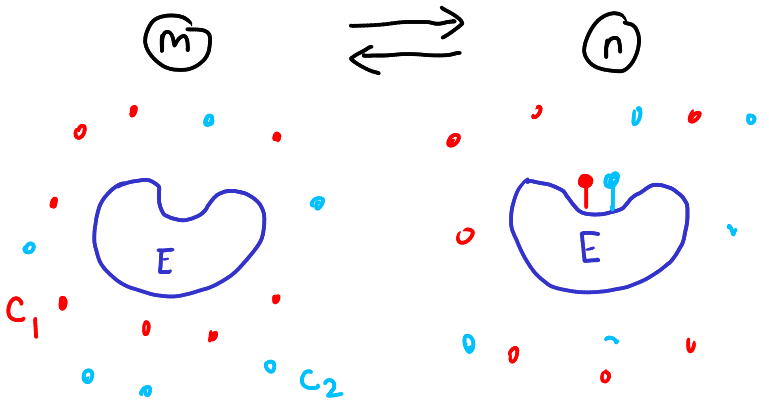
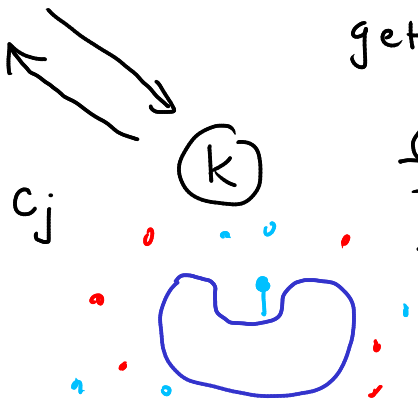


$$\frac{\Omega_{nm}}{\Omega_{mn}} = e^{-\beta(H_n - H_m - \mu_1 - \mu_2)}$$

for every molec. that binds we get a $-\mu_j$ term

type j molec: $\mu_j = \mu_0^j + k_B T \ln c_j$



$$\frac{\Omega_{kn}}{\Omega_{nk}} = e^{-\beta(H_k - H_n + \mu_1)}$$

unbinding: $+\mu_j$ term

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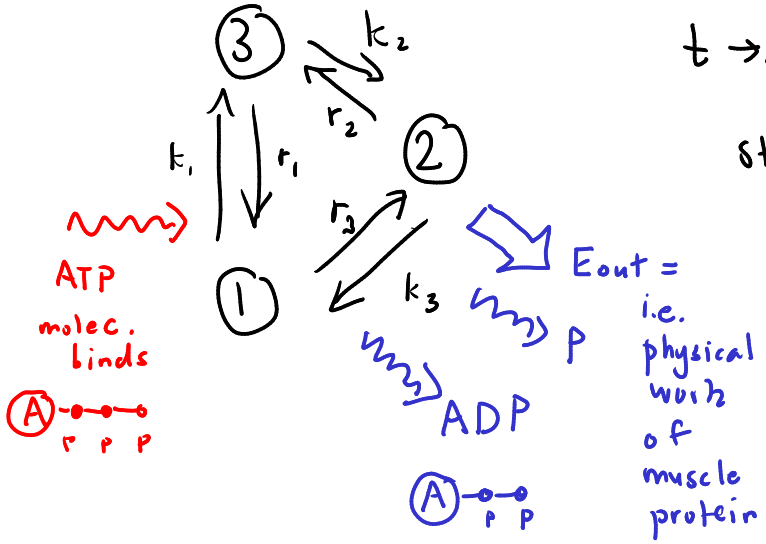
example: simplified muscle protein



$t \to \infty$: $J_{31}(t), J_{23}(t), J_{12}(t) \to J$

stat. current:

$$J = \frac{k_1 k_2 k_3}{K}\left(1 - \frac{r_1 r_2 r_3}{k_1 k_2 k_3}\right)$$

K: pos. funct. of rates

$\mu_{ATP} = \mu_0^{ATP} + k_B T \ln c_{ATP}$

$\mu_{ADP} = \mu_0^{ADP} + k_B T \ln c_{ADP}$

etc.

$$\frac{k_1}{r_1} = e^{-\beta(H_3 - H_1 - \underbrace{\mu_{ATP}}_{E_{in} \text{ for photon}})}$$

$$\frac{k_2}{r_2} = e^{-\beta(H_2 - H_3)}$$

$$\frac{k_3}{r_3} = e^{-\beta(H_1 - H_2 + \underbrace{\mu_{ADP} + \mu_P + E_{out}}_{E_{out} \text{ for photon}})}$$

$$\Rightarrow \quad J = \frac{k_1 k_2 k_3}{K}\left(1 - e^{-\beta(\underbrace{\mu_{ATP} - \mu_{ADP} - \mu_P}_{\equiv \Delta\mu} - E_{out})}\right)$$

$$\Delta\mu = \mu_0^{ATP} - \mu_0^{ADP} - \mu_0^{P} \Big] \; 12\ k_BT + k_BT \ln \frac{C_{ATP}}{C_{ADP}\, C_P}$$

chem. potential diff. b/t reactants & products of chem. reaction (ATP hydrolysis)

$= 21\text{-}29\ k_BT$ for typical cells across all life

if $E_{out} < \Delta\mu \Rightarrow J > 0$ NESS

power budget $\quad \underset{\text{net power}}{\dot{W}} = \frac{1}{2}\sum_{nm} J_{nm} W_{nm}$

$= J(\Delta\mu - E_{out})$

$= P_{in} - P_{out}$

$P_{in} = J\,\Delta\mu \qquad P_{out} = J\,E_{out}$

$\eta = \frac{P_{out}}{P_{in}} = \frac{E_{out}}{\Delta\mu}$ typically $\approx 0.4\text{-}0.6$ for muscle proteins