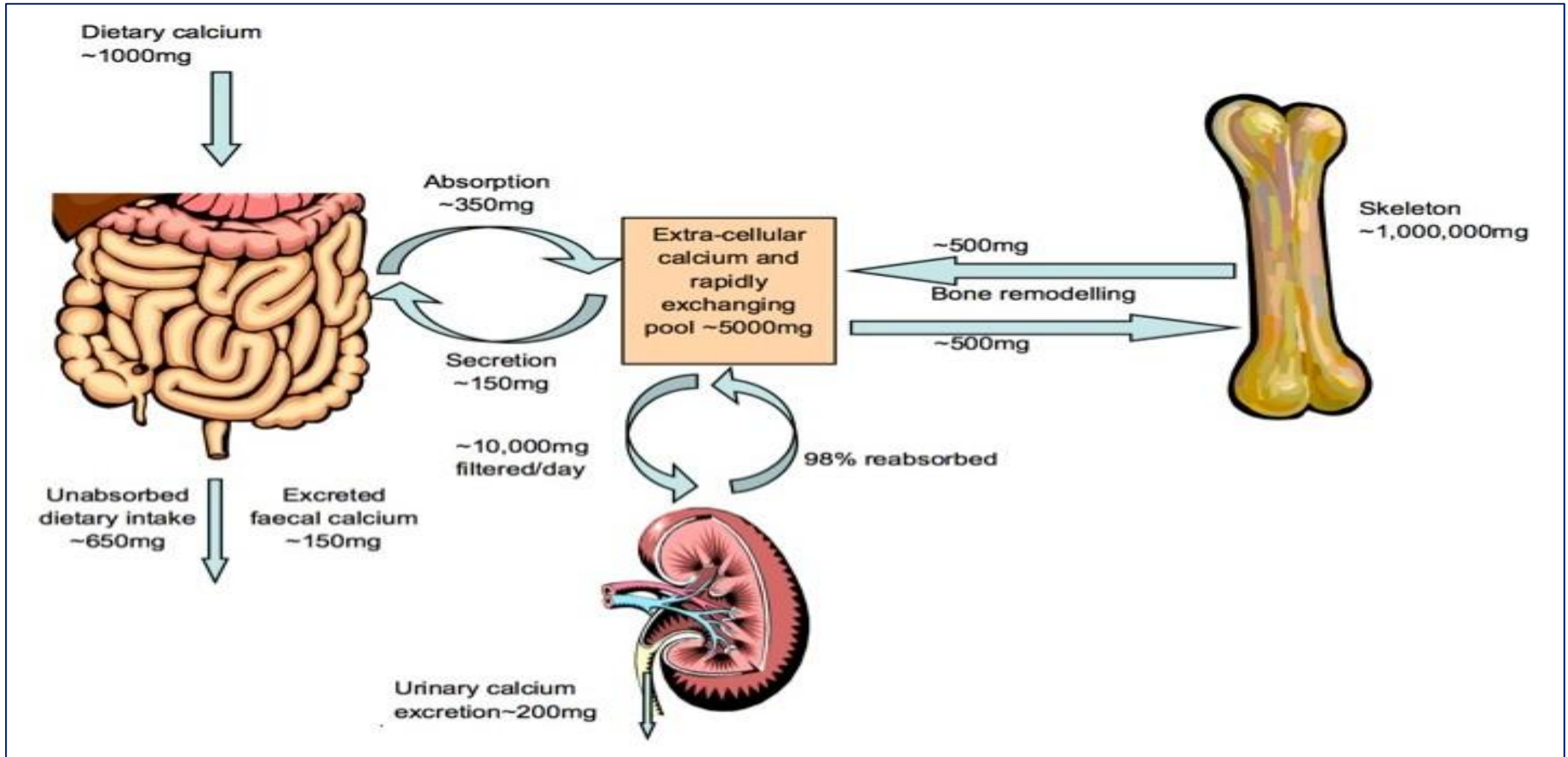


Calcium metabolism

- Distribution of Calcium in human body
- Intra cellular concentration : 10 micromole/ lt
- Extra cellular concentration : 2.5 mmol/ lt
- **Influx:**
 1. $\text{Na}^+/\text{Ca}^{2+}$ exchange—low affinity for calcium
 2. $\text{Ca}^{2+}/\text{H}^+$ ATPase exchange



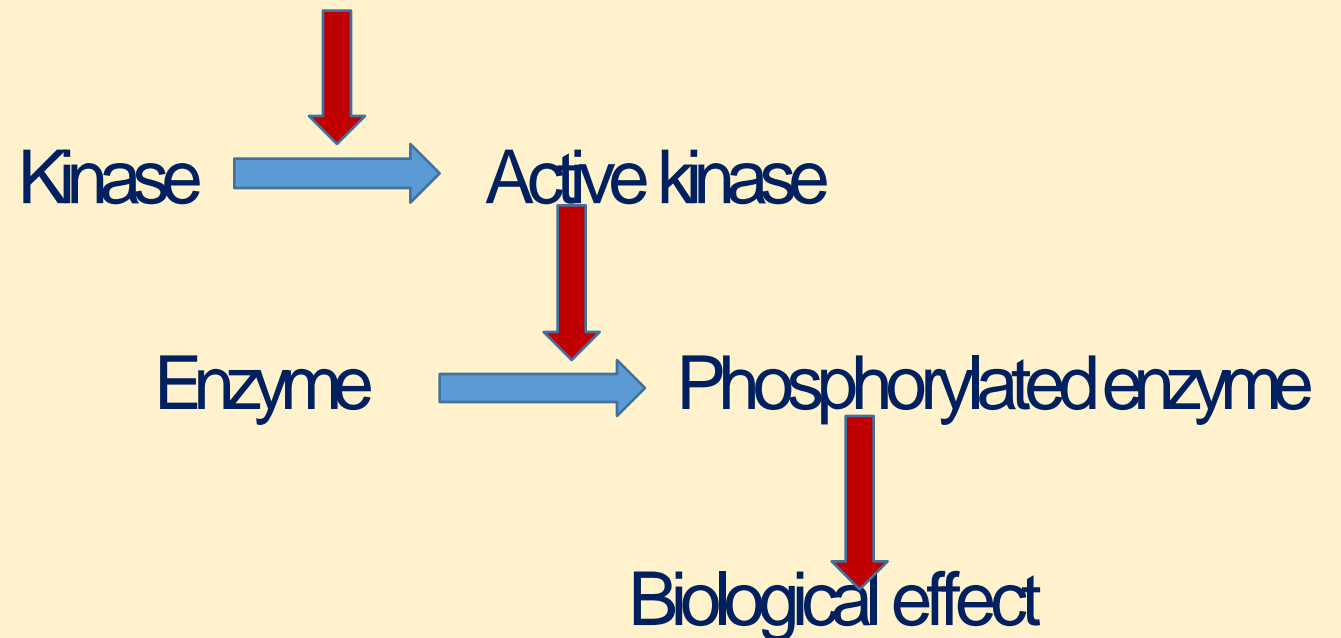
Calcium balance in a human body

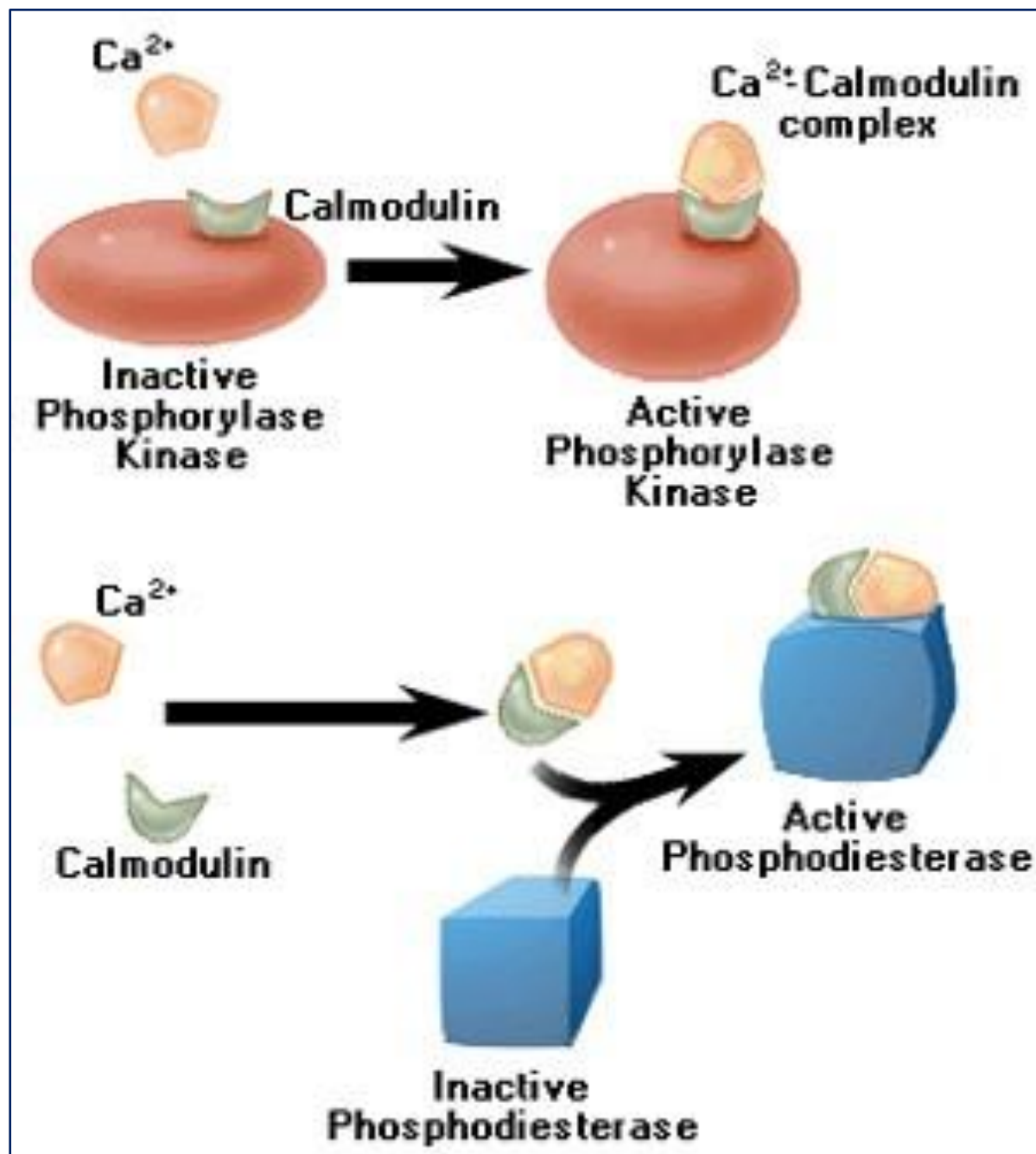


Functions of Calcium

□ 1. Activation of enzymes (1) through “Calmodulin ”

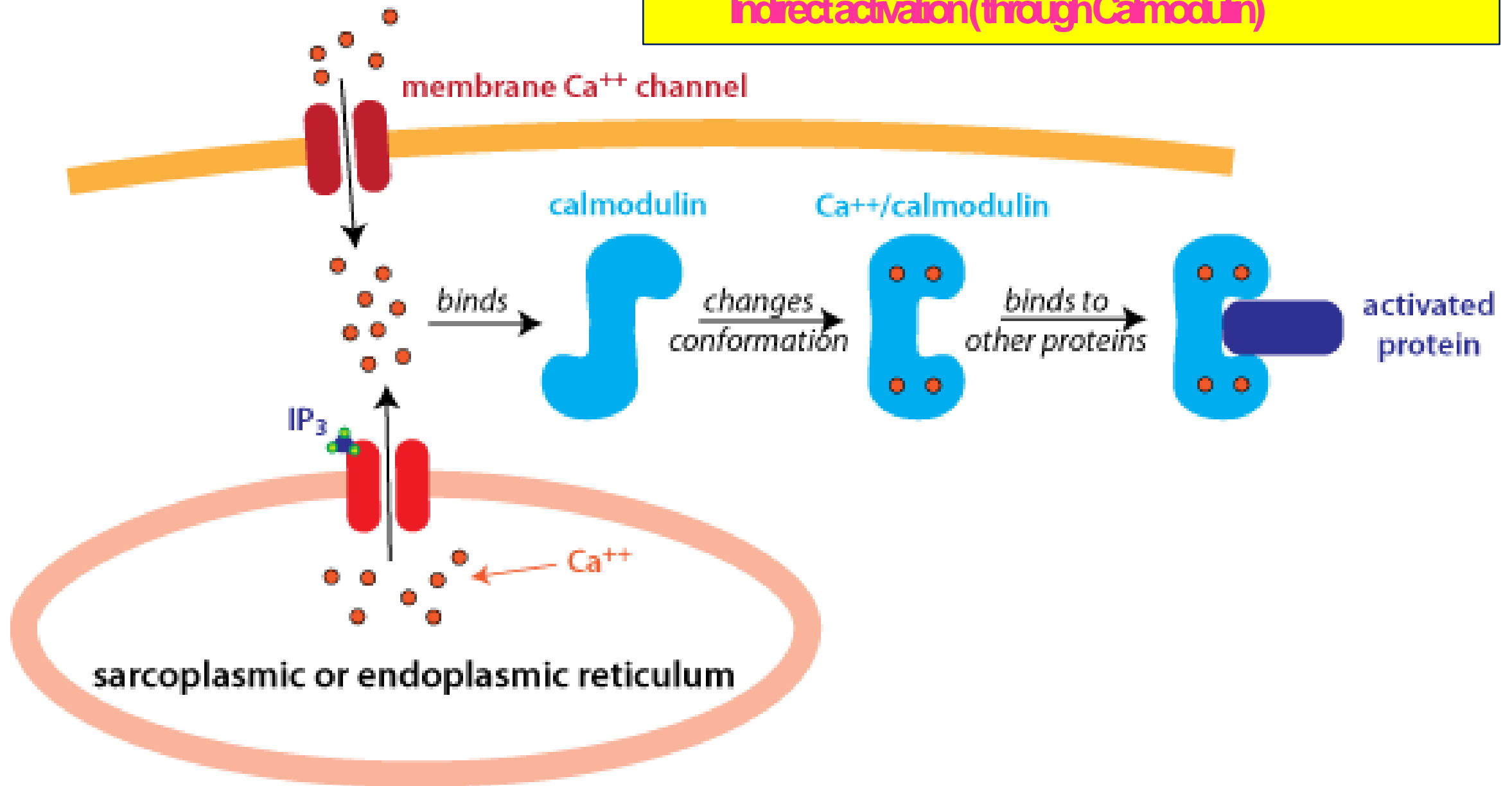
□ Calcium + Calmodulin → Calcium-Calmodulin





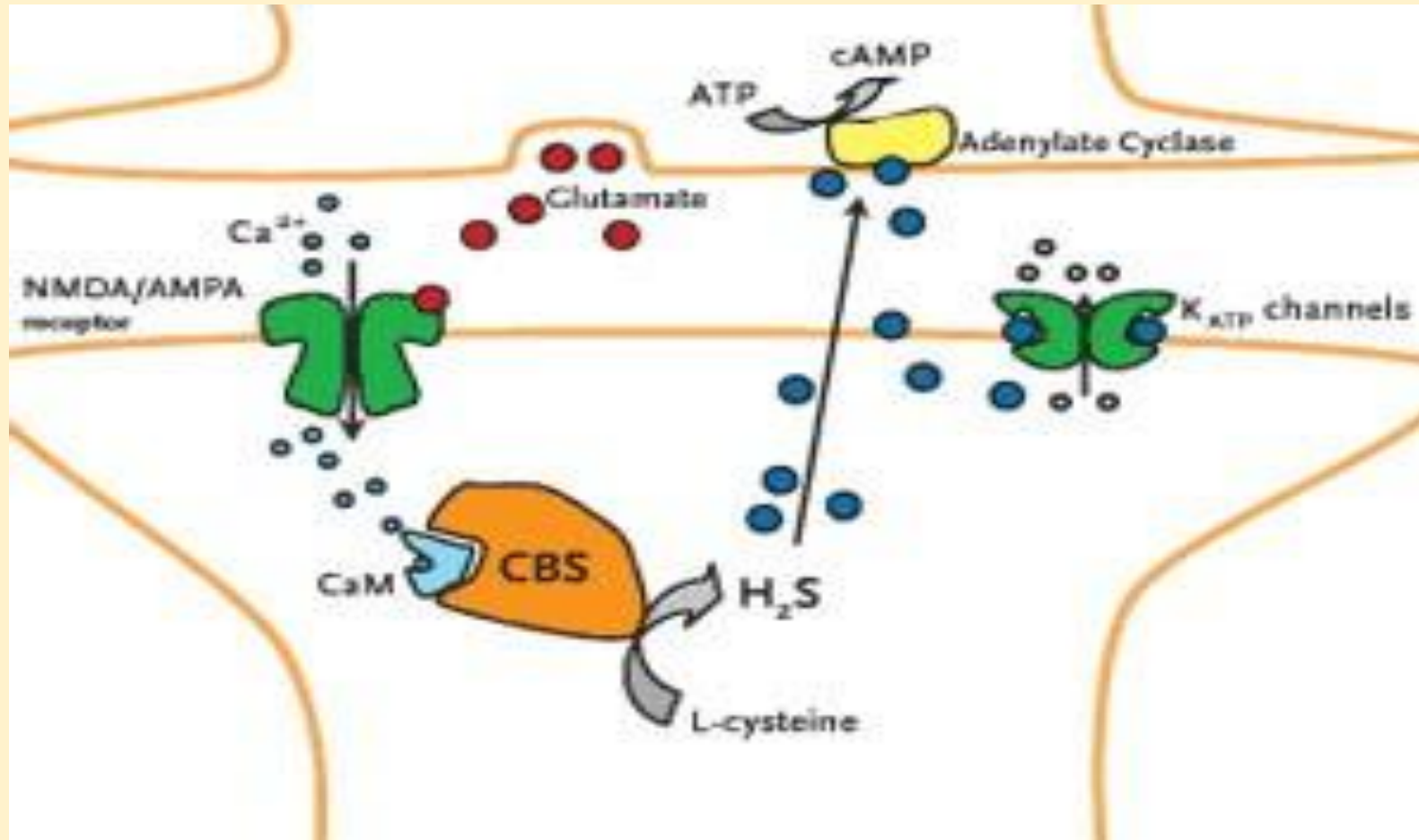
Indirect activation (through Calmodulin)

Indirect activation (through Calmodulin)

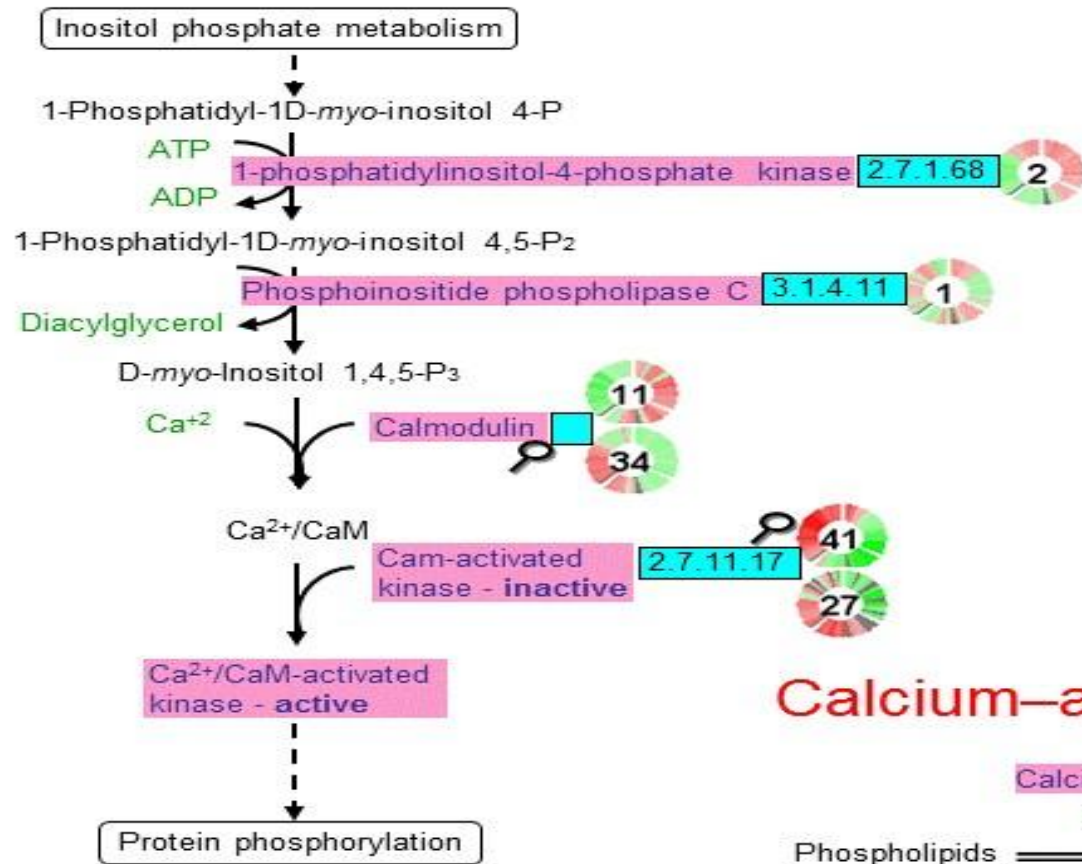


Functions of Calcium

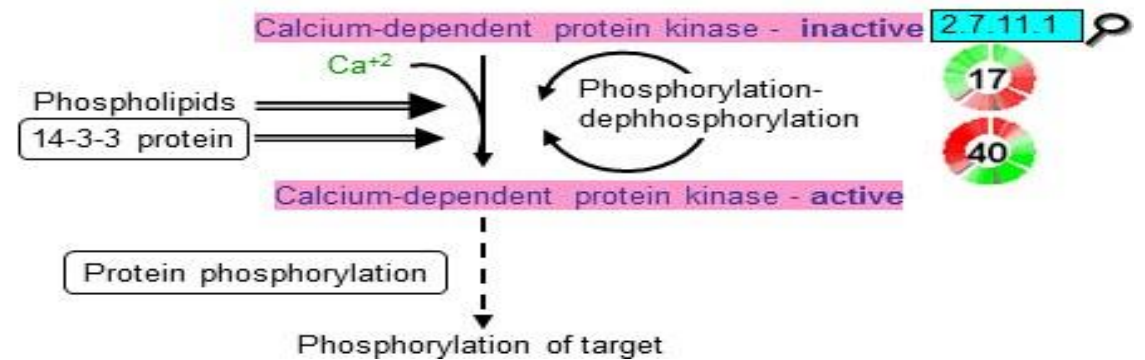
□ 1. Activation of Adenylate Cyclase: Indirect activation (through Calmodulin)



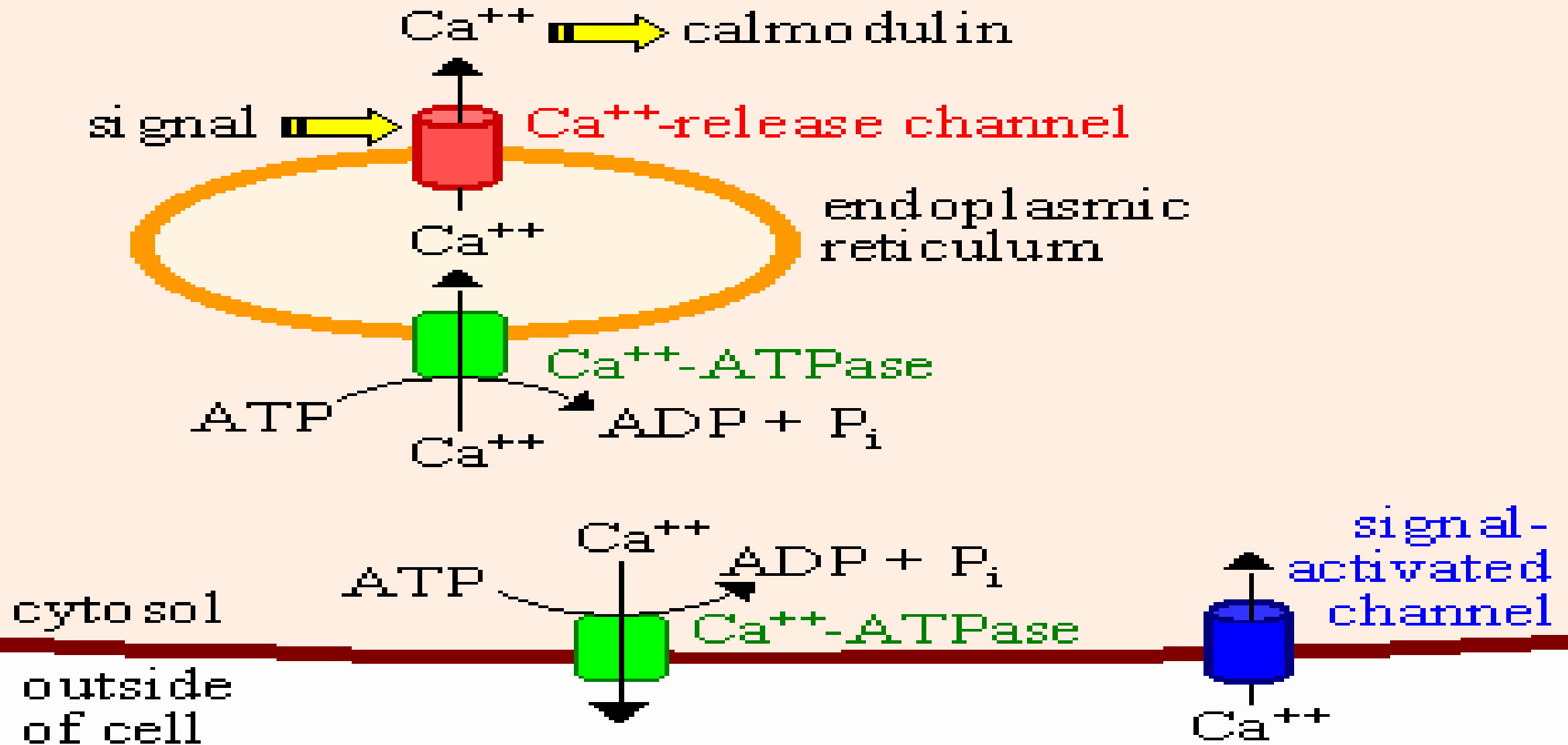
Calcium – calmodulin activation of protein kinases



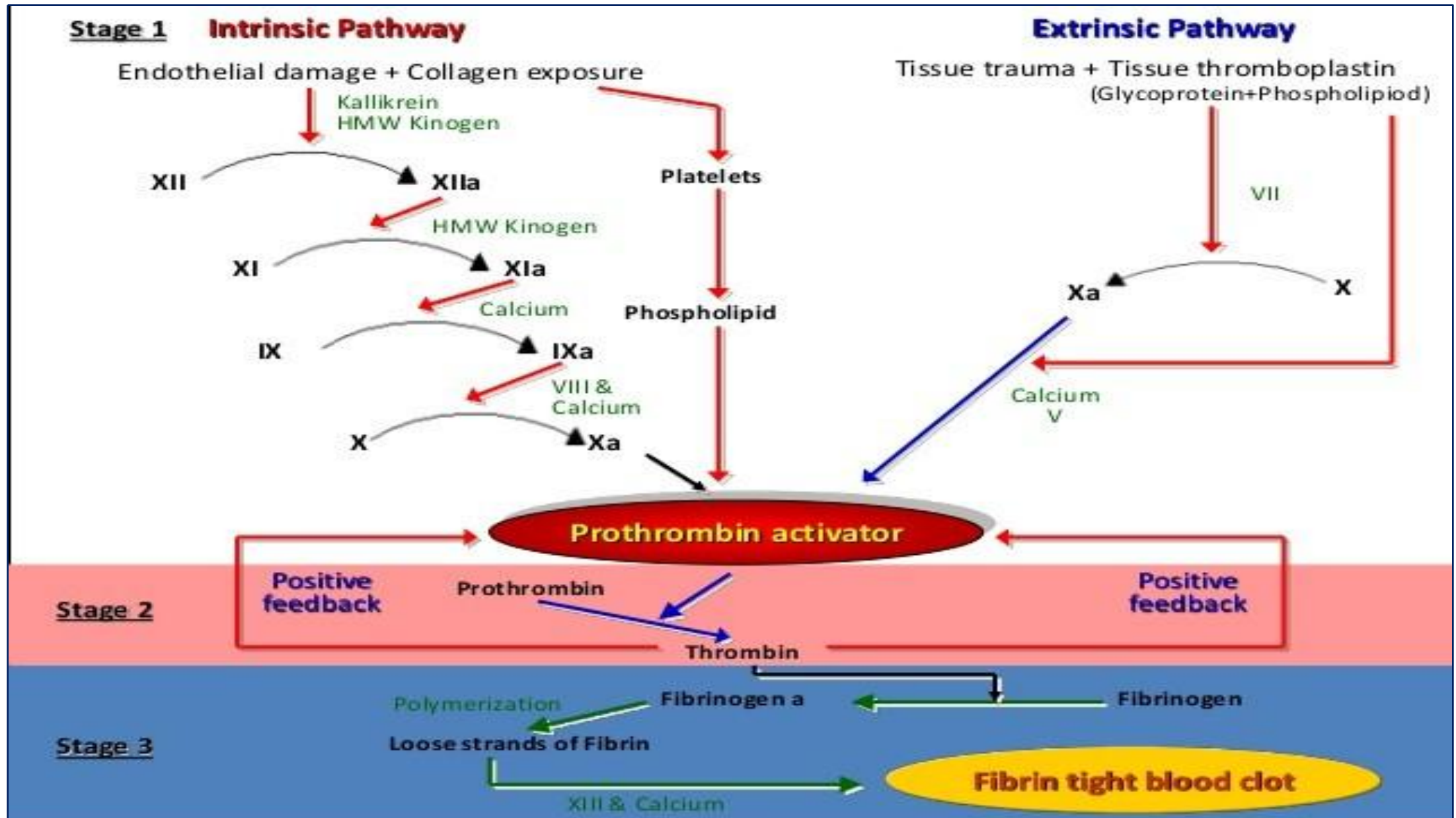
Calcium-activated protein kinases

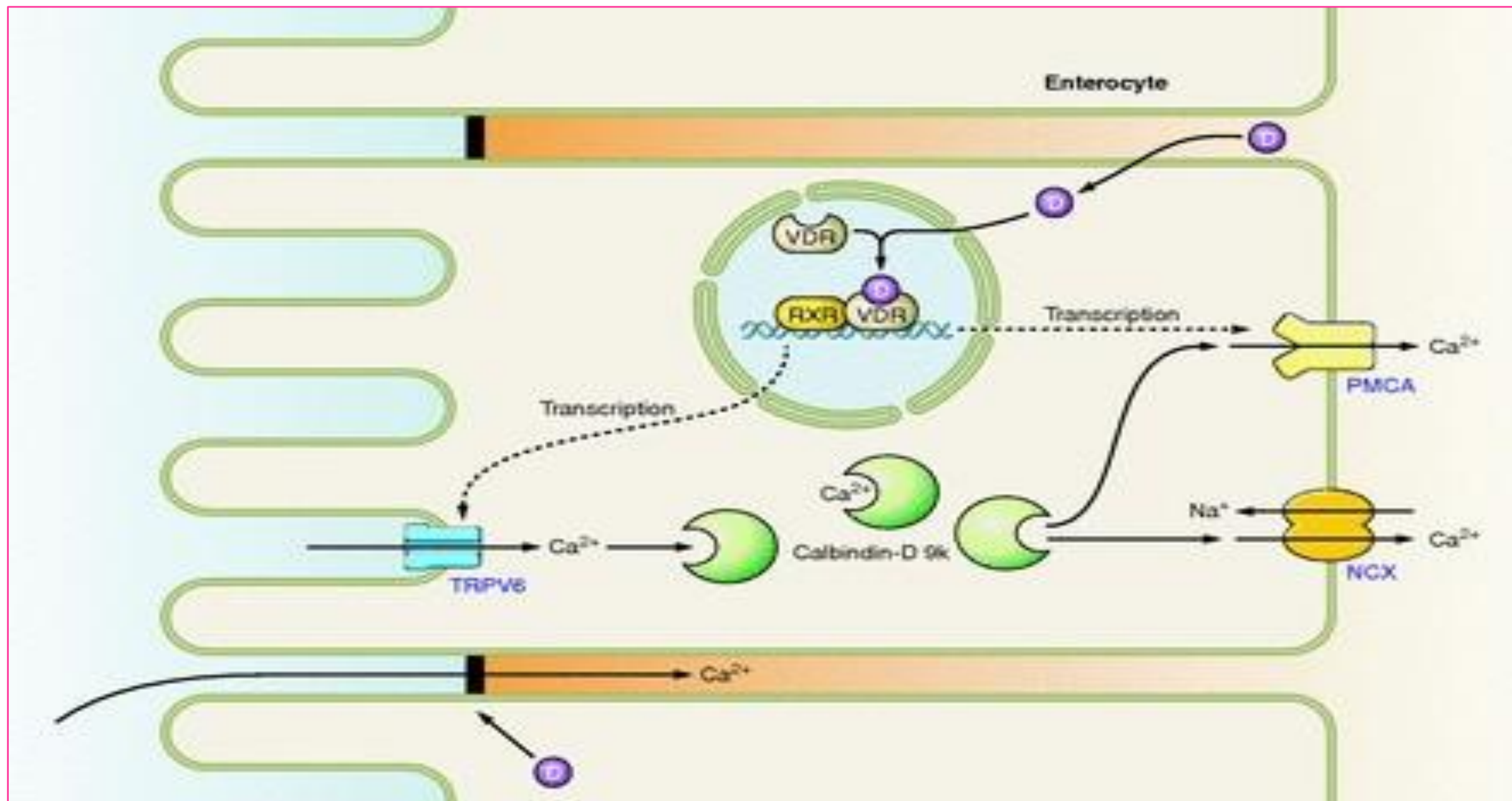


Indirect activation (through Calmodulin)



Direct activation (without Calmodulin)





Functions of Calcium : Calcium mediated phosphorylation of myosin

❖ excitation & contraction of muscle fiber

De phosphorylated myosin light chain kinase

CAMP activated protein kinase 

phosphorylated inactive myosin light chain kinase

 (+) Ca^{2+} -Calmodulin

Calcium-Calmodulin myosin light chain kinase



Myosin relaxed + ATP → myosin phosphorylated (contraction) + ADP



FUNCTIONS OF CALCIUM

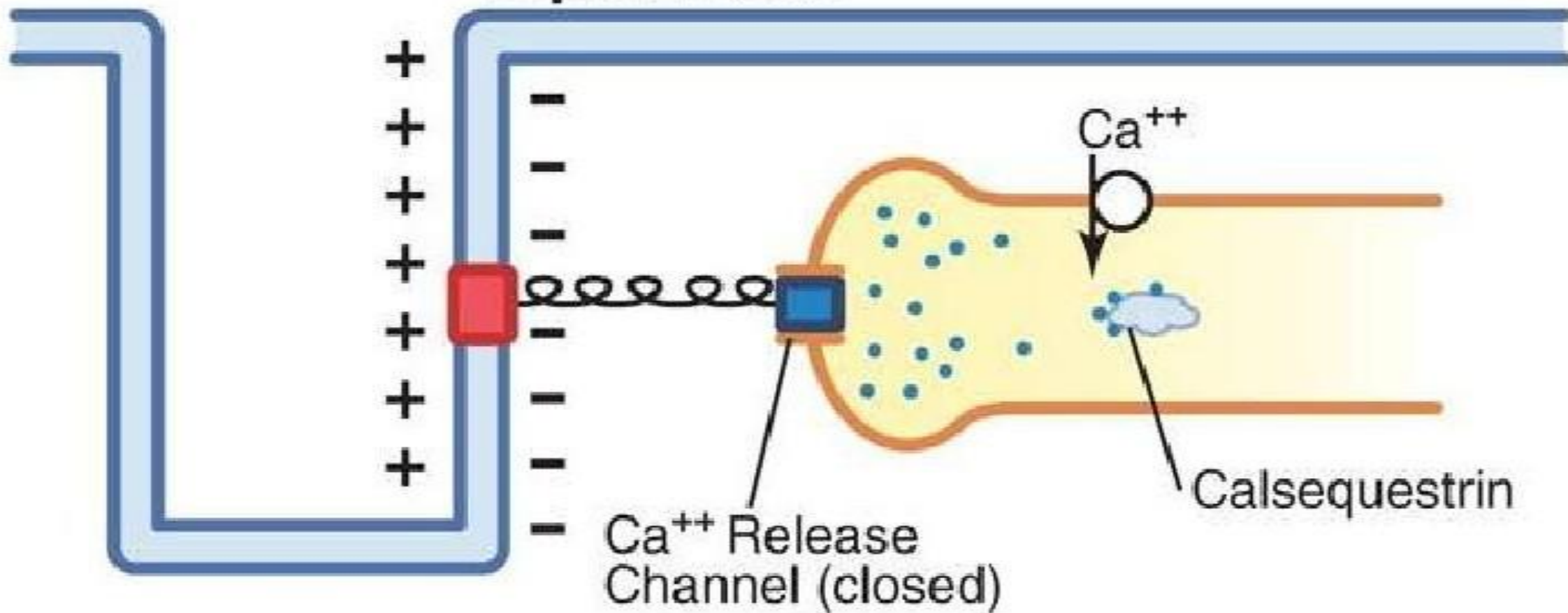
- **B. Calsequestrin:**

(1) Calcium binding protein

(2) Active transport of Ca^{2+}

Calcium decreases 'neuromuscular irritability' Calcium deficiency causes 'Tetany'

Repolarization



sarcoplasmic reticulum Ca²⁺-ATPase actively pumps Ca²⁺ back into the sarcoplasmic reticulum where Ca²⁺ rebinds to calsequestrin.

Role of Calsequestrin in Calcium Metabolism

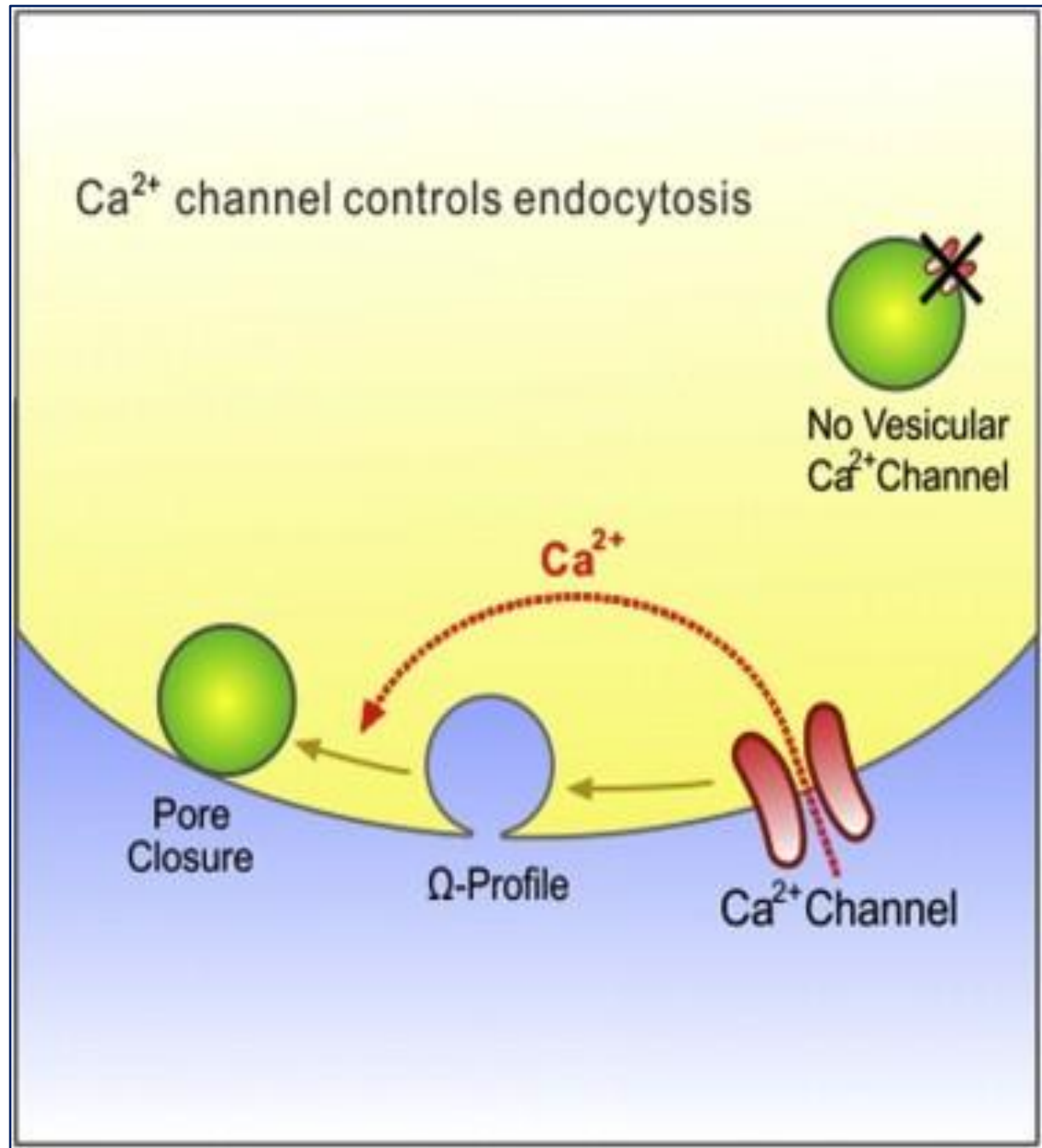
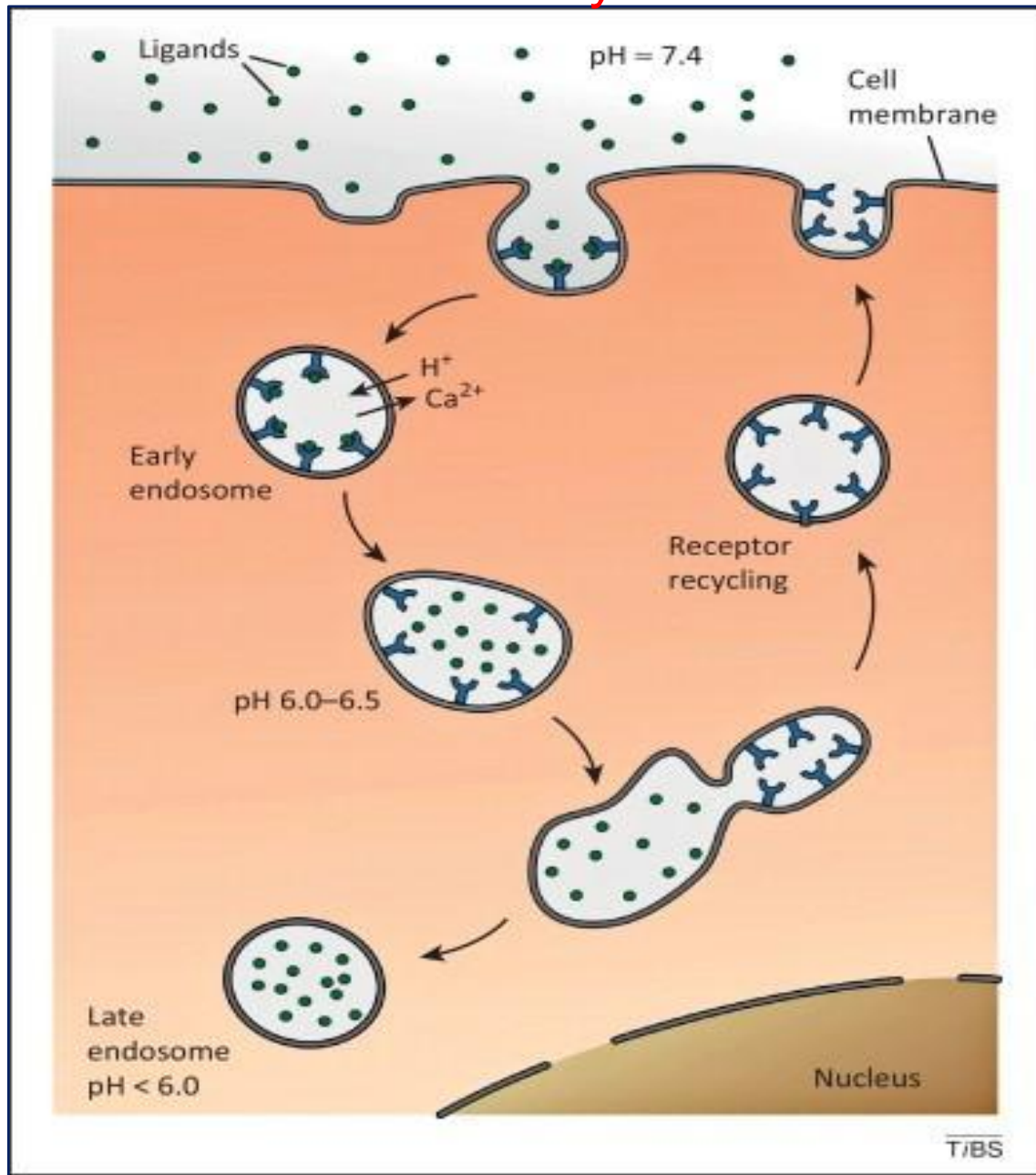
FUNCTIONS OF CALCIUM

Microfilament regulated processes

- Cell mobility
- Endocytosis
- Secretory vesicle
- Degranulation

Regulated by Calcium Calmodulin complex

Role of calcium in endocytosis

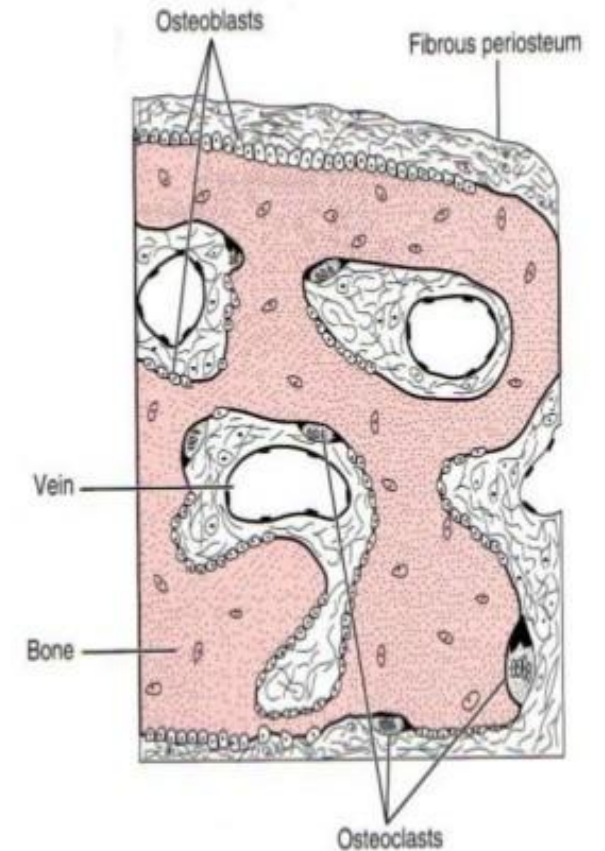


Functions of Calcium

Bone & teeth formation
Osteoblast: bone deposition
Osteoclast → demineralization

Calcium functions (Bone)

- **Osteoclasts** (bone cells) remodel the bone by dissolving or resorbing bone
- **Osteoblasts** (bone forming cells) synthesize new bone to replace the resorbed bone
- Found on the outer surfaces of the bones and in the bone cavities



Factors regulating blood calcium levels

1. VITAMIN D

2. PTH

3. CALCITONIN

4. PHOSPHOROUS
LEVELS

5. SERUM PROTEIN

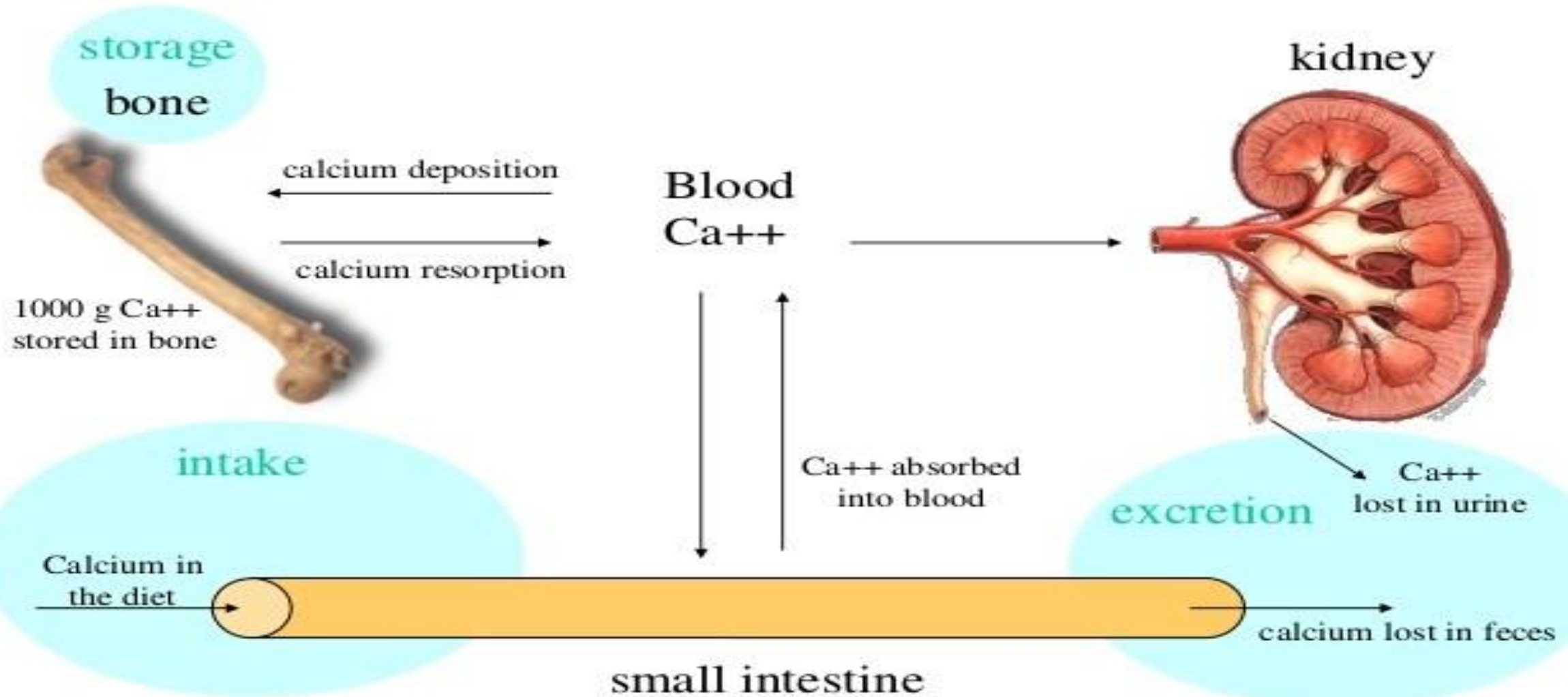
6. ACIDOSIS/ALKALOSIS
7. KIDNEY FUNCTION

8. AGE

Major factors

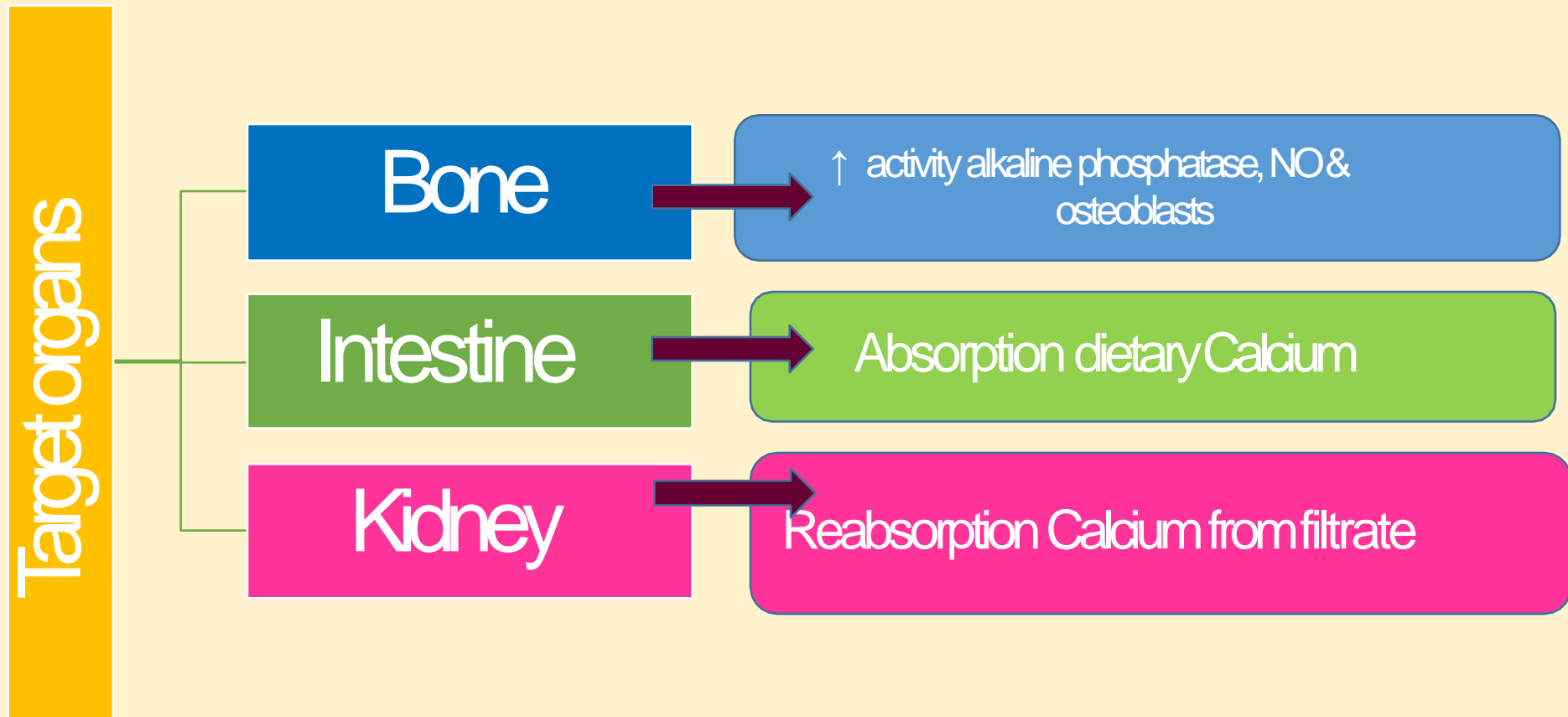
Minor factors

Calcium homeostasis



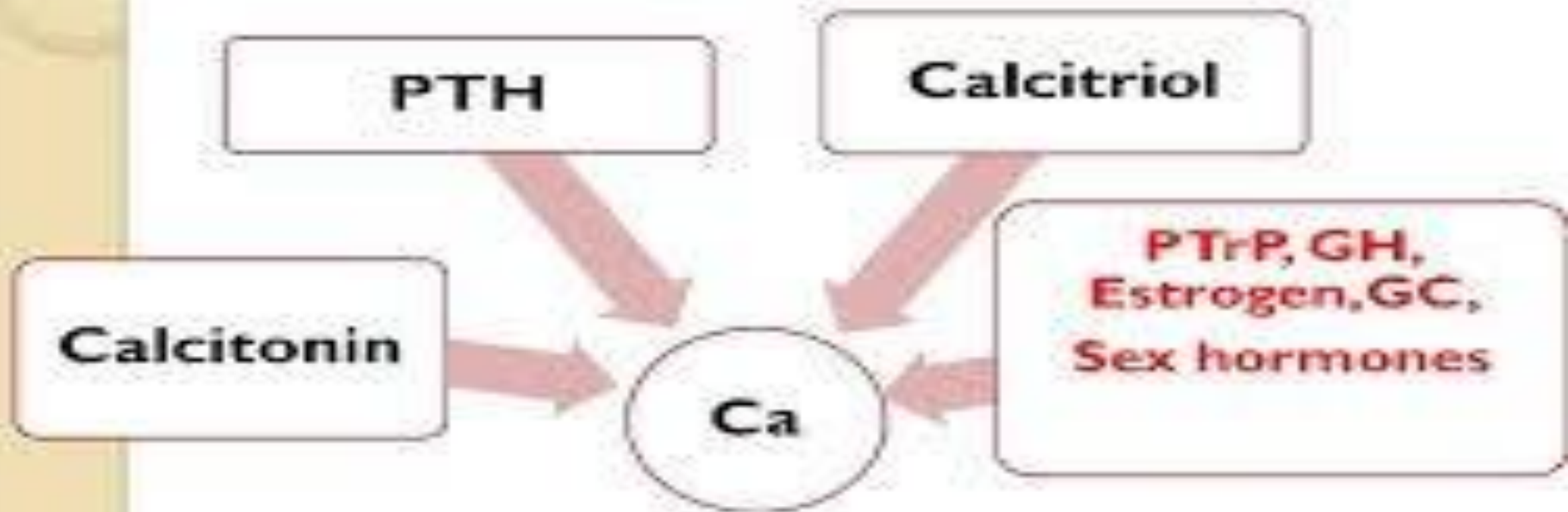
Factors regulating blood calcium levels

1. VITAMIN D

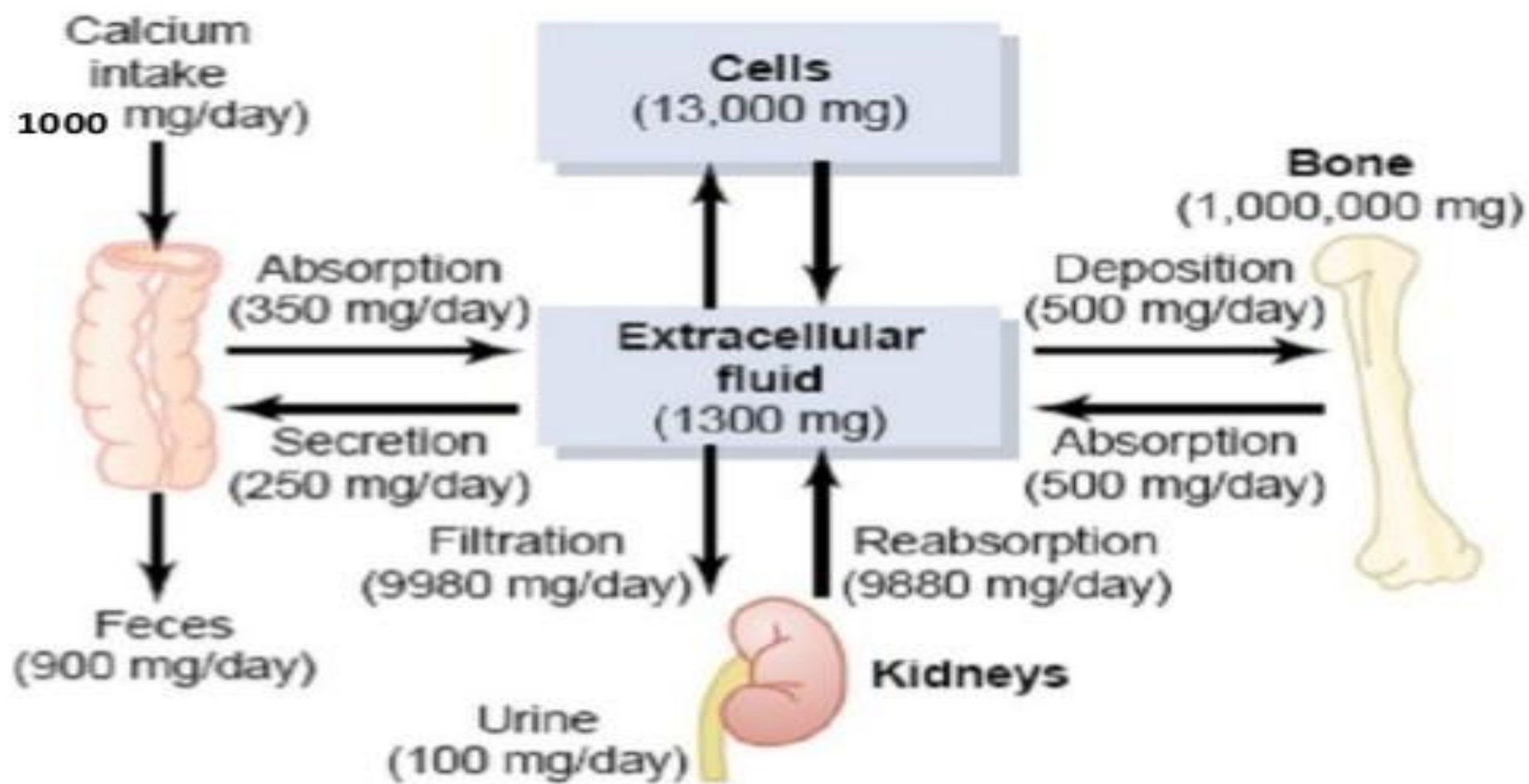


Vitamin D → increase synthesis calcium binding protein → increase absorption of Calcium
Hyper vitaminosis → Hyper-calcemia

CALCIUM METABOLISM



Calcium Exchange Between Different Tissue Compartments



THANK-YOU