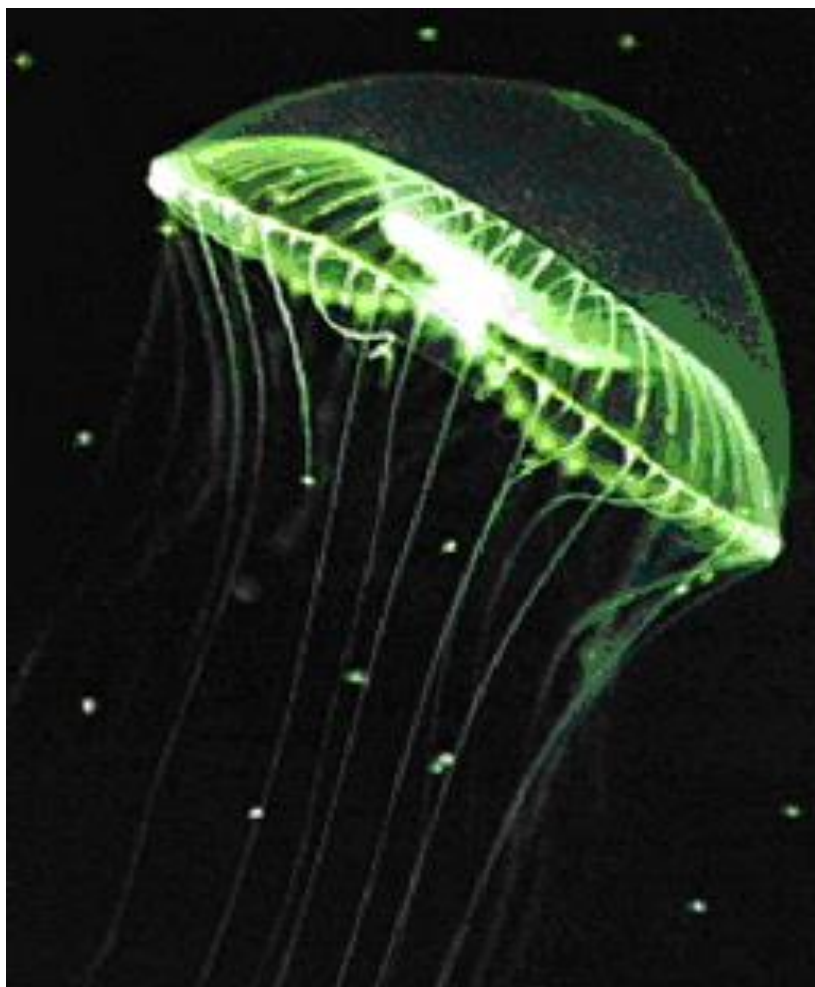
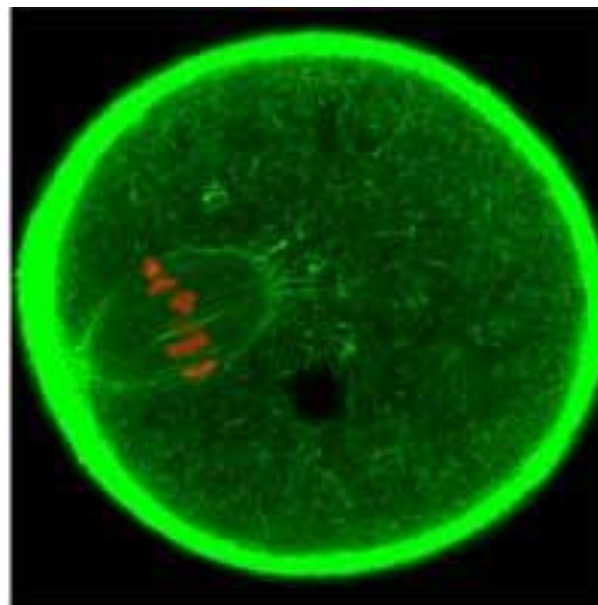


| Ione | Raggio (Å) | Ione | Raggio (Å) |
|-----------------|------------|------------------|------------|
| Na ⁺ | 1.02 | Mg ²⁺ | 0.72 |
| K ⁺ | 1.38 | Ca ²⁺ | 1.00 |

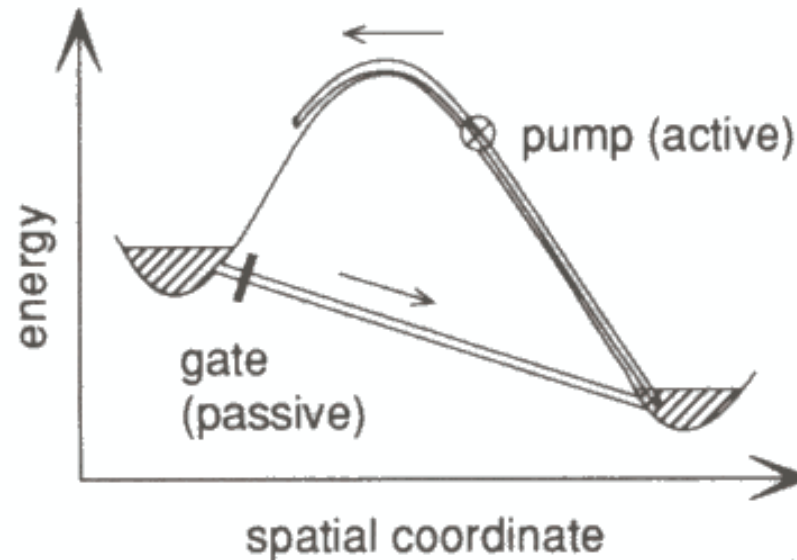


Green Fluorescent Protein (GFP) =
sensore fluorescente per Ca²⁺

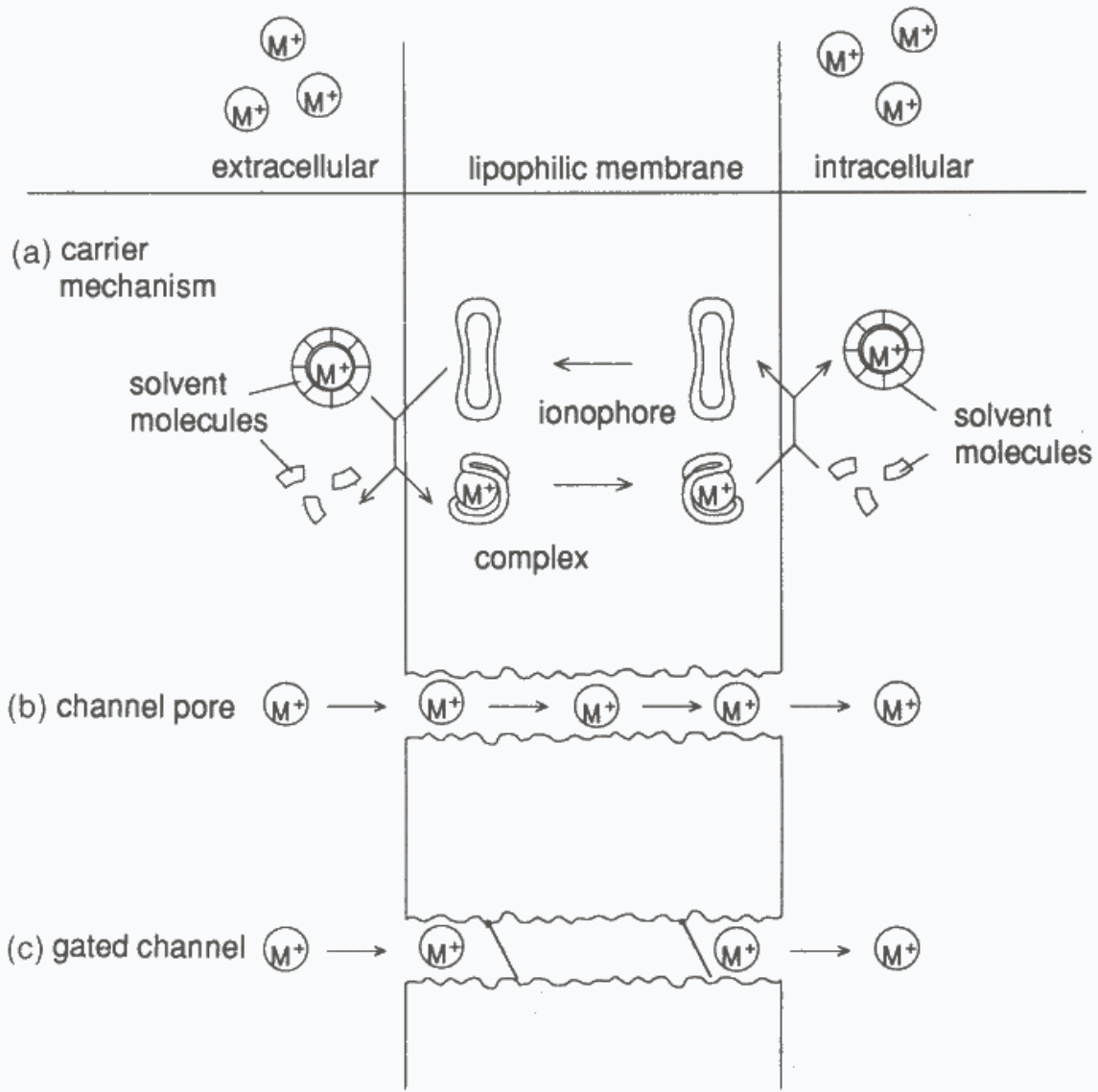


| Ione | Intracellulare (mM) | Extracellulare (mM) |
|------------------|---------------------|---------------------|
| Na ⁺ | 10 | 150 |
| K ⁺ | 100 | 5 |
| Mg ²⁺ | 2.5 | 1.5 |
| Ca ²⁺ | 0.1 ^a | 2.5 |
| Cl ⁻ | 4 | 100 |

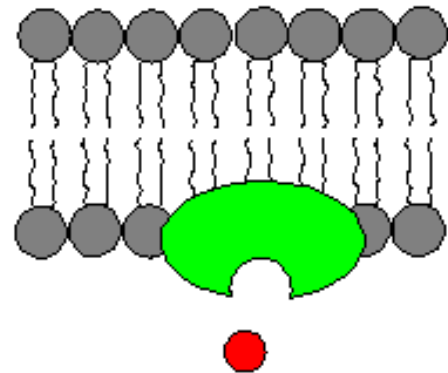
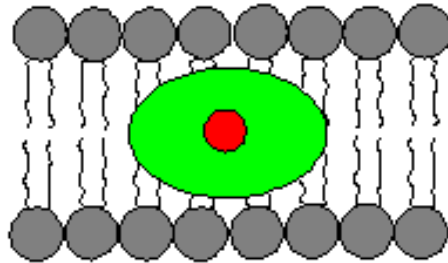
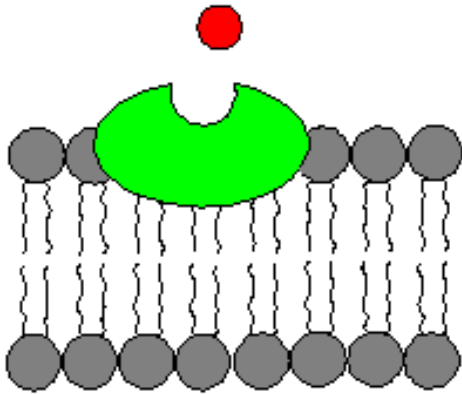
^a0.1 μM nel citoplasma della cellula a riposo, cioè 10⁴ volte meno che all'esterno



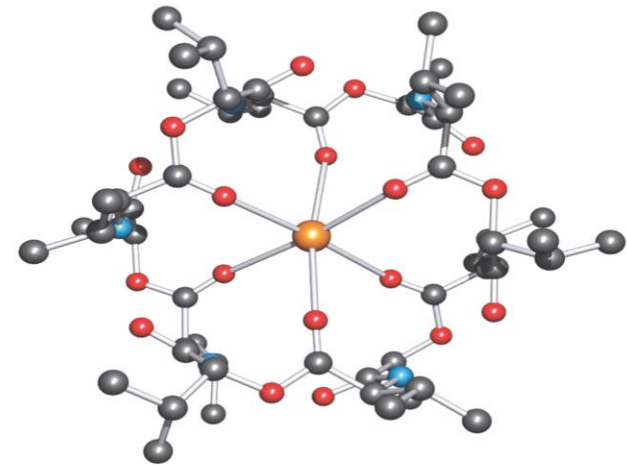
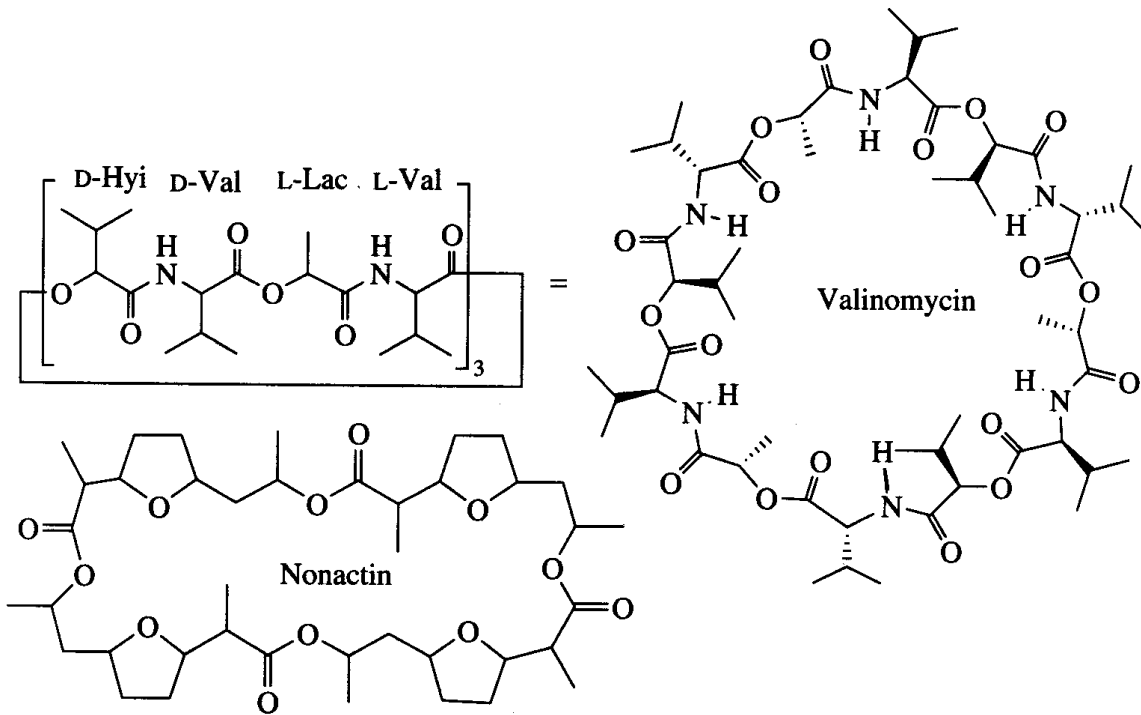
ion-transport mechanisms



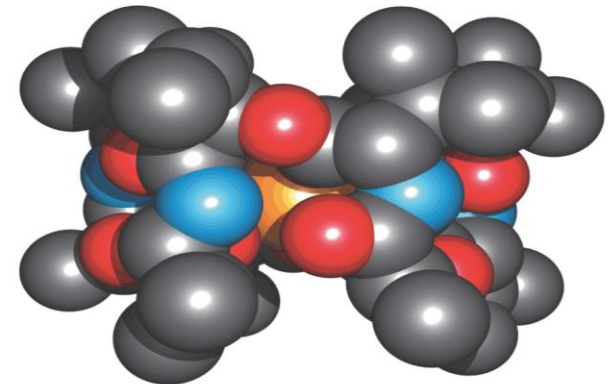
Ionofori



Ionofori



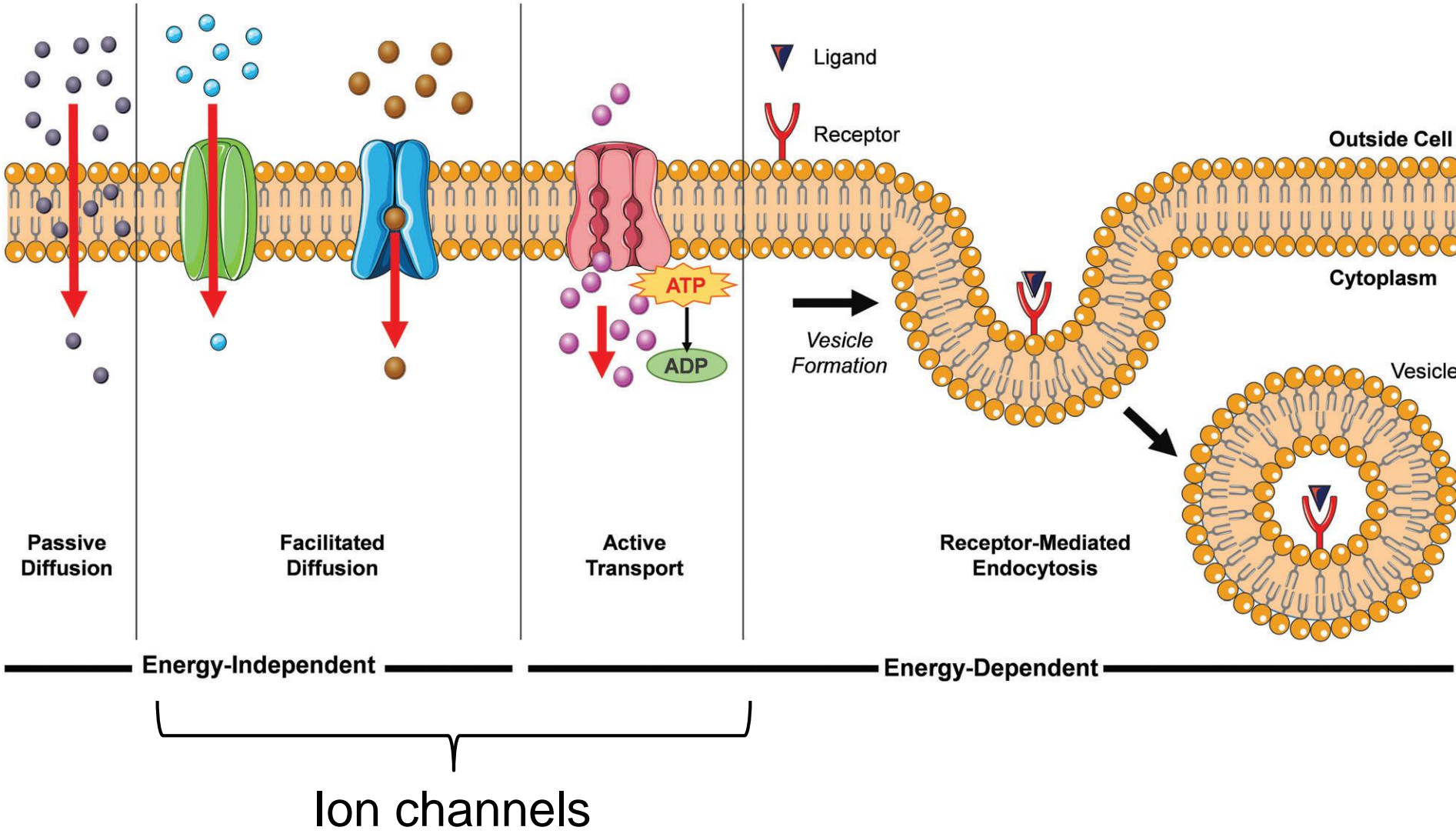
Addotto valinomycinina – K⁺



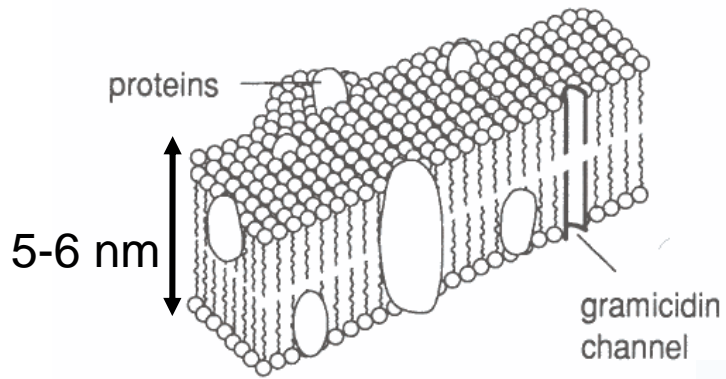
La valinomycinina trasporta $10^3 - 10^4$ ioni K^+ al secondo attraverso la membrana dei mitocondri senza alterare la concentrazione di Na^+ .

La selettività K^+/Na^+ è dell'ordine di 10^4 .

Meccanismi di trasporto trans-membrana



Ion channels



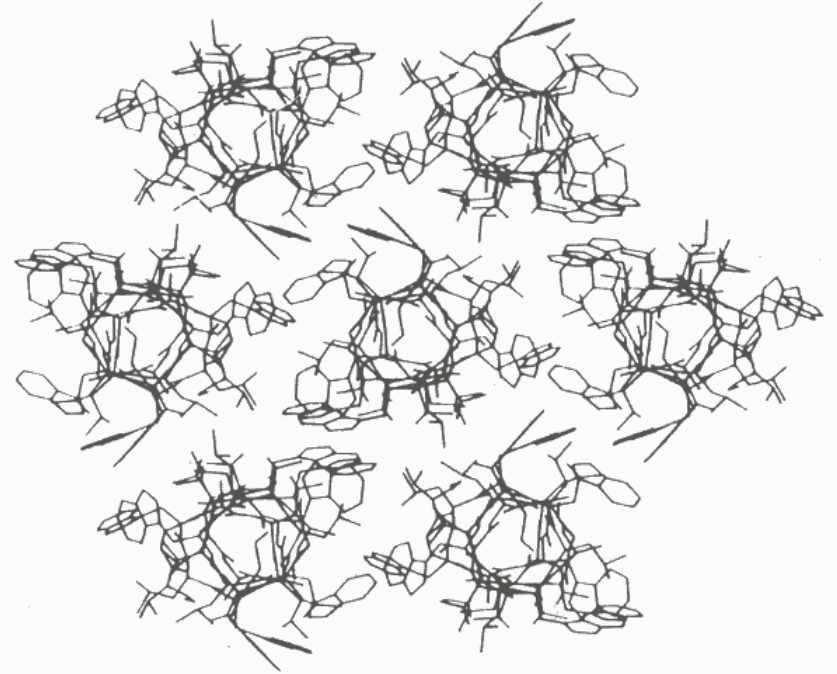
gramicidin channel

0.4 nm

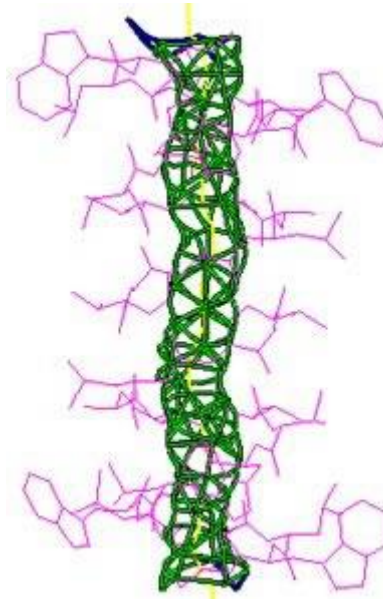
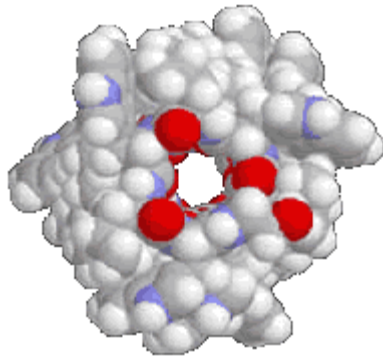
fluid double layer

3 nm

Gramicidina A
15 aminoacidi

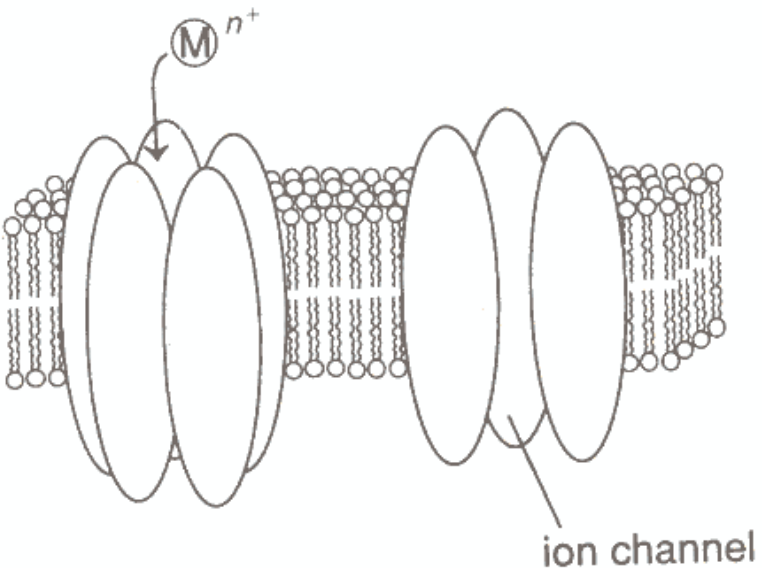


Gramicidina A

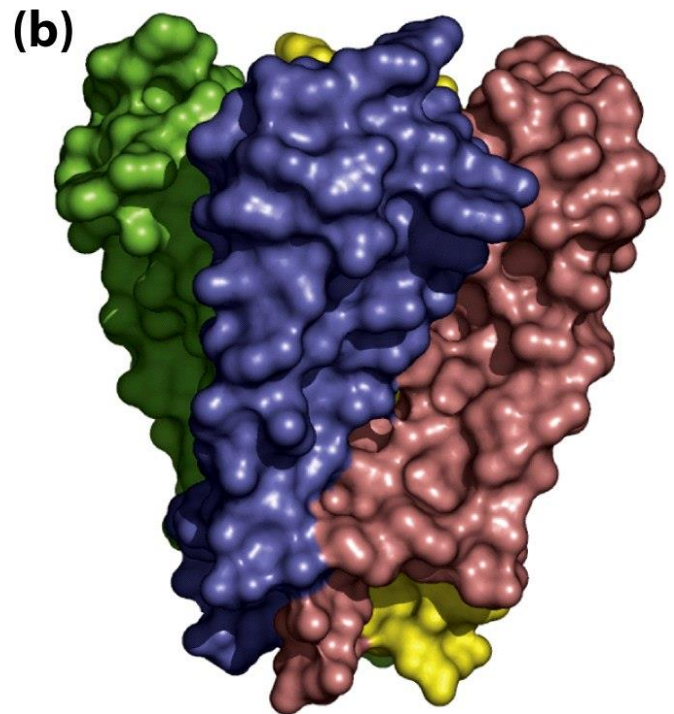
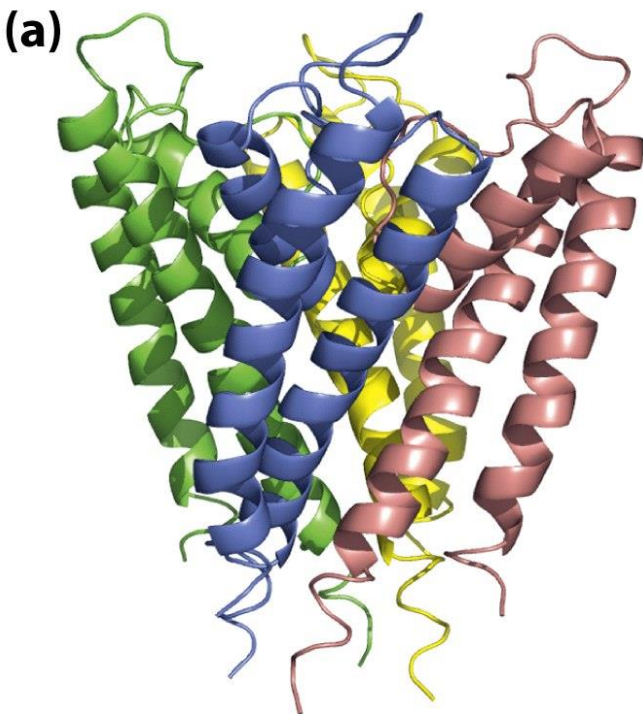


La gramicidina A trasporta 10^7 ioni K^+ o Na^+ al secondo attraverso la membrana. I cationi divalenti bloccano il poro.

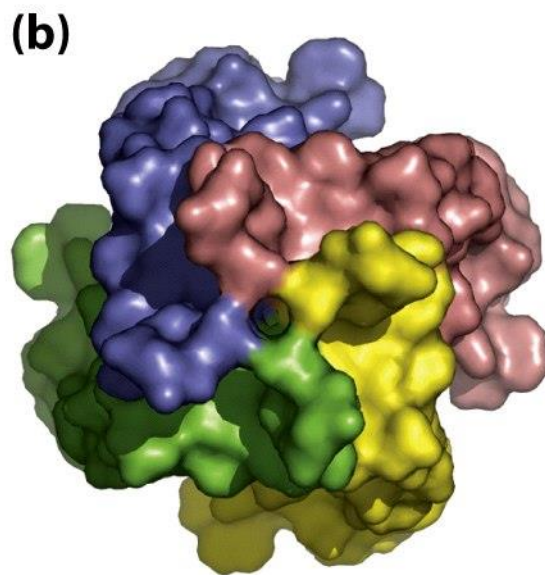
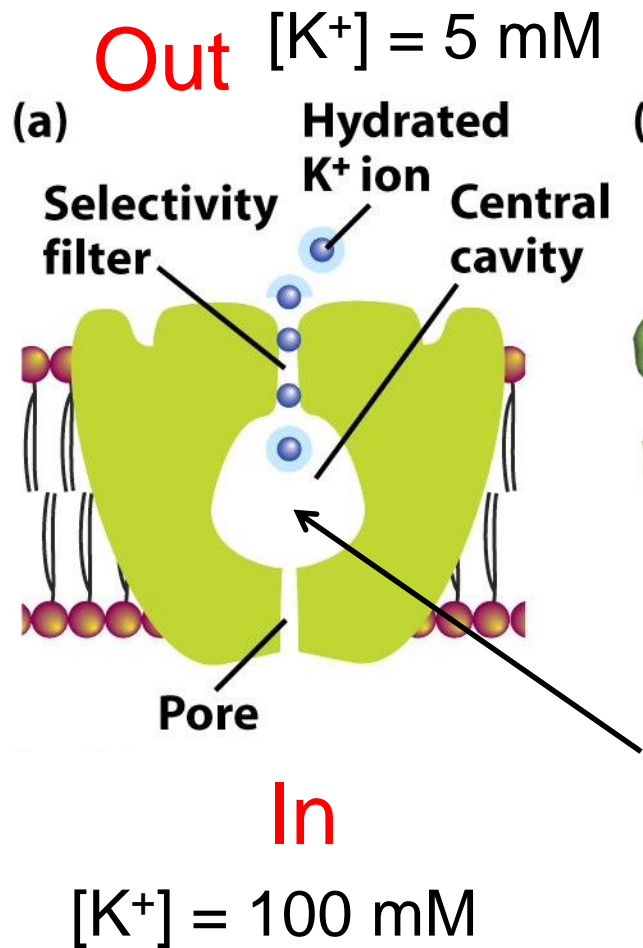
Proteine trans-membrana



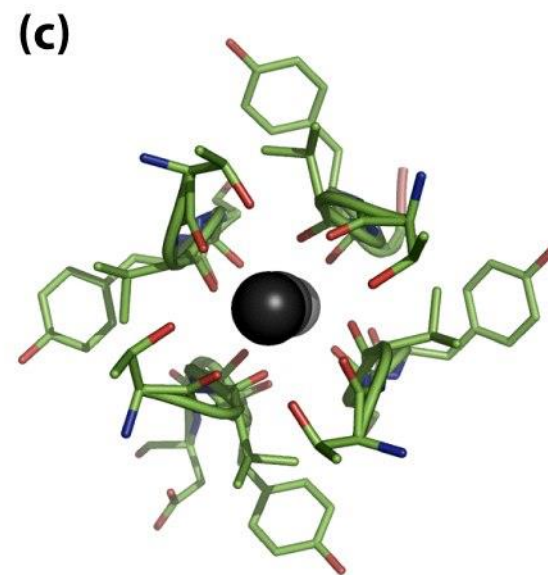
Canale del K^+

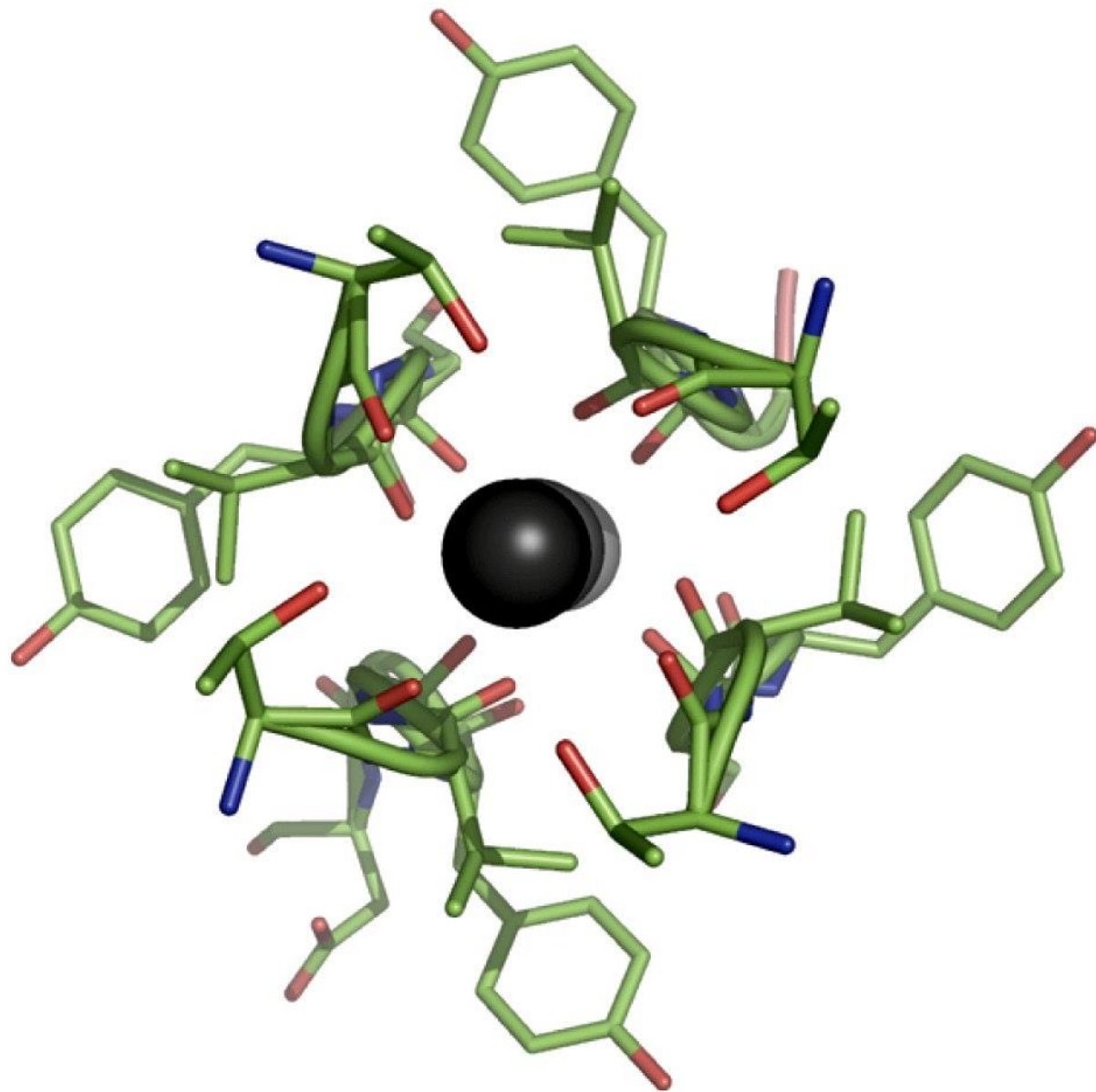


Canale del K^+ *potential gated*

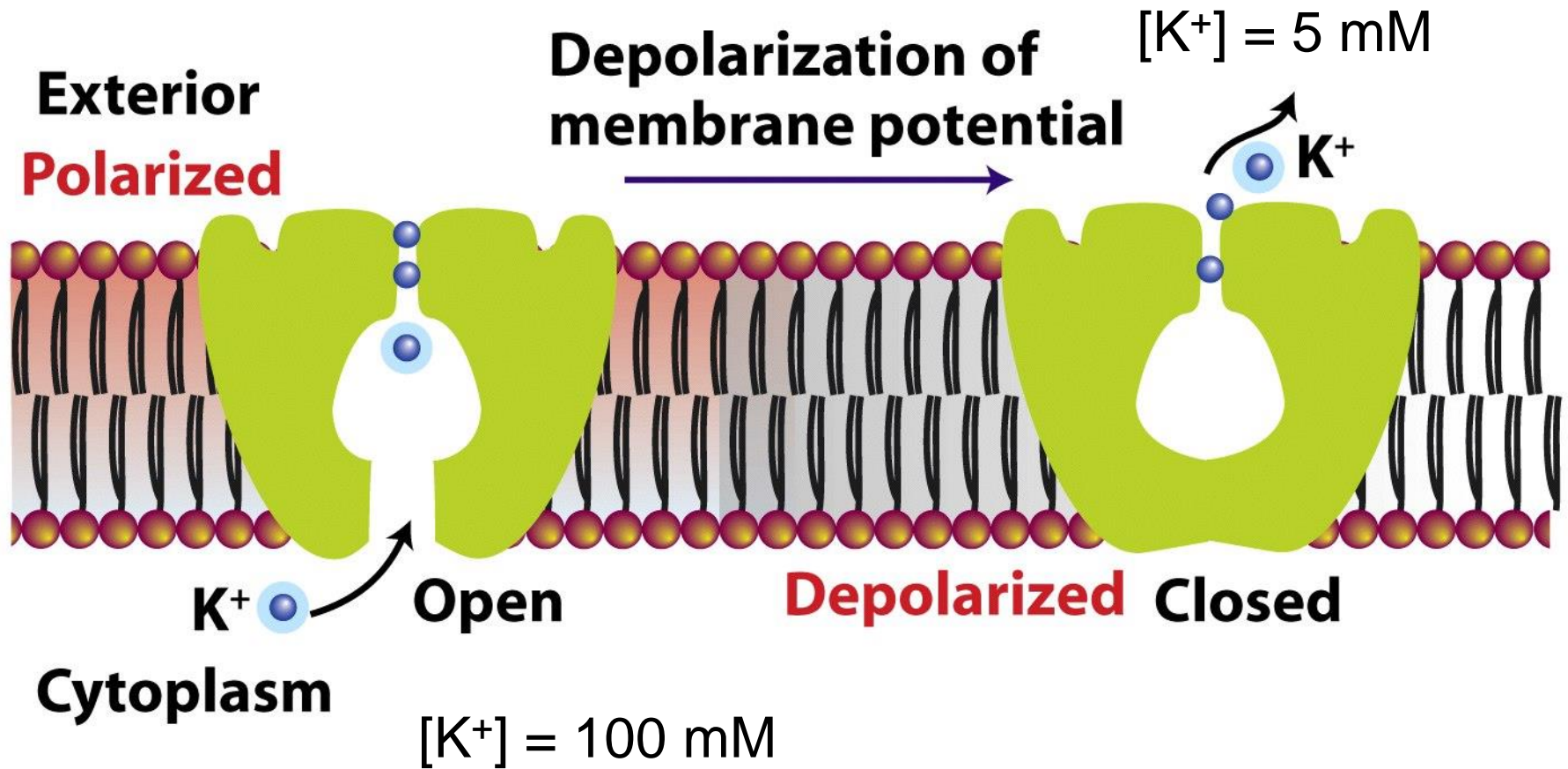


$\varnothing = 1 \text{ nm}$
 $[K^+] = 2 \text{ M}$

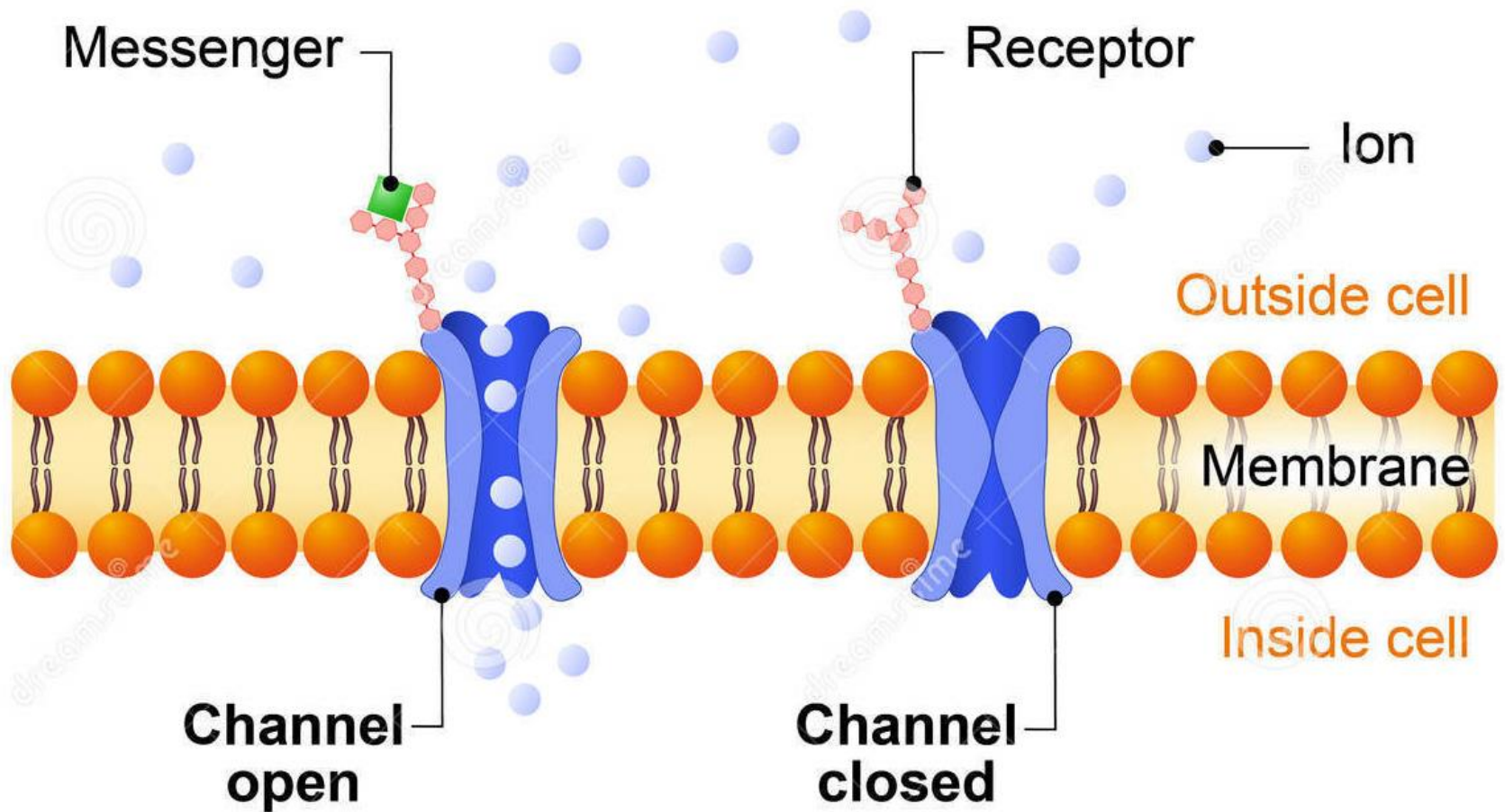




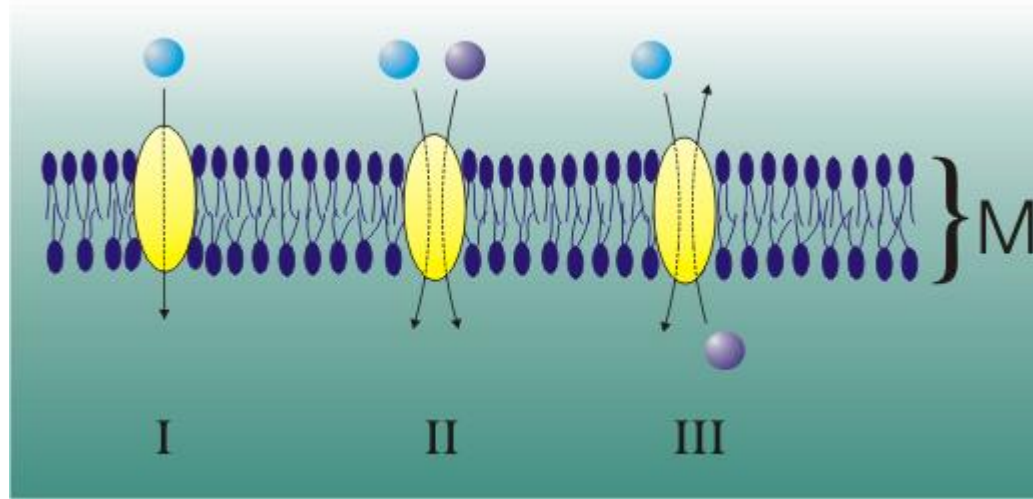
Canale del K^+ *potential gated*



Ligand-gated ion channel



Pompe ioniche (ATPasi)

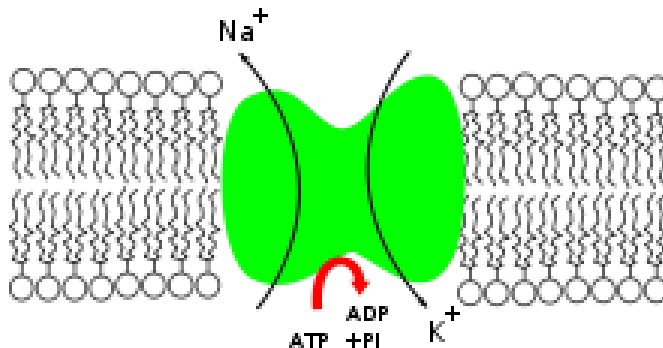


Uniporto

Simporto

Antiporto

Pompa ionica *antiporto* Na^+/K^+ -ATPasi

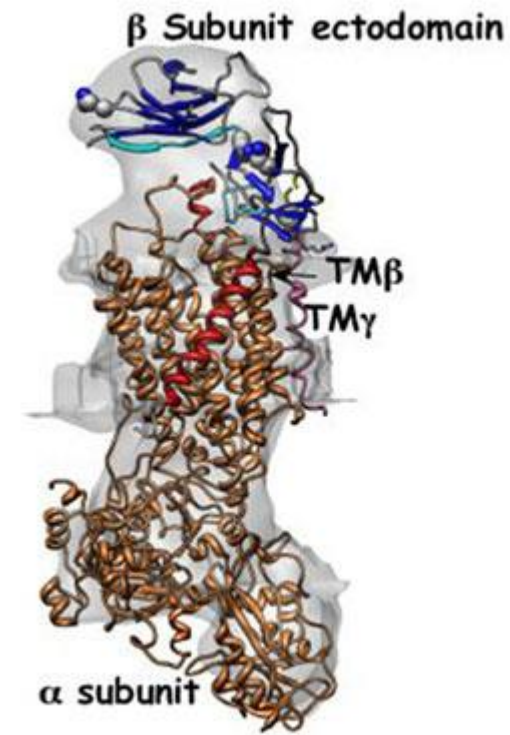
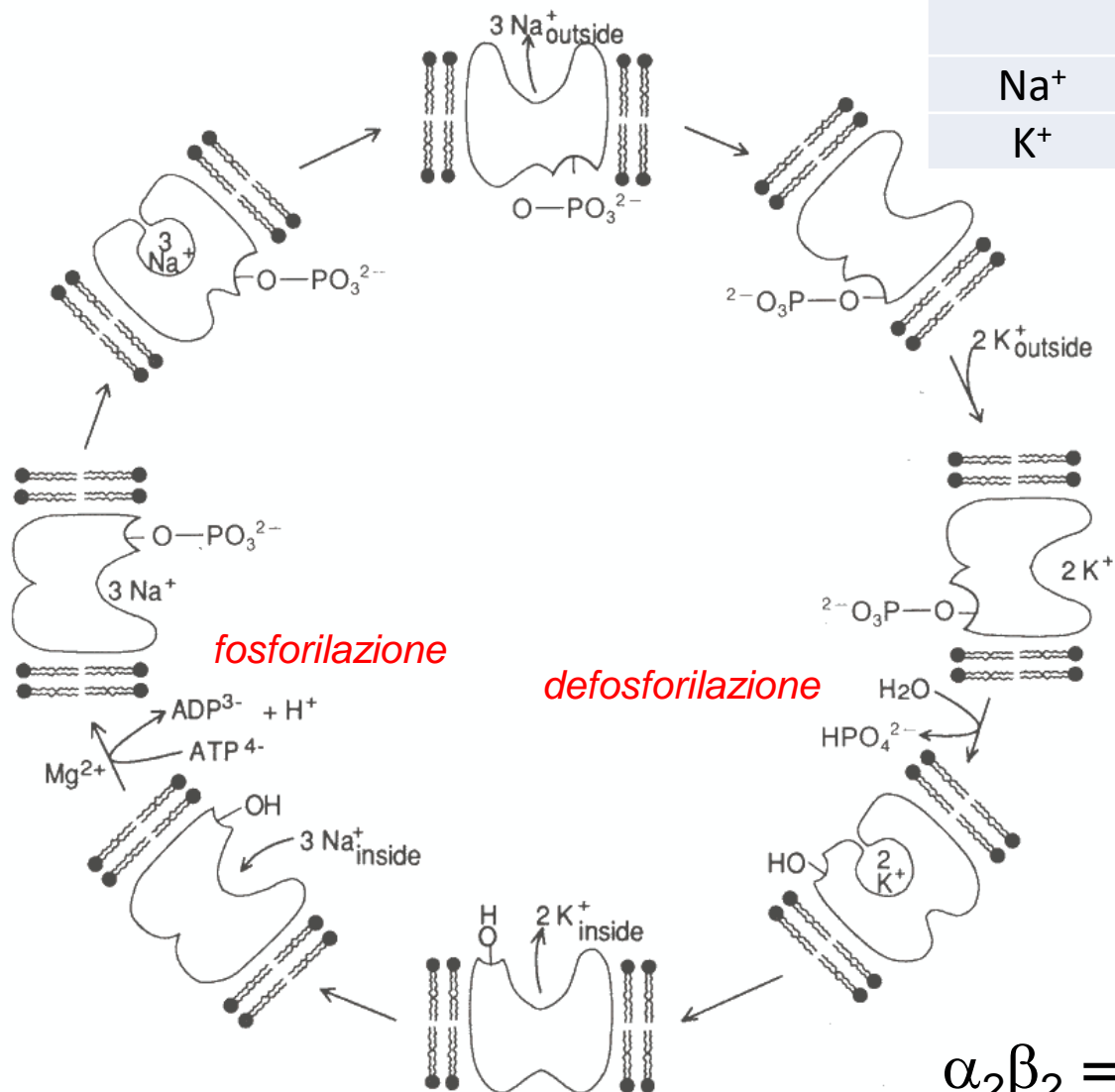


| Ione | Intracellulare (mM) | Extracellulare (mM) |
|-----------------|---------------------|---------------------|
| Na ⁺ | 10 | 150 |
| K ⁺ | 100 | 5 |

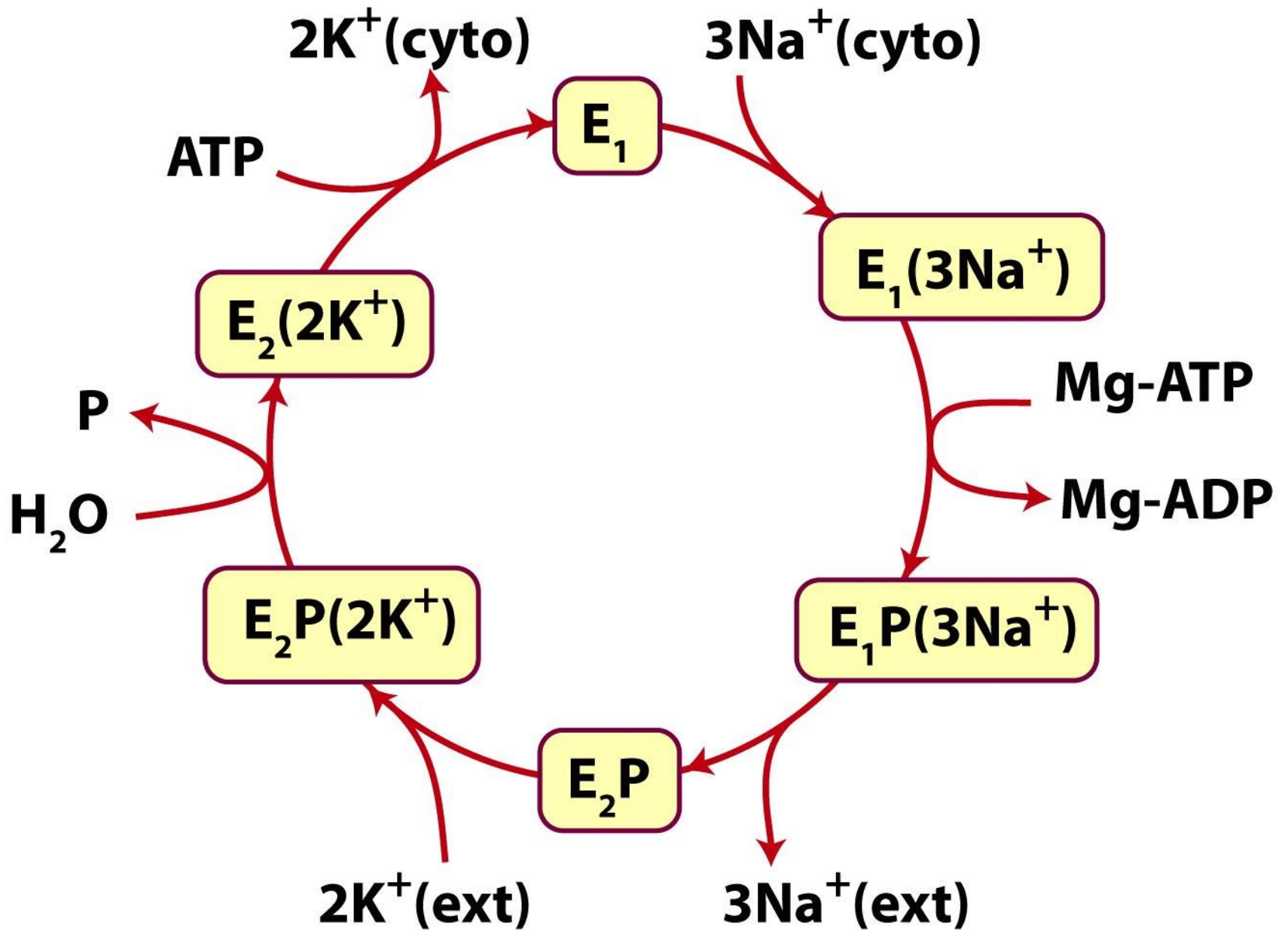
Pompa ionica *antiporto* Na⁺/K⁺-ATPasi

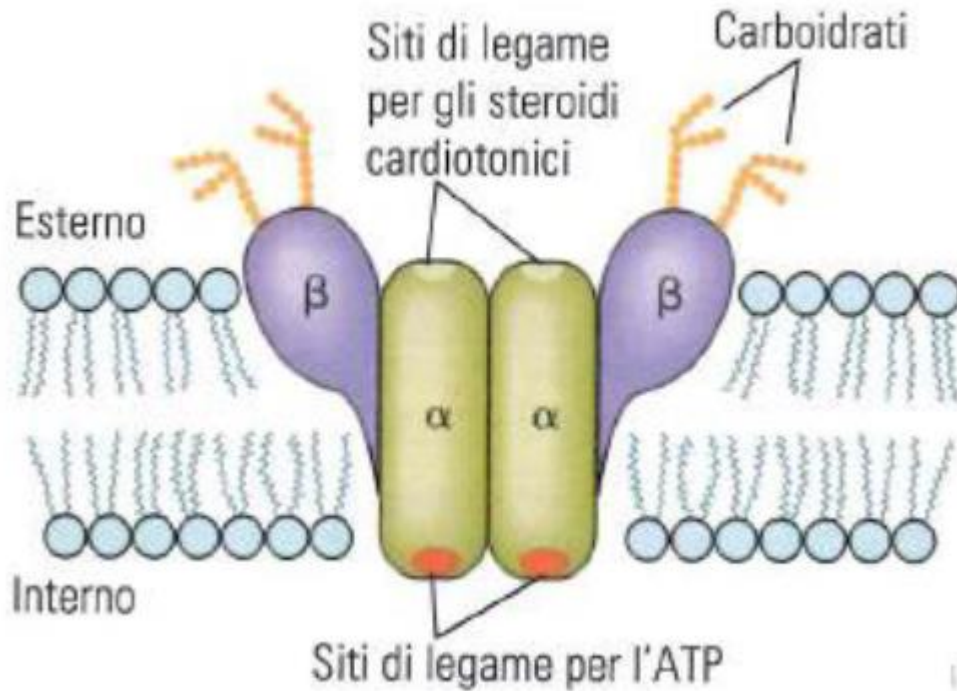


| Ione | Intracellulare (mM) | Extracellulare (mM) |
|-----------------|---------------------|---------------------|
| Na ⁺ | 10 | 150 |
| K ⁺ | 100 | 5 |



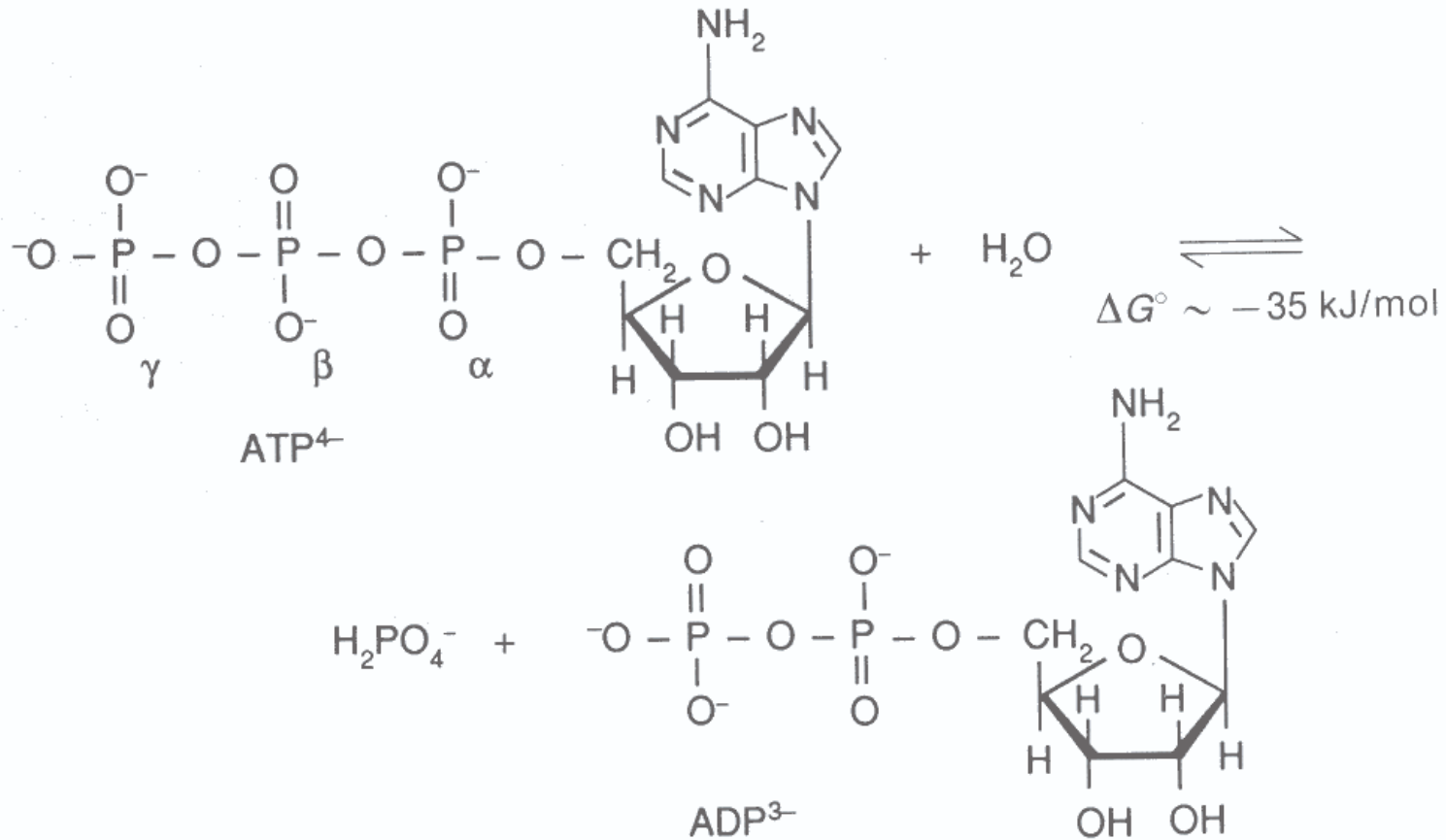
$$\alpha_2\beta_2 = 2 \times 112(\alpha) + 2 \times 35(\beta)$$





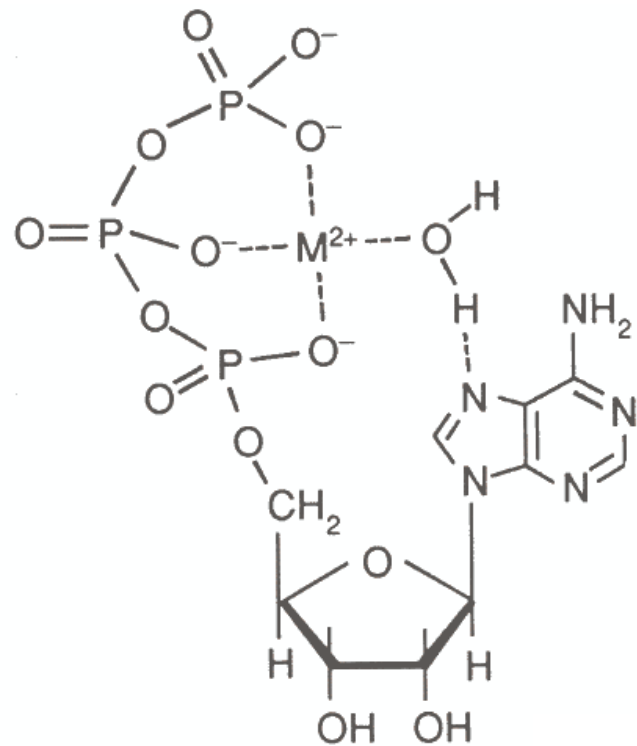
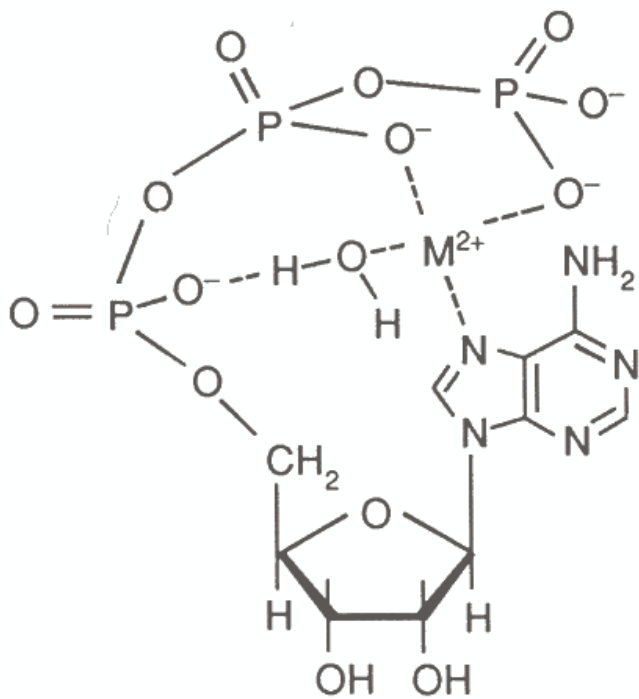
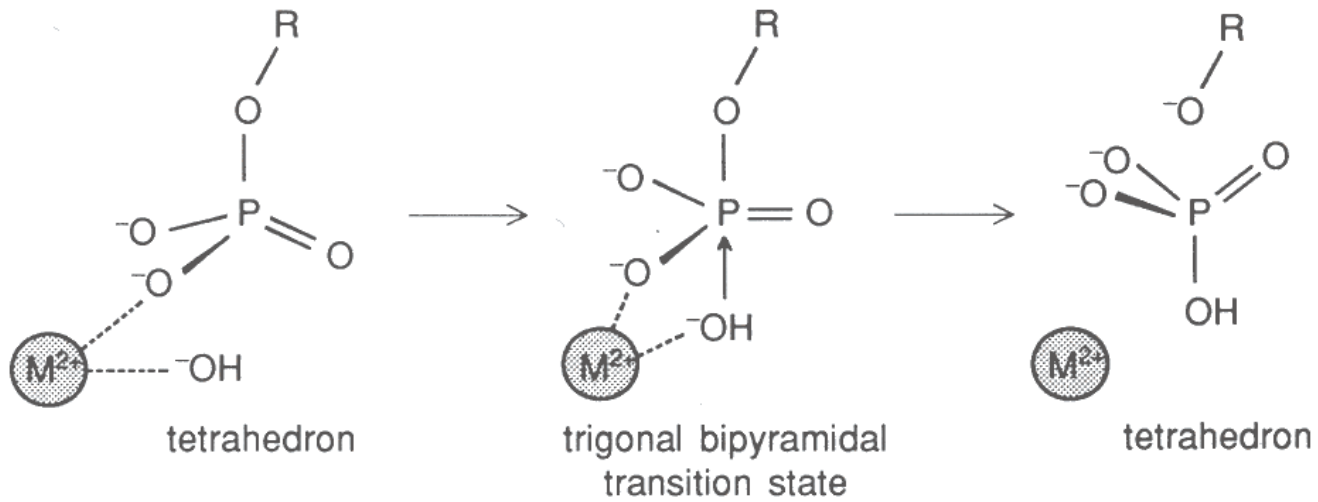
A livello del muscolo cardiaco, l'inibizione della pompa Na^+/K^+ da parte della digitalina fa aumentare $[\text{Na}^+]$ all'interno della cellula, portando all'attivazione della pompa antiporto $\text{Na}^+/\text{Ca}^{2+}$, e quindi ad un aumento della $[\text{Ca}^{2+}]$ intracellulare che ha come conseguenza l'intensificazione della contrazione muscolare (effetto cardiotonico).

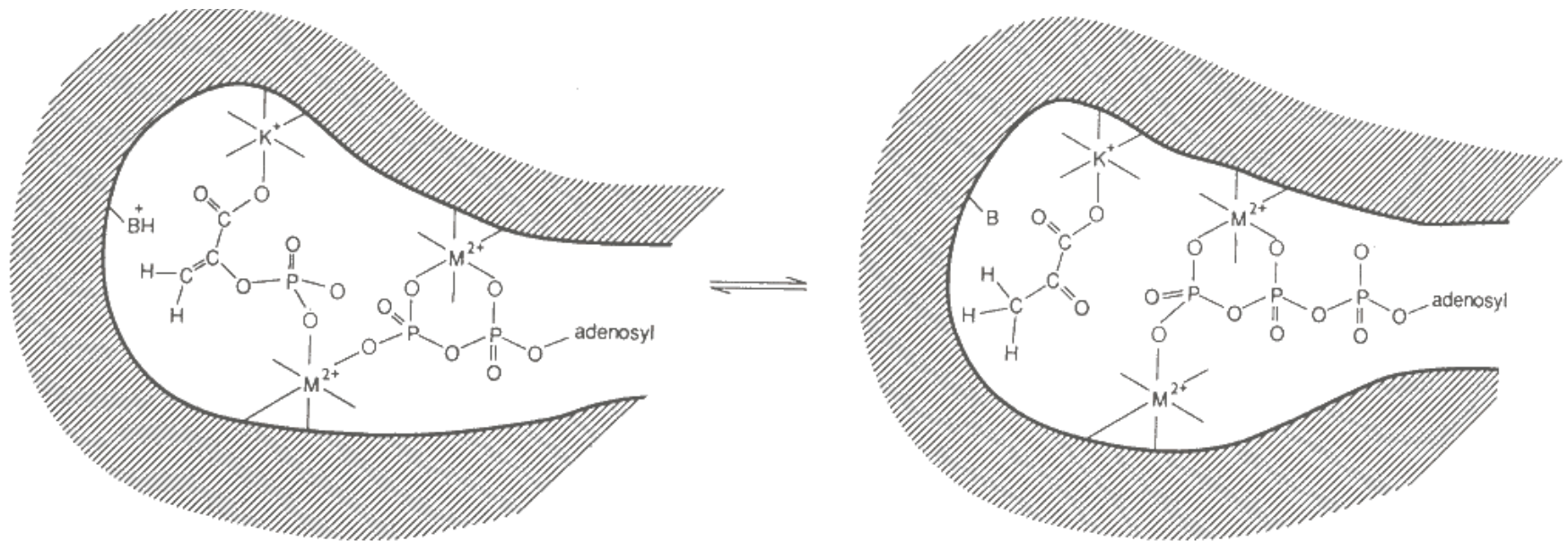
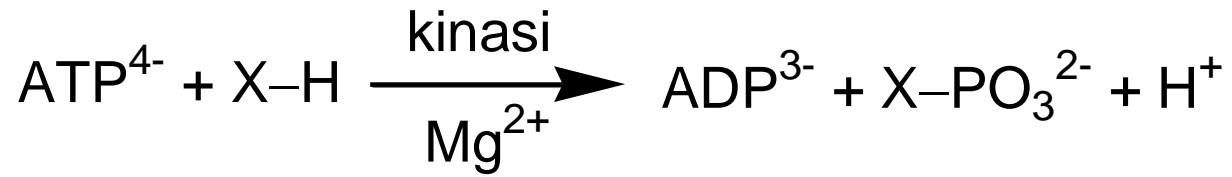
Magnesio



In media, un adulto sintetizza ed usa ogni giorno una quantità di ATP che corrisponde al proprio peso corporeo

S_N2

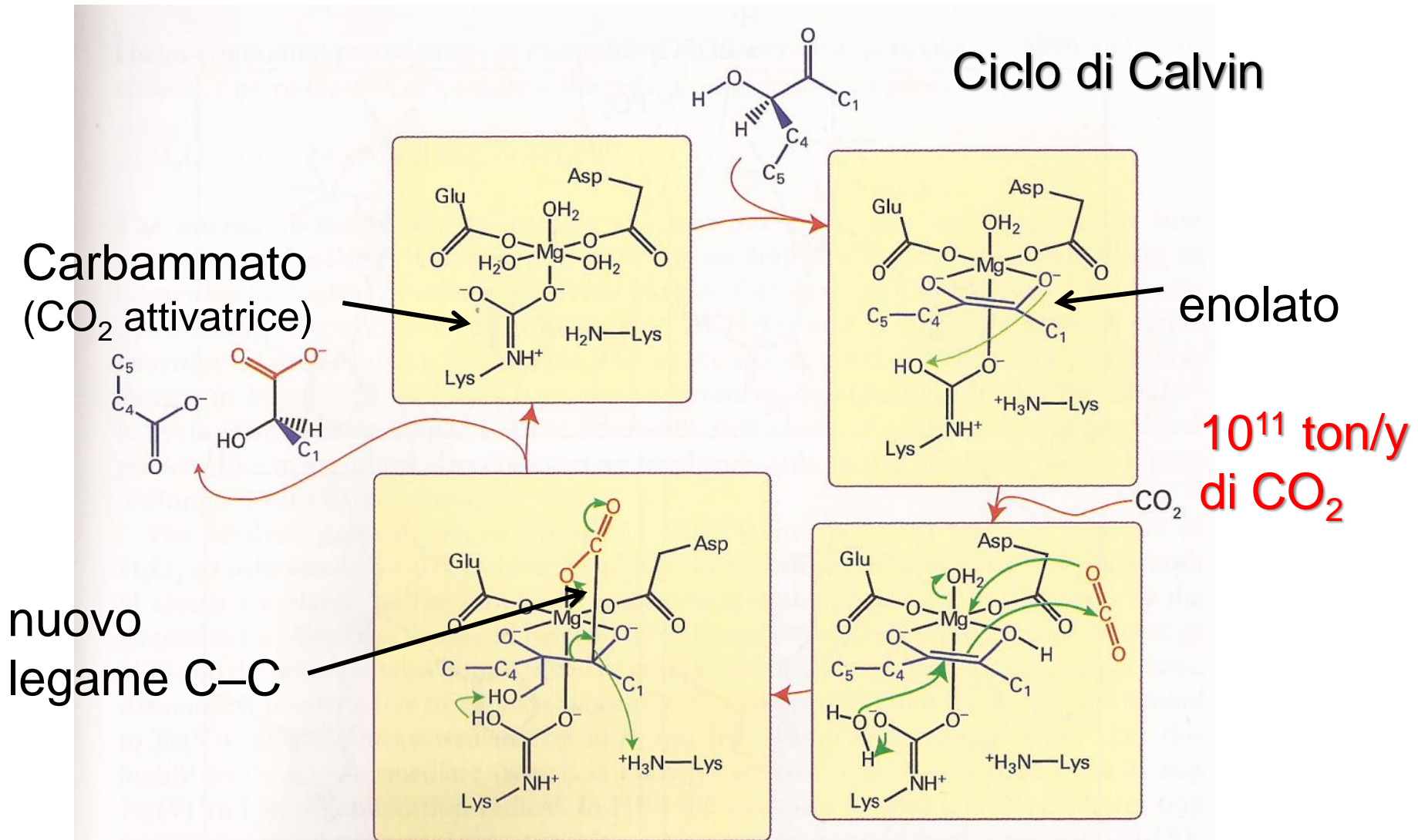
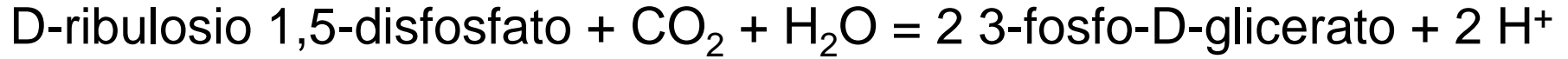




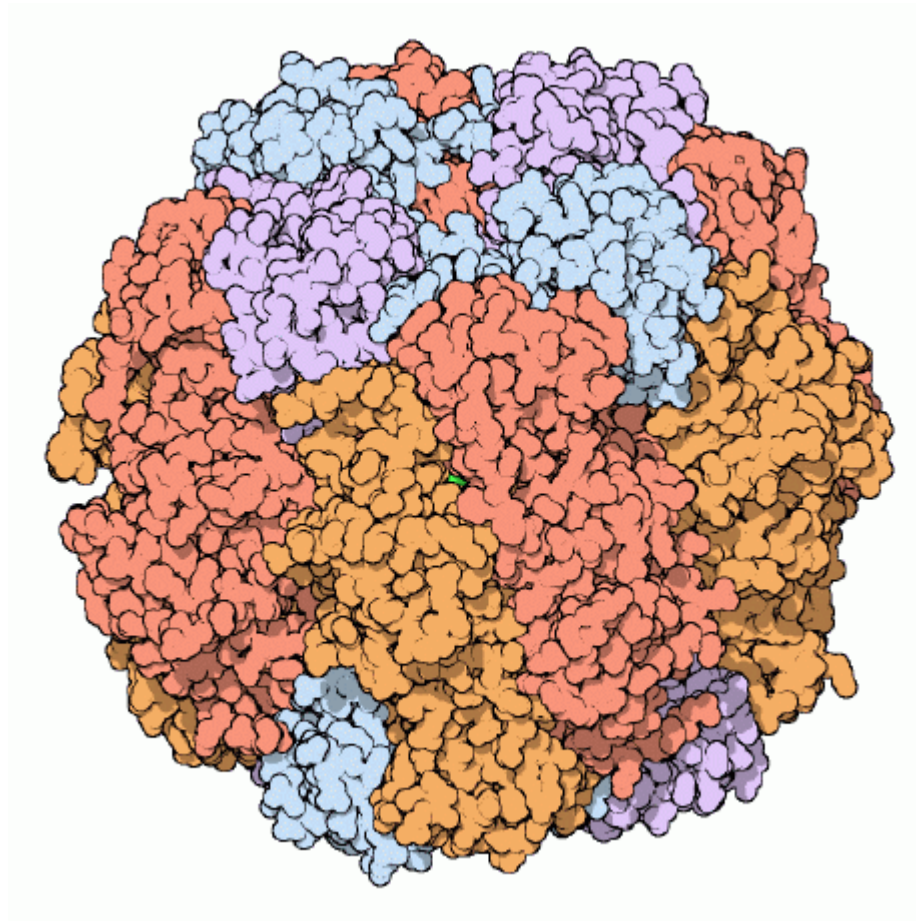
Piruvato-kinasi

Ribulosio bisfosfato carbossilasi (*RuBisCo*)

l'enzima più abbondante della biosfera



Rubisco

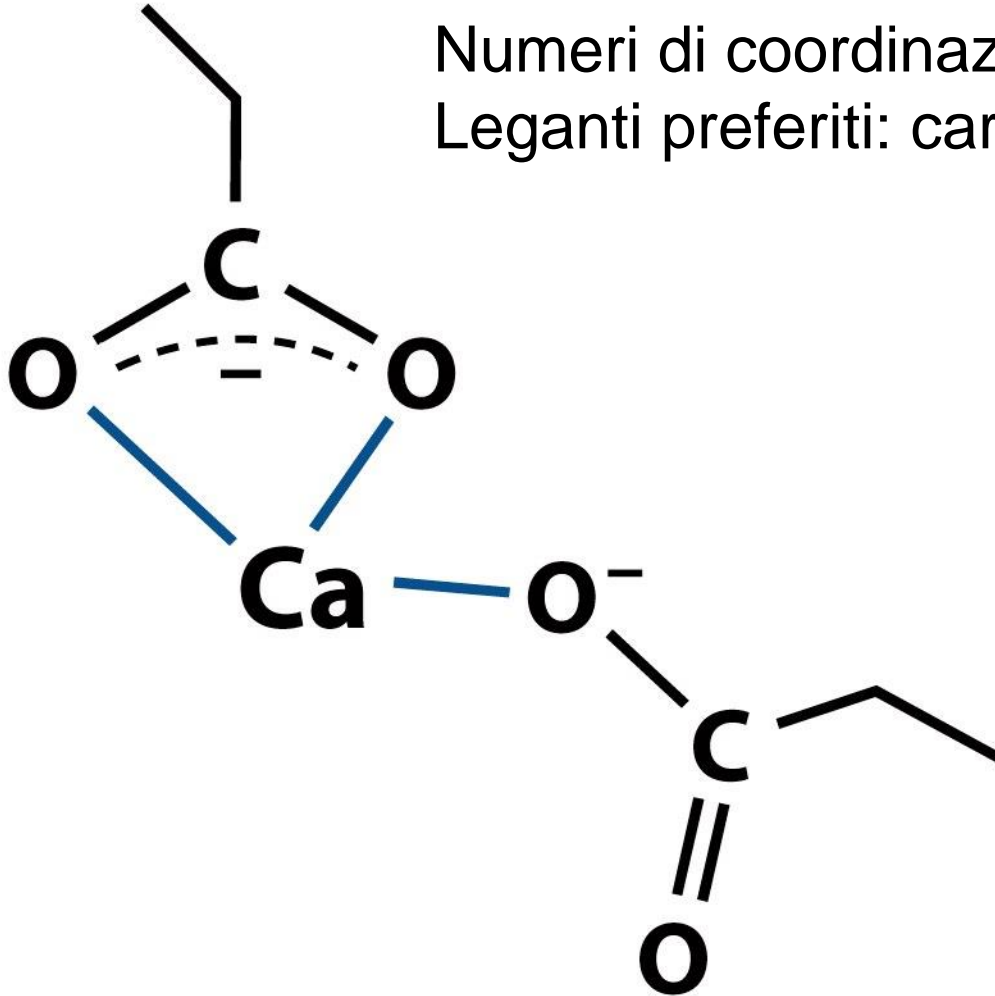


16 subunità, L_8S_8

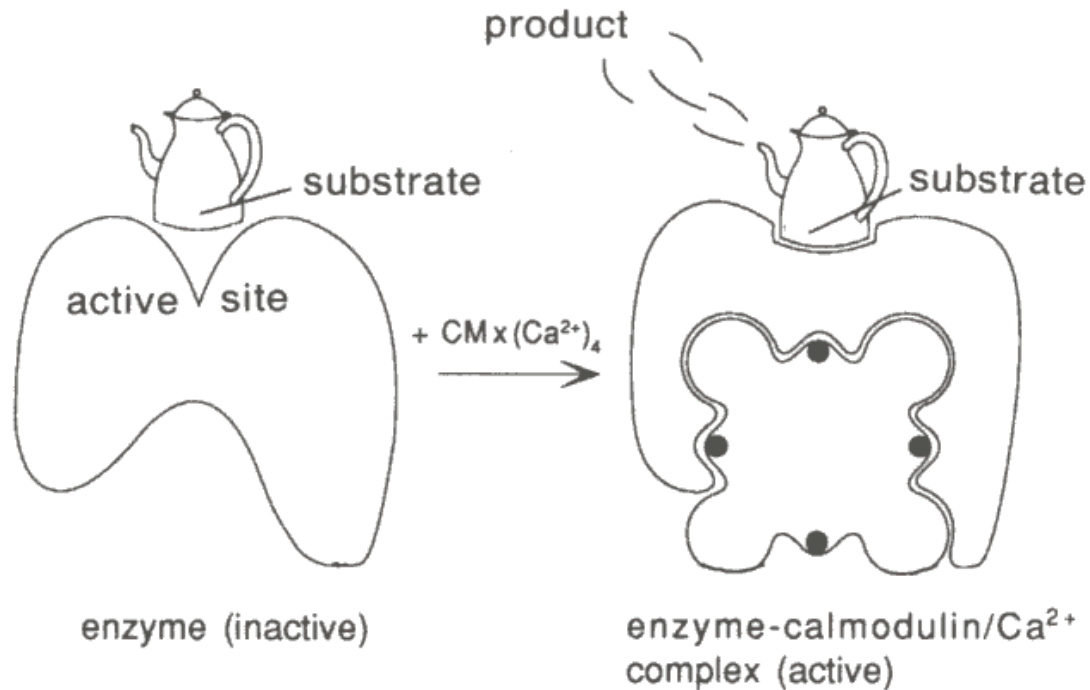
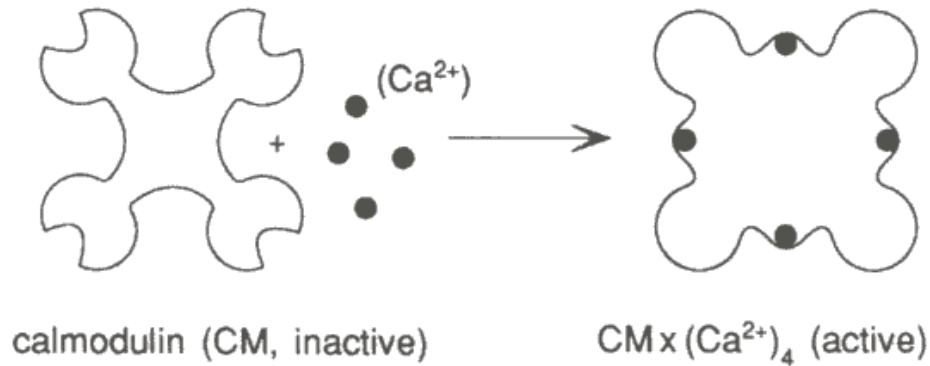
due siti attivi di Mg all'interfaccia di ogni coppia L_2

Calcio

Numeri di coordinazione elevati: 7 – 8
Leganti preferiti: carbossilati

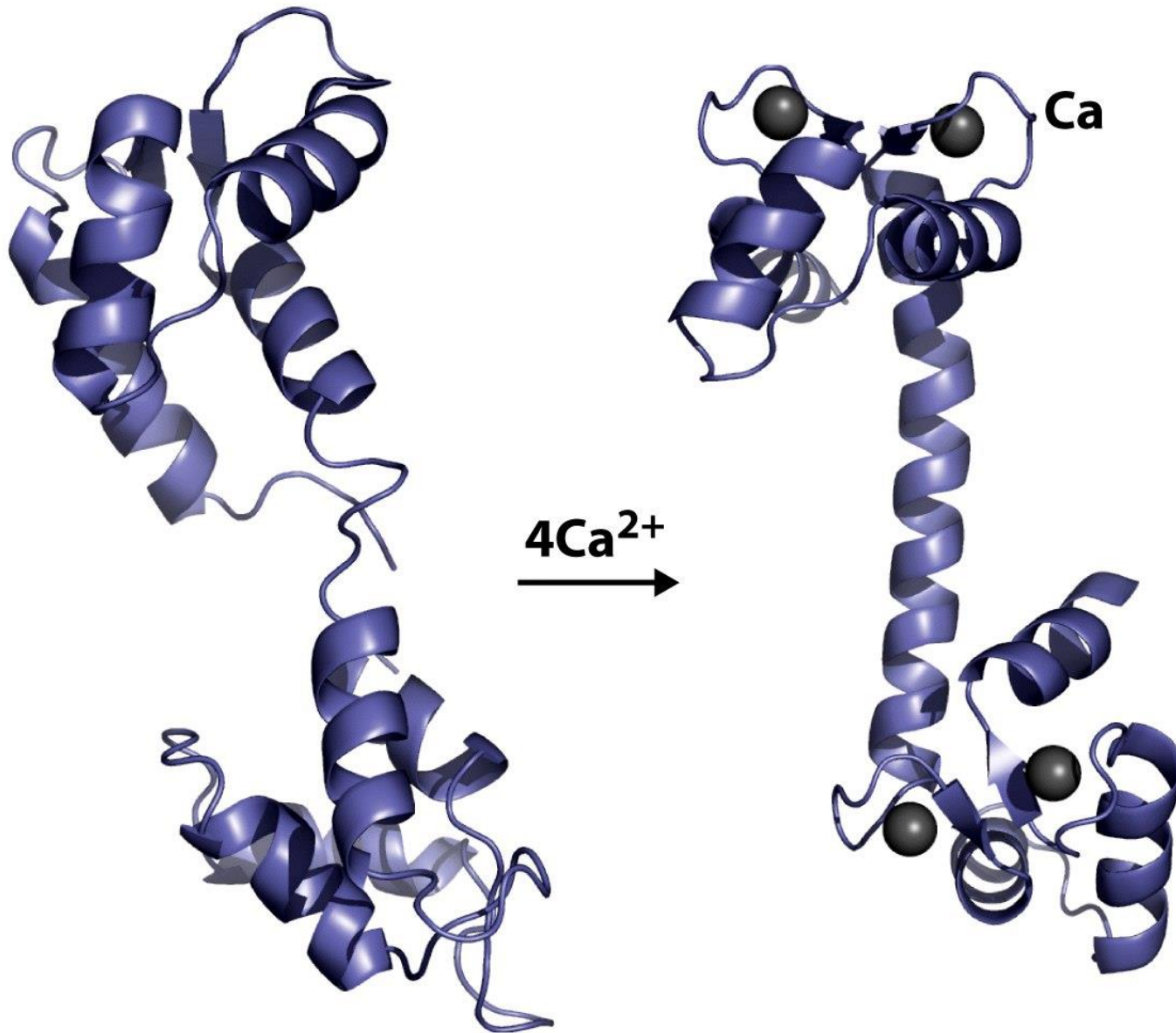


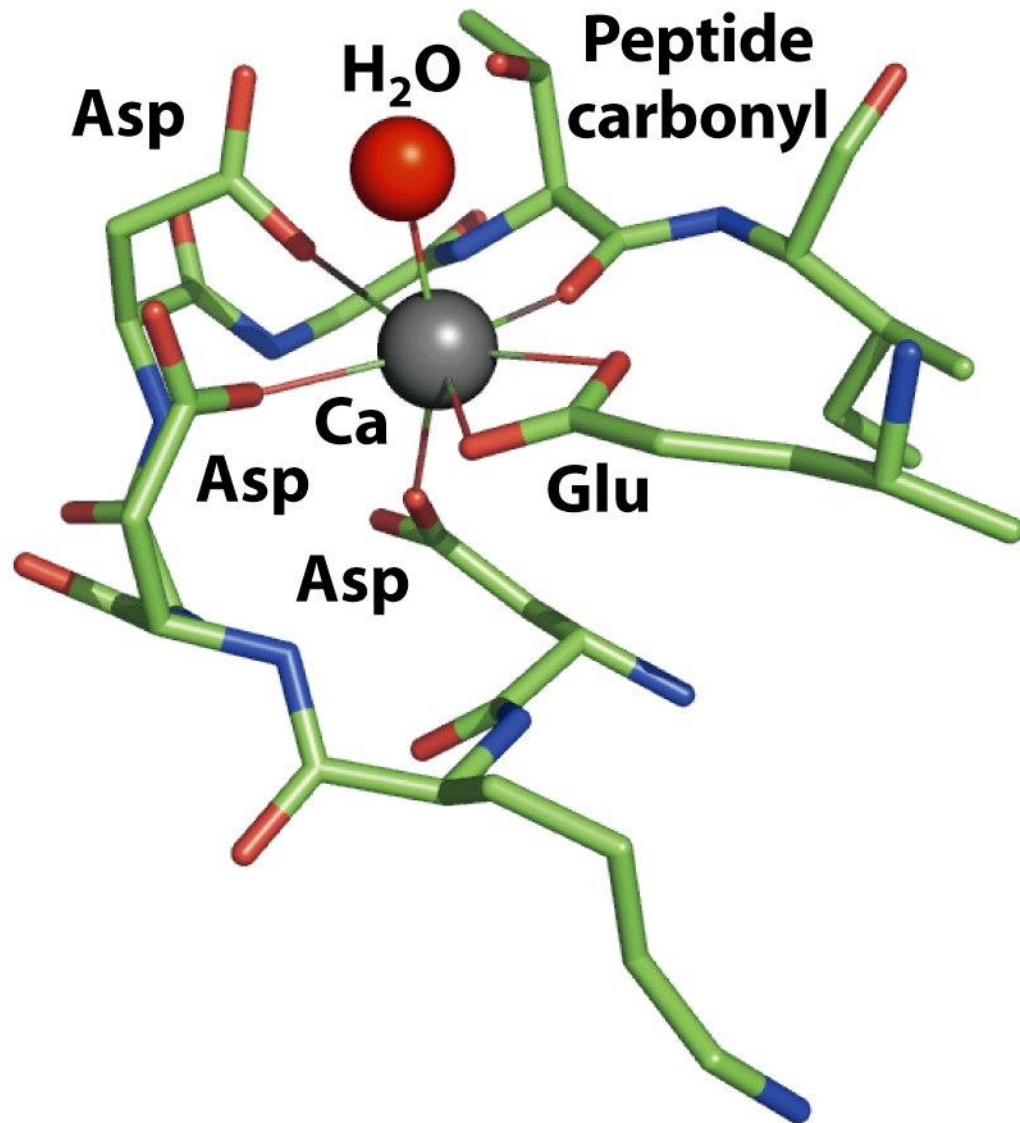
Ca²⁺: messaggero secondario



e.g.: NO sintasi (NO), adenilato e guanilato ciclasti (cAMP, cGMP), NAD kinasi (NADP)

Variazione conformazionale in una calmodulina

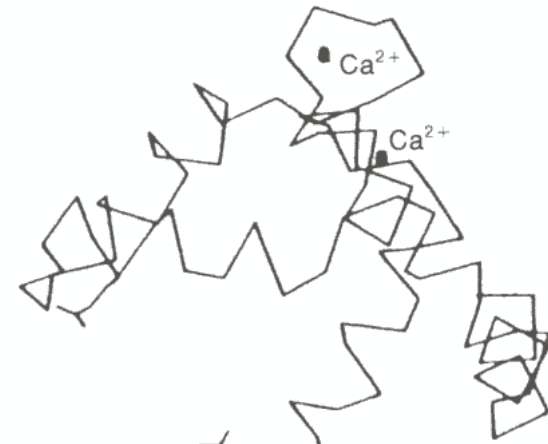
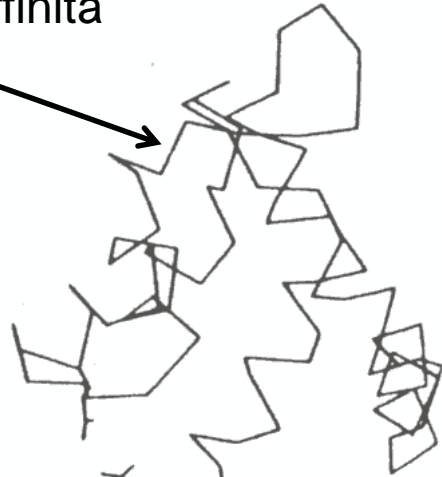
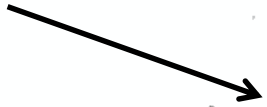




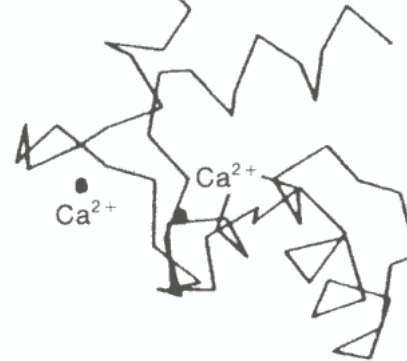
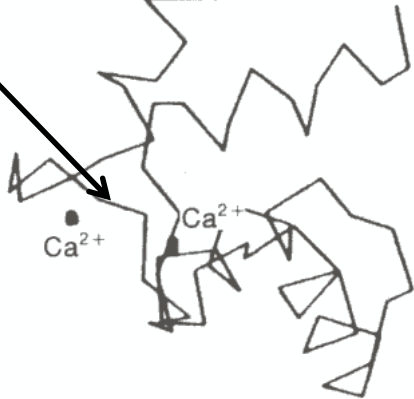
Uno dei siti di coordinazione del Ca^{2+} della calmodulina

Troponina-C

Siti di binding ad affinità minore



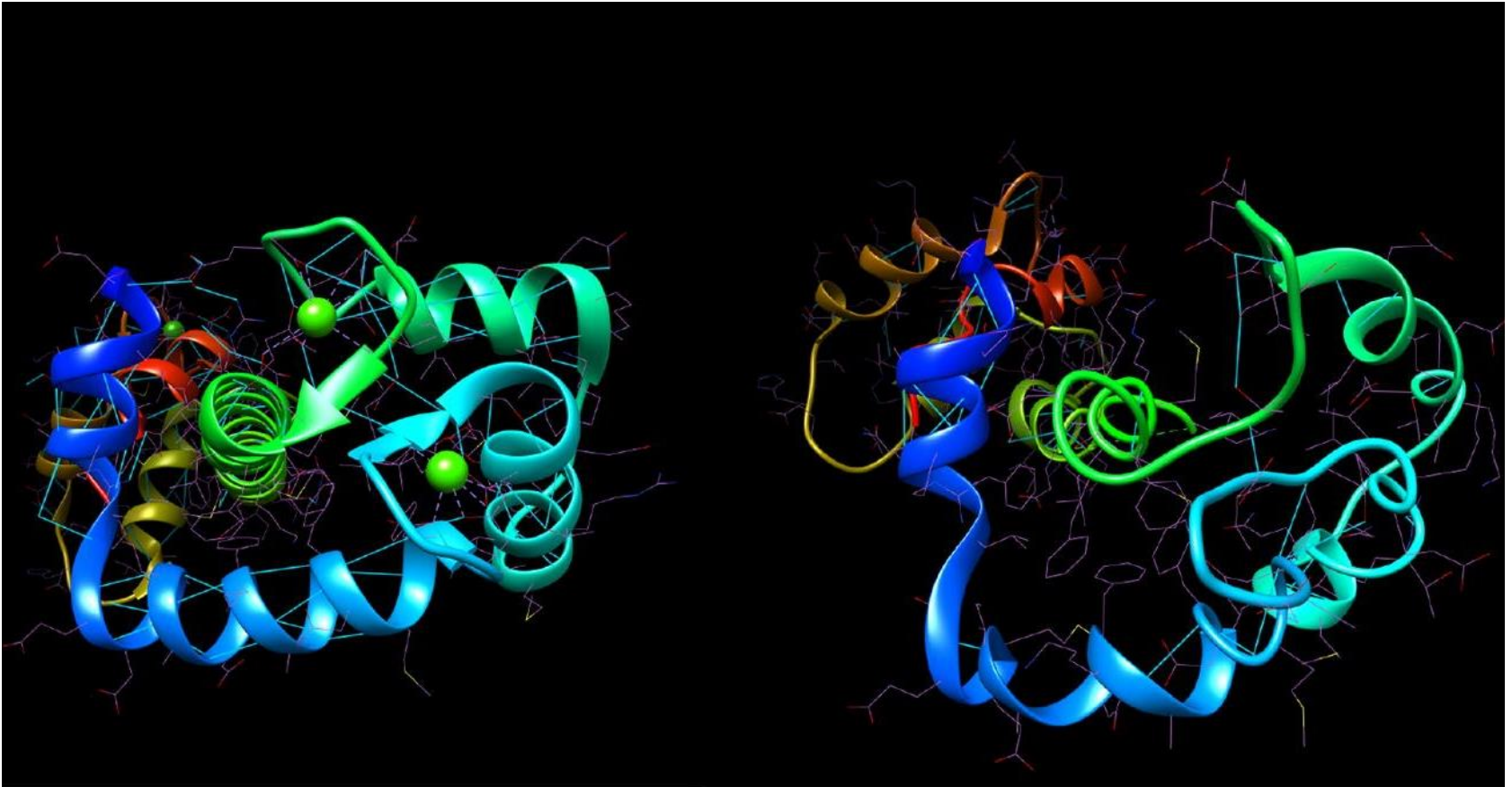
Siti di binding ad elevata affinità ($K > 10^6$)



→ *actina*
miosina

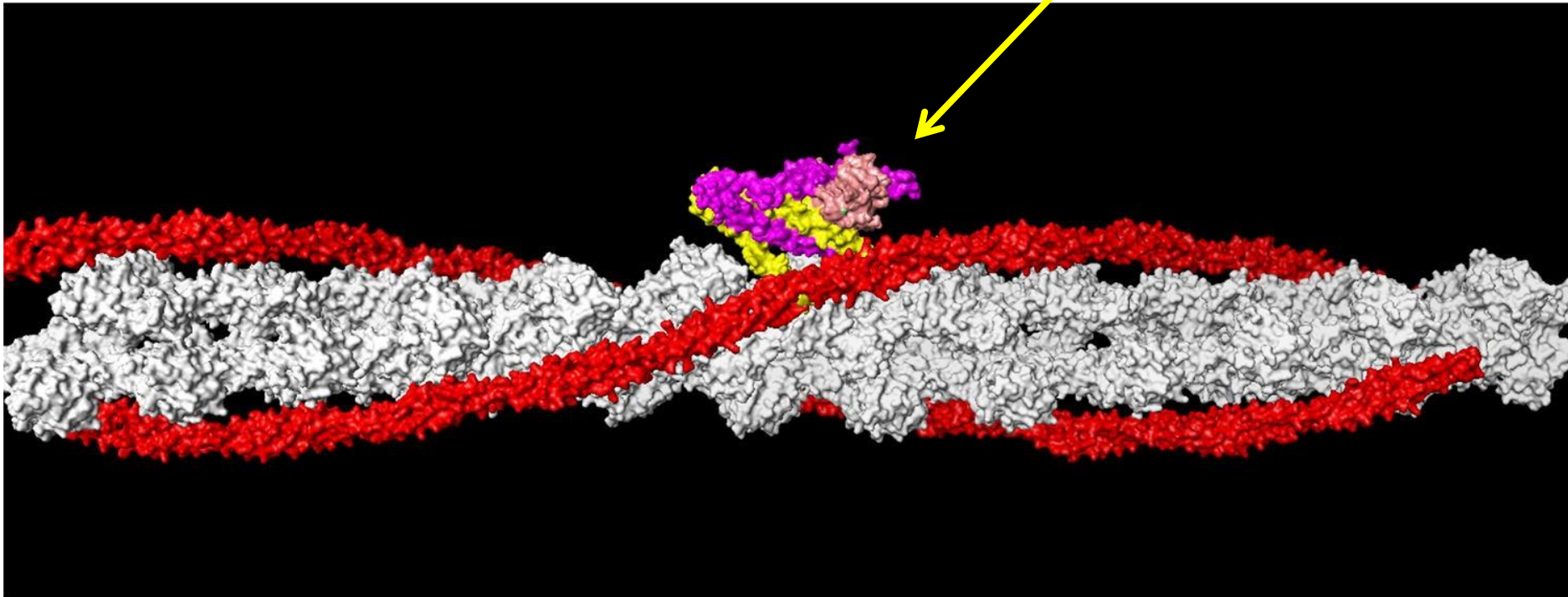
(componenti proteici del filamento muscolare)

Variazioni conformazionali indotte dal *binding* del calcio nella *Troponina C*



Modello di filamento muscolare

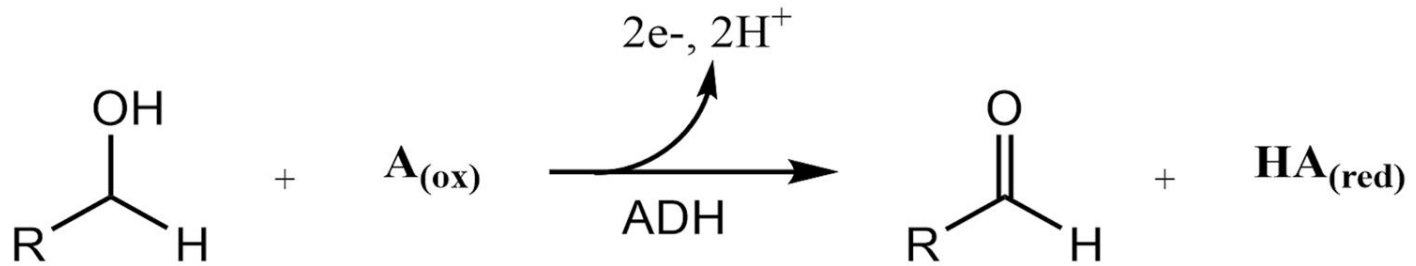
Troponina



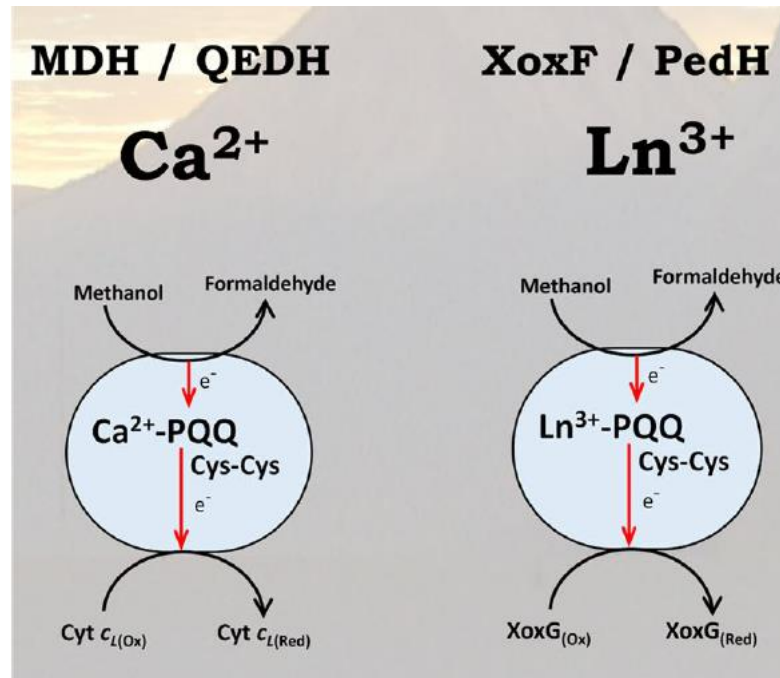
Actina = bianco

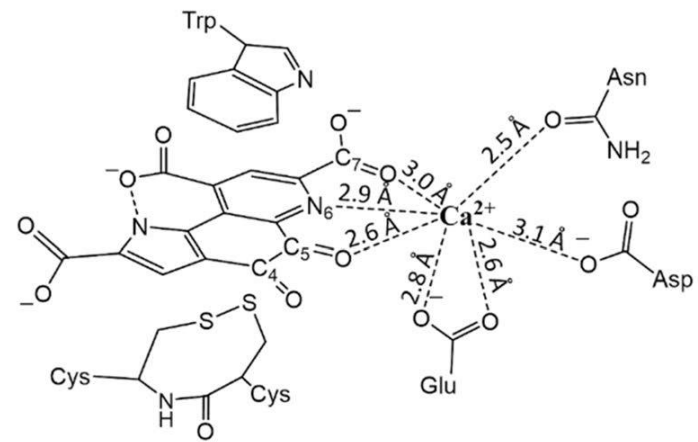
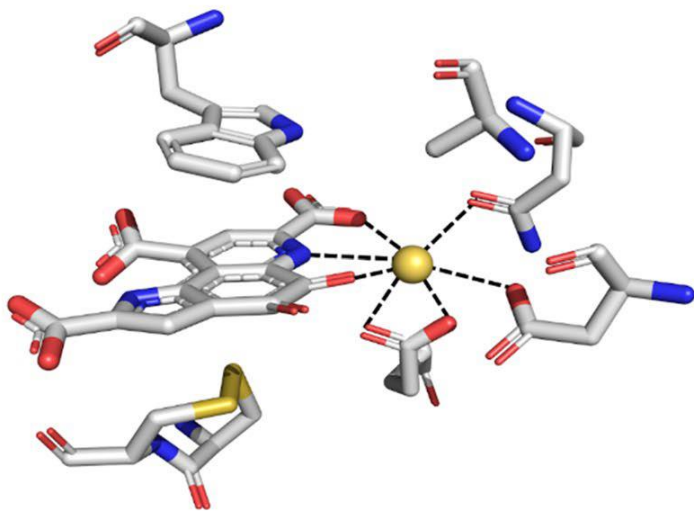
Tropomiosina = rosso

Alcol deidrogenasi (ADHs) dipendenti da PQQ (Pyrroloquinoline quinone)

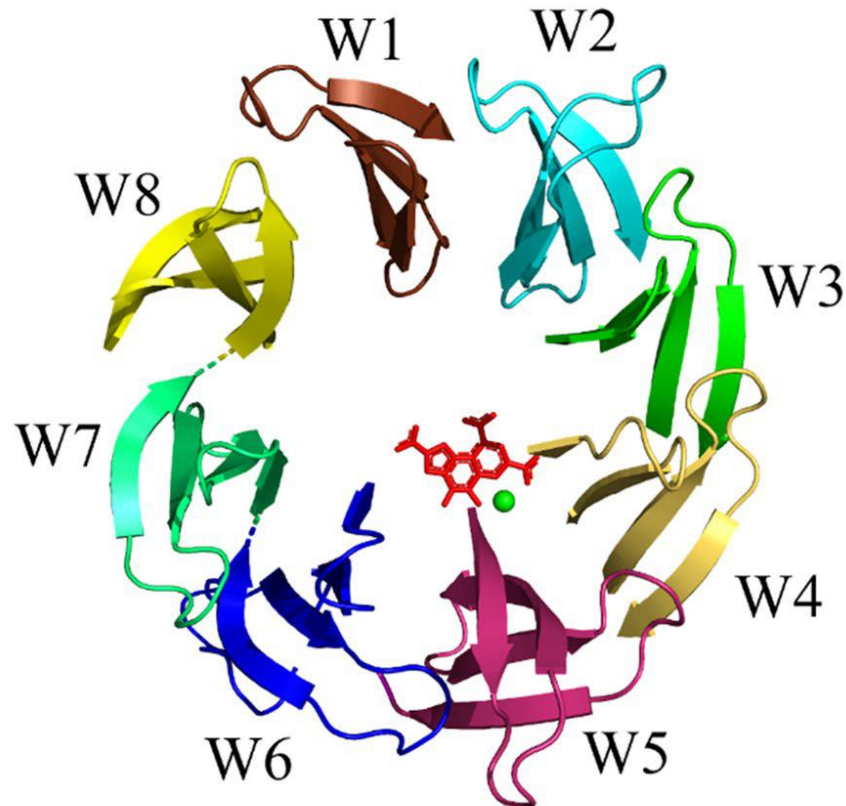


R, usually: CH₃, CH₂CH₃, CH₂CH₂CH₃, CH₂CH₂CH₂CH₃

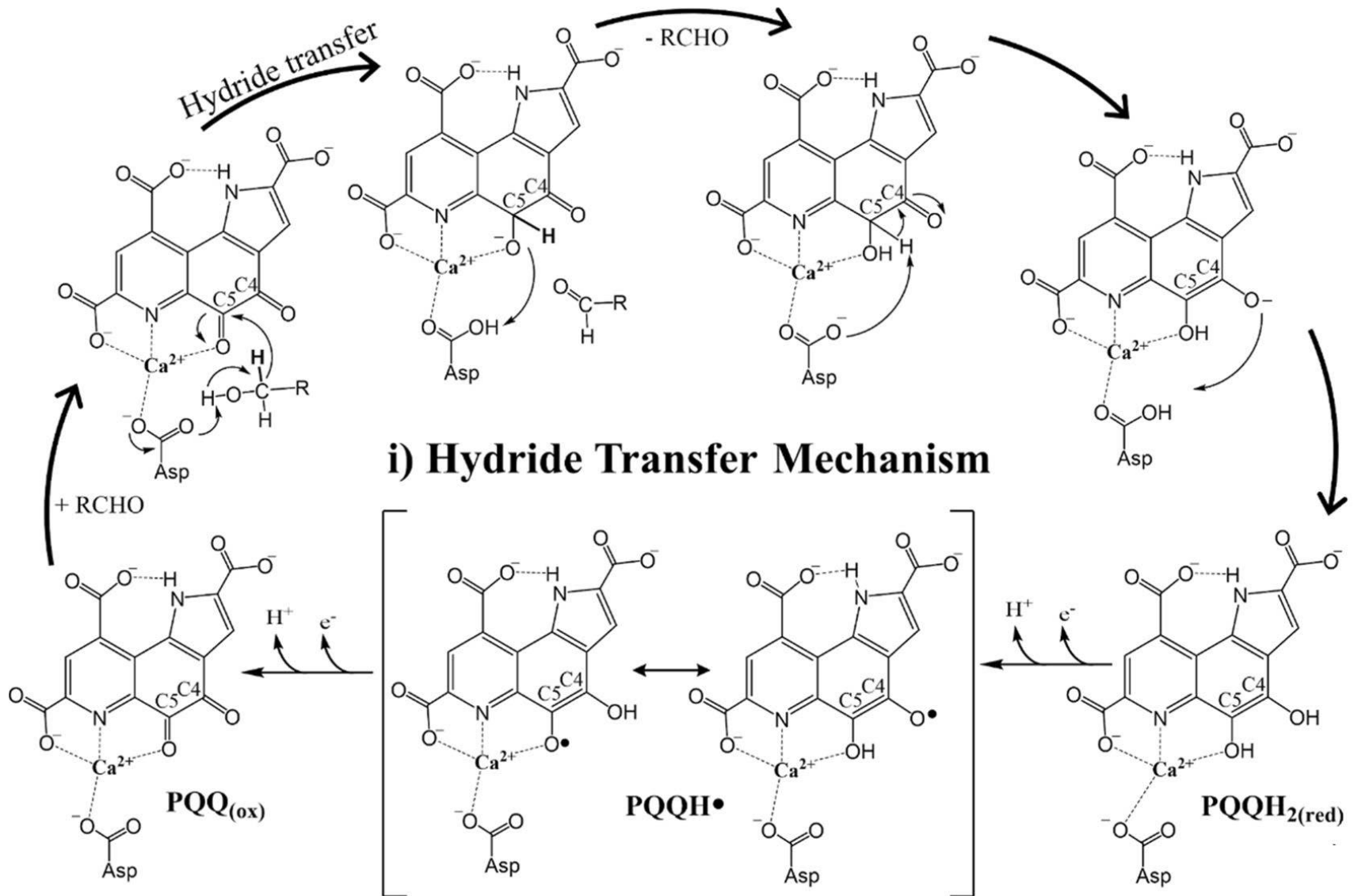


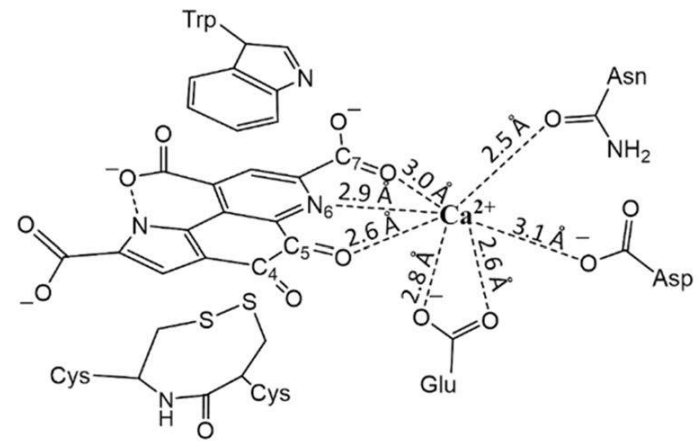
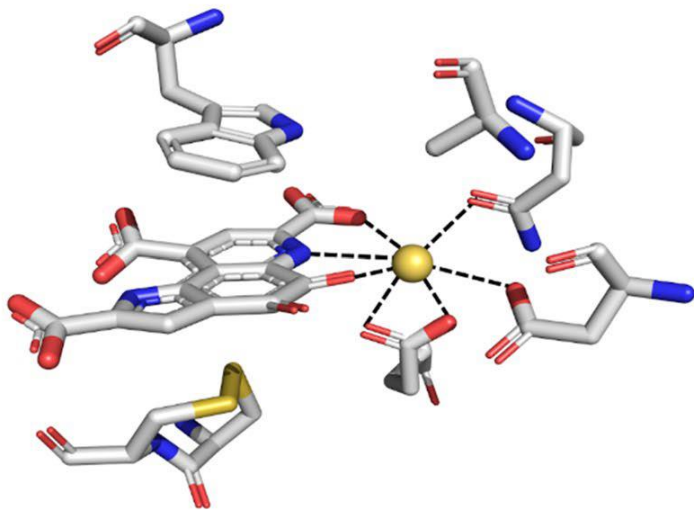


Sito attivo Ca^{2+} -PQQ della *methanol dehydrogenase*, MDH

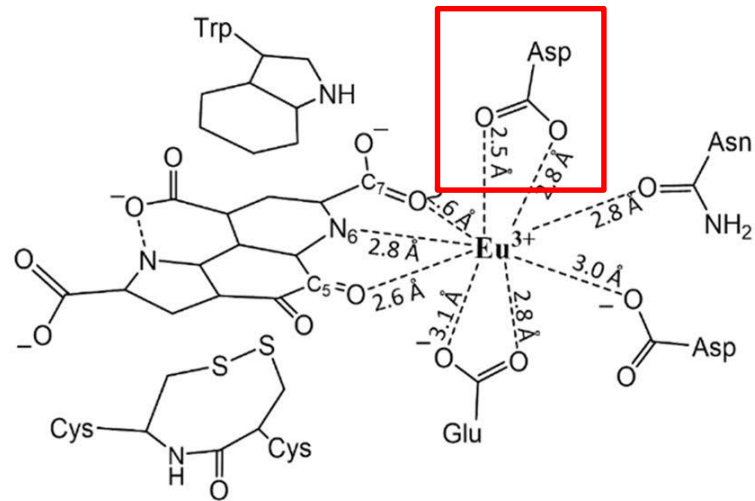
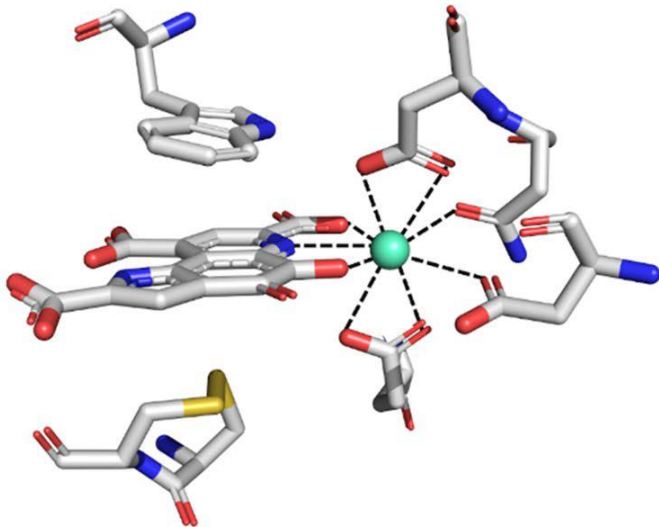


Ipotesi di meccanismo



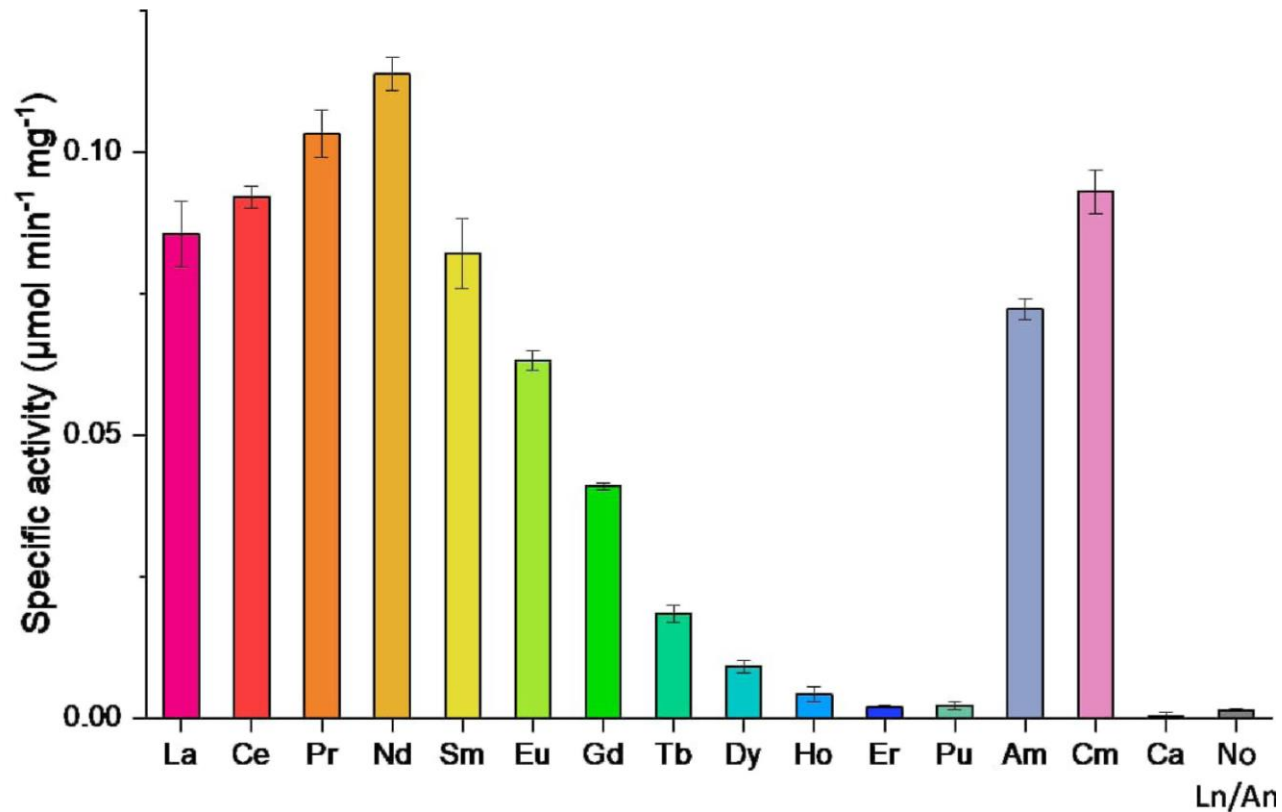


Sito attivo Ca^{2+} -PQQ della *methanol dehydrogenase*, MDH



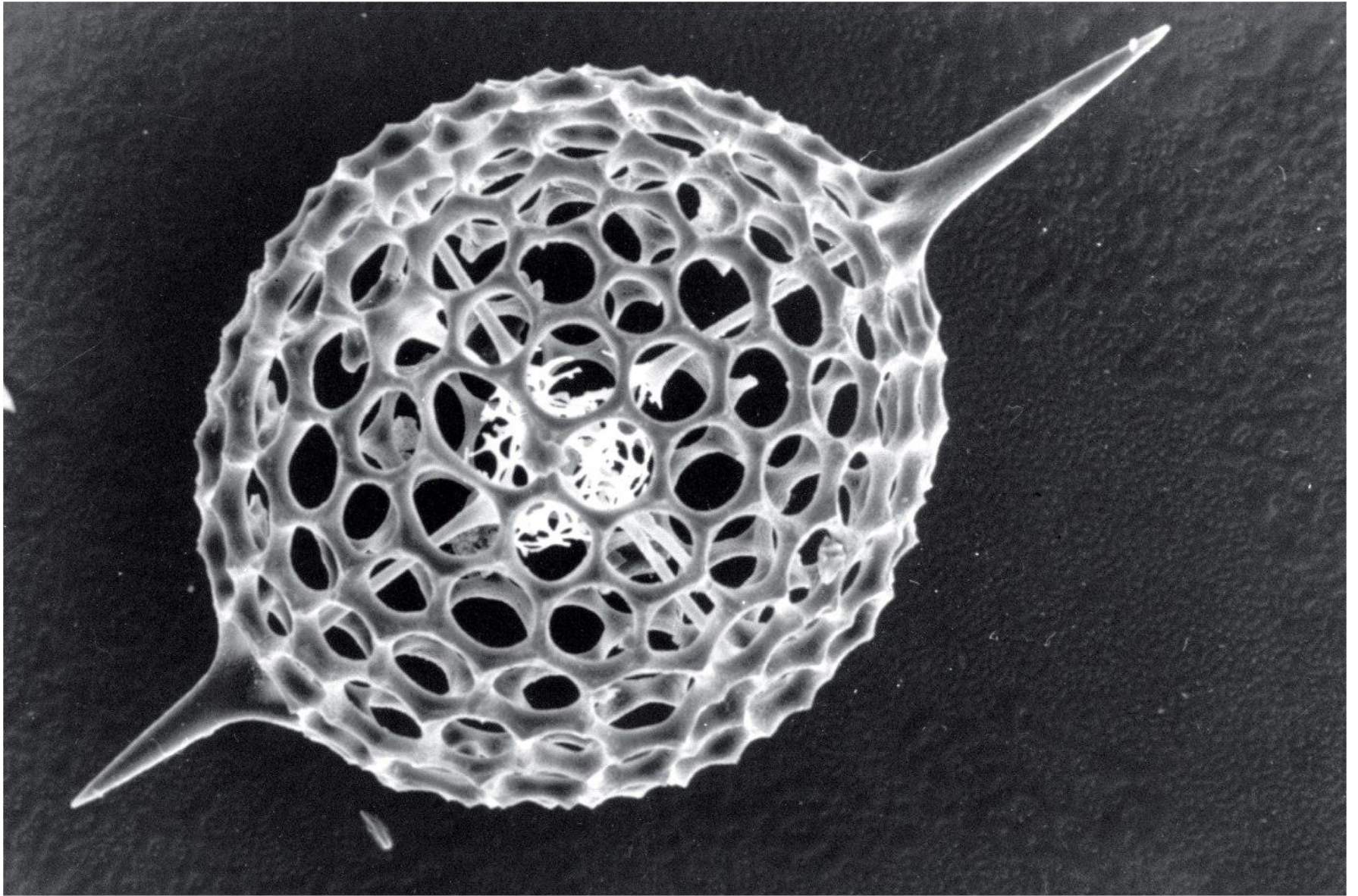
Sito attivo Ln^{3+} -PQQ della *methanol dehydrogenase*, MDH

Dipendenza dell'attività enzimatica dalla natura di Ln^{3+}

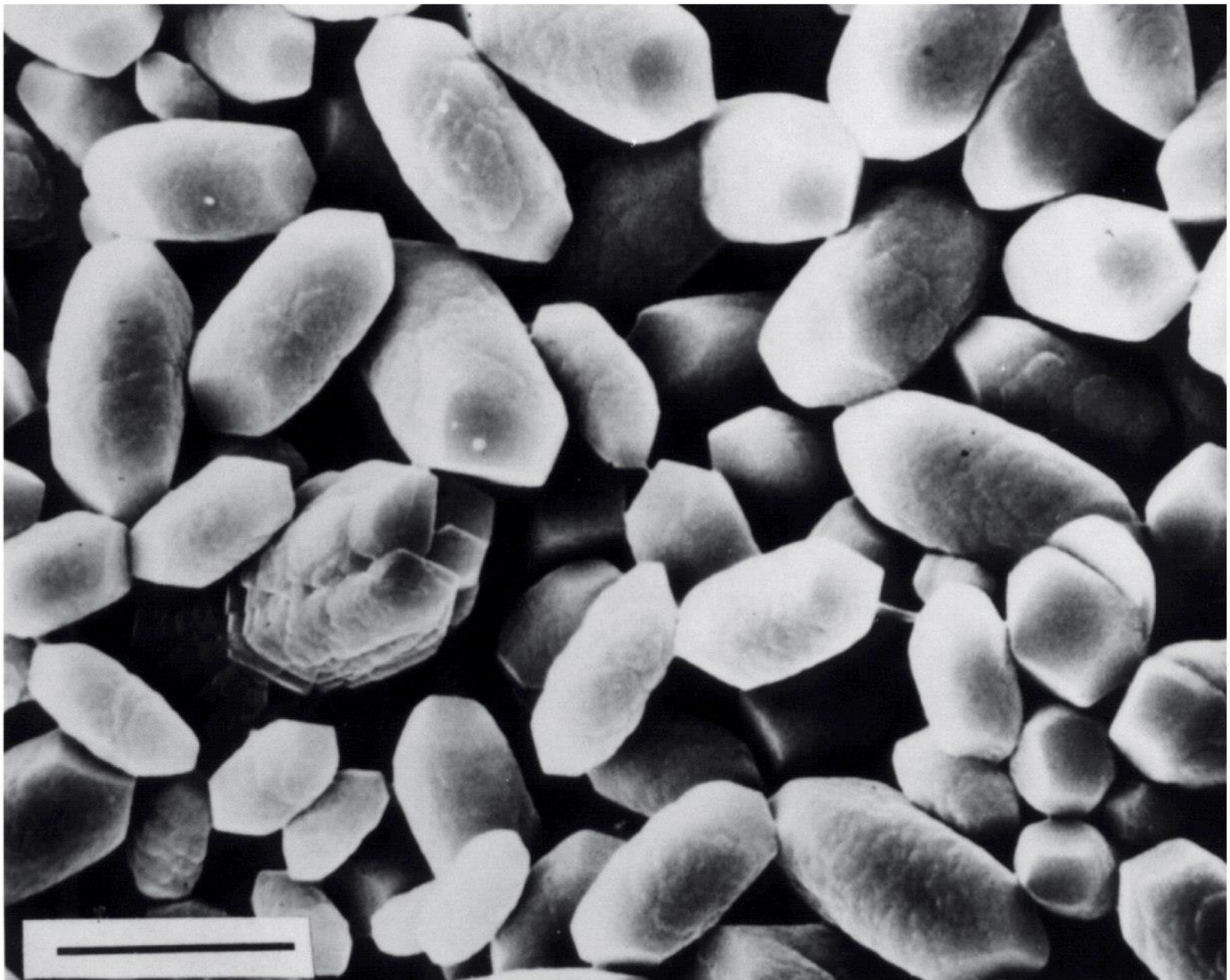


I principali biominerali di elementi alcalino-terrosi

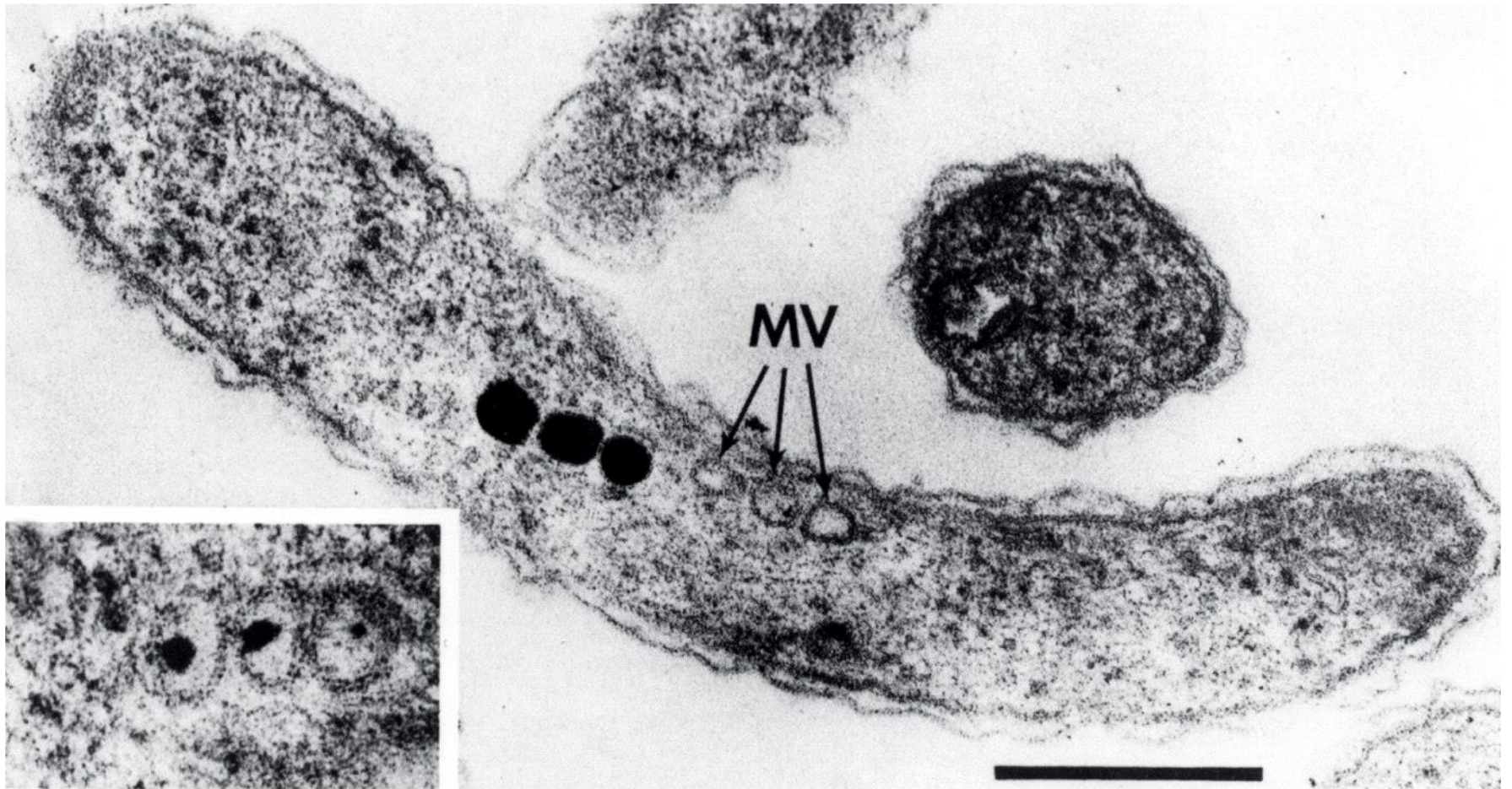
| Composto | Minerale | Presenza negli organismi viventi |
|---|--|---|
| MgCO_3 | Magnesite | Scheletro del corallo |
| CaCO_3 | Aragonite | Conchiglie e perle |
| CaCO_3 | Calcite | Uova di uccello, sistemi gravitazionali nell'orecchio interno |
| $\text{CaCO}_3 \cdot n\text{H}_2\text{O}$ | Amorfo | Immagazzinamento di calcio nelle piante |
| $\text{Ca}(\text{C}_2\text{O}_4) \cdot n\text{H}_2\text{O}$ | Whewellite (n = 1) Weddellite (n = 2) | Immagazzinamento di calcio nelle piante, calcoli renali |
| $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{Ca}(\text{OH})_2$ | Idrossiapatite | Ossa e denti nei vertebrati |
| $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ | Gesso | Sistema gravitazionale nelle meduse |
| SrSO_4 | Celestite | Esoscheletro di certo plankton |
| BaSO_4 | Barite | Sistema gravitazionale nelle alghe |



Microscheletro siliceo di una radiolaria



Cristalli di calcite nell'orecchio interno: sensori gravitazionali



Cristalli di magnetite in archeobatteri magnetotattici

Table 26.1 The approximate concentrations (mol dm⁻³), where known, of elements (apart from C, H, O, N, P, S, Se, Br, I, B, Si and W) in different biological zones

| Element | External fluids (sea water) | Free ions in external fluids (blood plasma) | Cytoplasm (free ions) | Comments on status in cell |
|---------|-----------------------------|---|-------------------------|---|
| Na | $> 10^{-1}$ | 10^{-1} | $< 10^{-2}$ | Not bound |
| K | 10^{-2} | 4×10^{-3} | $\leq 3 \times 10^{-1}$ | Not bound |
| Mg | $> 10^{-2}$ | 10^{-3} | $\approx 10^{-3}$ | Weakly bound as ATP complex |
| Ca | $> 10^{-3}$ | 10^{-3} | $\approx 10^{-7}$ | Concentrated in some vesicles |
| Cl | 10^{-1} | 10^{-1} | 10^{-2} | Not bound |
| Fe | 10^{-17} (Fe(III)) | 10^{-16} (Fe(III)) | $< 10^{-7}$ (Fe(II)) | Too much unbound Fe is toxic (Fenton chemistry) in and out of cells |
| Zn | $< 10^{-8}$ | 10^{-9} | $< 10^{-11}$ | Totally bound, but may be exchangeable |
| Cu | $< 10^{-10}$ (Cu(II)) | 10^{-12} | $< 10^{-15}$ (Cu(I)) | Totally bound, not mobile. Mostly outside cytoplasm |
| Mn | 10^{-9} | | $\approx 10^{-6}$ | Higher in chloroplasts and vesicles |
| Co | 10^{-11} | | $< 10^{-9}$ | Totally bound (cobalamin) |
| Ni | 10^{-9} | | $< 10^{-10}$ | Totally bound |
| Mo | 10^{-7} | | $< 10^{-7}$ | Mostly bound |