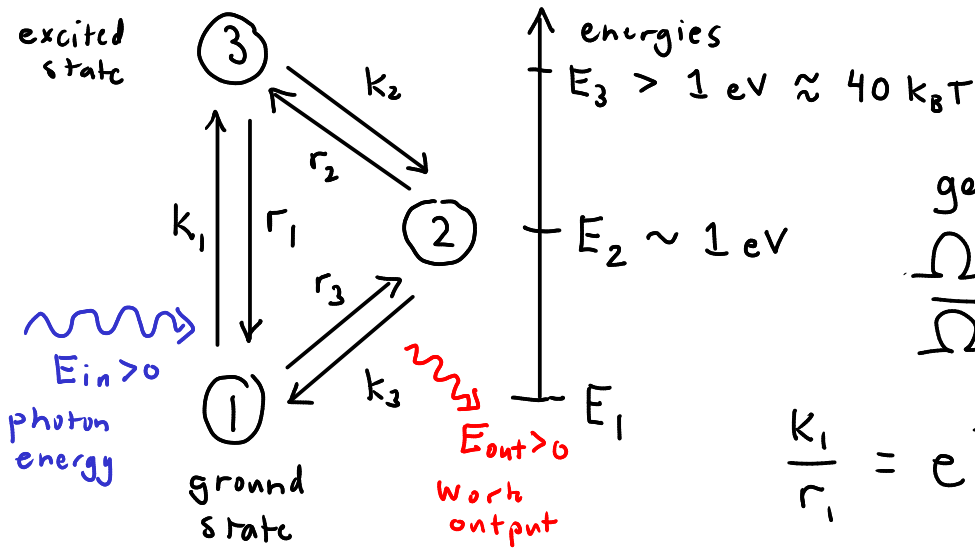


simple 3-state model of light-sensitive model



r_1 = spontaneous fluorescence:
typically fast
 $\sim [ps - ns]^{-1}$

general rule:

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

work added into sys $\downarrow$

$\downarrow W_{21}$

$$\frac{k_1}{r_1} = e^{-\beta(E_3 - E_1 - E_{in})}$$

$$\frac{k_2}{r_2} = e^{-\beta(E_2 - E_3)} \quad W_{23} = 0$$

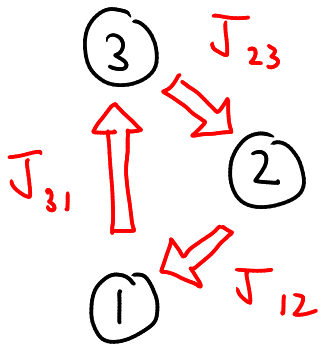
$$\frac{k_3}{r_3} = e^{-\beta(E_1 - E_2 + E_{out})} \quad W_{12} = -E_{out}$$

k_2 = rearrangement of protein after photon absorp.
(lose some energy to heat $E_3 \rightarrow E_2$)

$$\frac{k_2}{r_1} \sim 0.1 - 0.7 \text{ for photoproteins}$$

fraction of "detected" absorptions:

$$\frac{k_2}{r_1 + k_2} = \frac{k_2/r_1}{1 + k_2/r_1} \quad \text{can be much smaller than 1}$$



$$0 = \sum_n J_{nm}^s \quad \text{stat. state}$$

$$\Rightarrow J_{12}^s = J_{23}^s = J_{31}^s \equiv J$$

$$J = J_{12}^s = k_3 p_2^s - r_3 p_1^s$$

$$J = J_{23}^s = k_2 p_3^s - r_2 p_2^s$$

$$J = J_{31}^s = k_1 p_1^s - r_1 p_3^s$$

$$p_1^s + p_2^s + p_3^s = 1$$

$$\Rightarrow \text{algebra } J = \frac{k_1 k_2 k_3 - r_1 r_2 r_3}{F}$$

F is an expression
involves k_i, r_i
 $F > 0$ always

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

$$= \frac{k_1 k_2 k_3}{F} \left(1 - e^{-\beta(E_{in} - E_{out})} \right)$$

$E_{out} < E_{in} : J > 0$ NESS clockwise around loop

earlier version : $E_{in} = E_{out} = 0 \Rightarrow J = 0$ ESS
(absence of photon)

Consider equilibrium scenario (dark w/ no photons)

prob. to be in state 2 in equil:

$$p_2^s = \frac{e^{-\beta E_2}}{e^{-\beta E_1} + e^{-\beta E_2} + e^{-\beta E_3}}$$

Boltzmann
expr.

$$k_B T = \frac{1}{40} \text{ eV}$$

$$\beta \approx 40 \text{ eV}^{-1}$$

$$E_1 = 0$$

$$E_2 \sim 1 \text{ eV}$$

$$E_3 > 1 \text{ eV}$$

$$= \frac{e^{-\beta E_2}}{1 + e^{-40} + e^{-100}}$$

$$\approx e^{-\beta E_2} \sim e^{-40}$$

smaller $T \Rightarrow$ larger $\beta \Rightarrow p_2^s$ should decrease

$$W_{nm} = -W_{mn}$$