$$\frac{\Omega_{nm}}{\Omega_{mn}} = e^{-\beta(E_n - E_m - W_{nm})}$$

W_{nm} → work done by env. on sys.

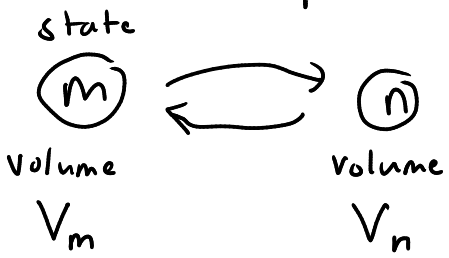
Q_{nm} = heat prov. by environment

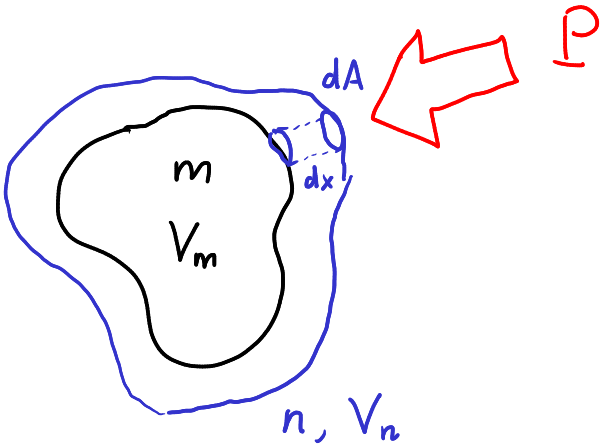
Go into details of typical W_{nm} for biological systems:

- work against pressure
- "chemical" work ⇒ chemical potentials

pressure:

biomolecule





$$\text{work done by sys on env.} = \int_{\text{area}} \underbrace{P\,\underbrace{dA}_{\text{force}}\,\overbrace{dx}^{dV}}_{\text{dist.}}$$

$$= P(V_n - V_m)$$

$$W_{nm} = -P(V_n - V_m)$$

$$(\text{by env. on sys.}) = -PV_n - (-PV_m)$$

$$= A_n - A_m$$

Conservative work

for state prop. $A_n \equiv -PV_n$

$$\Rightarrow \frac{\Omega_{nm}}{\Omega_{mn}} = e^{-\beta(E_n - E_m + PV_n - PV_m)}$$

$$= e^{-\beta (H_n - H_m)}$$

$H_n \equiv E_n + PV_n$

new state variable

= enthalpy of state n

if no other work terms: ESS where $E_n \to H_n$

$$p_n^s = \frac{e^{-\beta H_n}}{Z} \qquad Z = \sum_n e^{-\beta H_n}$$

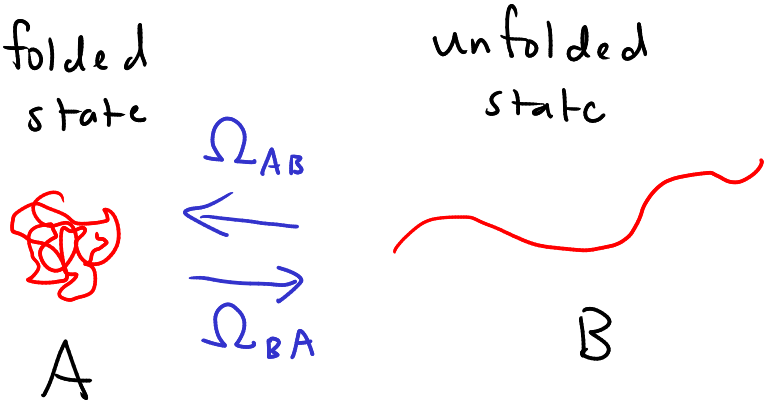
---

from now on: $\frac{\Omega_{nm}}{\Omega_{mn}} = e^{-\beta (H_n - H_m - W_{nm})}$

W_{nm}: non-pressure work terms

Most biological "states" are actually coarse-grained descriptions ("macrostates") corresponding to many possible "microstates".

simple protein model



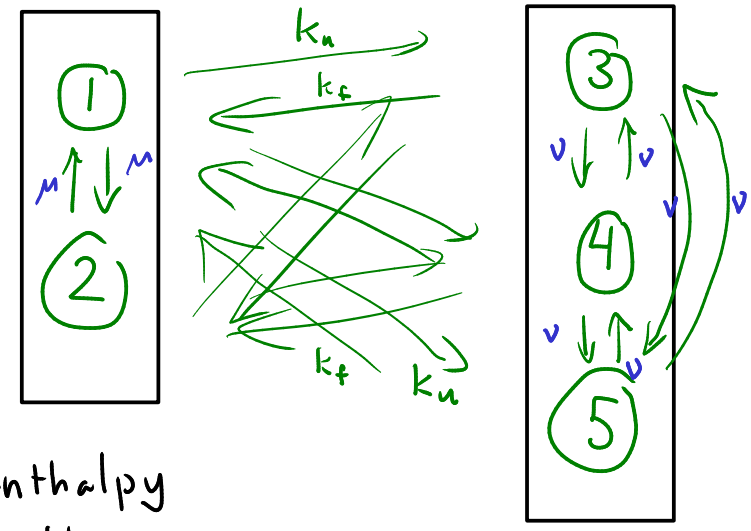
macrostate

$H_1 \approx H_2 \approx H_A$

$H_3 \approx \ldots \approx H_5 = H_B$

σ_A = # microstates in A = 2

σ_B = # microstates in B = 3

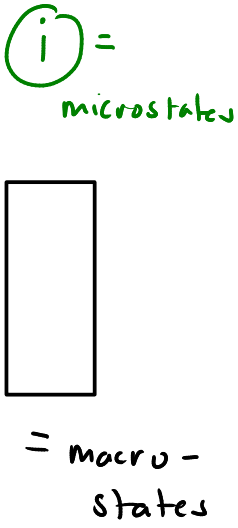


enthalpy H_A

enthalpy H_B

$A \xrightarrow{k_u} B$ unfolding

$B \xrightarrow{k_f} A$ folding



GOAL: create a coarse-grained master eqn. for A + B given the original (5 state) system