HPCA translocation biophysics examination
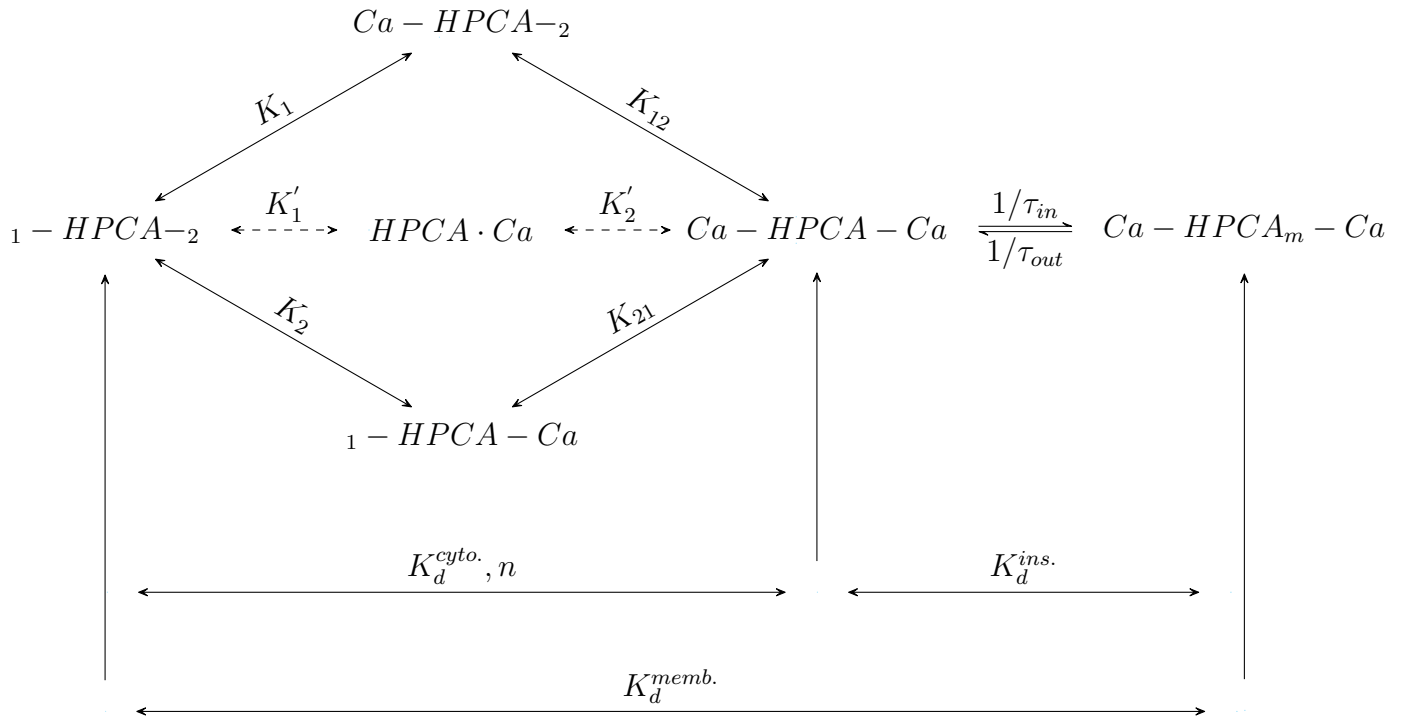# War, day 41

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General scheme

Kinetic model

Calcium binding

$$K_1 = \frac{[HPCA]_0[Ca^{2+}]}{[Ca - HPCA_{-2}]} \tag{1}$$

$$[Ca - HPCA_{-2}] = \frac{[HPCA]_0[Ca^{2+}]}{K_1} \tag{2}$$

$$K_2 = \frac{[HPCA]_0[Ca^{2+}]}{[_1{-}HPCA - Ca]} \tag{3}$$

$$[_1{-}HPCA - Ca] = \frac{[HPCA]_0[Ca^{2+}]}{K_2} \tag{4}$$

$$K_1' = \frac{[HPCA]_0[Ca^{2+}]}{[HPCA \cdot Ca]} = \frac{[HPCA]_0[Ca^{2+}]}{[Ca - HPCA_{-2}] + [_1{-}HPCA - Ca]} \tag{5}$$

$$K_1' = \frac{[HPCA]_0[Ca^{2+}]}{\frac{[HPCA]_0[Ca^{2+}]}{K_1} + \frac{[HPCA]_0[Ca^{2+}]}{K_2}} = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2}} = \frac{K_1 K_2}{K_1 + K_2} \tag{6}$$

Cooperativity

Membrane insertion

$$\tau_{in} \propto \frac{a^2}{D} \tag{7}$$

$$\tau_{out} \propto e^{\frac{\Delta E}{kT}} \tag{8}$$

General model

$$Y = \frac{\frac{\tau_{out}}{\tau_{in}}\left(\frac{[Ca^{2+}]}{K_d^{cyto.}}\right)^n}{1 + \left(\frac{[Ca^{2+}]}{K_d^{cyto.}}\right)^n + \frac{\tau_{out}}{\tau_{in}}\left(\frac{[Ca^{2+}]}{K_d^{cyto.}}\right)^n} \tag{9}$$

$$\frac{\tau_{out}}{\tau_{in}} \gg 1 \Rightarrow Y \approx \frac{\frac{\tau_{out}}{\tau_{in}}\left(\frac{[Ca^{2+}]}{K_d^{cyto.}}\right)^n}{1 + \frac{\tau_{out}}{\tau_{in}}\left(\frac{[Ca^{2+}]}{K_d^{cyto.}}\right)^n} \tag{10}$$

$$Y \approx \frac{\left(\frac{[Ca^{2+}]}{K_d^{cyto.} \sqrt[n]{\frac{\tau_{in}}{\tau_{out}}}}\right)^n}{1 + \left(\frac{[Ca^{2+}]}{K_d^{cyto.} \sqrt[n]{\frac{\tau_{in}}{\tau_{out}}}}\right)^n} = \frac{\left(\frac{[Ca^{2+}]}{K_d^{memb.}}\right)^n}{1 + \left(\frac{[Ca^{2+}]}{K_d^{memb.}}\right)^n} \tag{11}$$

$$K_d^{memb.} = K_d^{cyto.} \sqrt[n]{\frac{\tau_{in}}{\tau_{out}}} = K_d^{cyto.} \sqrt[n]{\frac{a^2}{D\tau_{out}}} \tag{12}$$