Last time

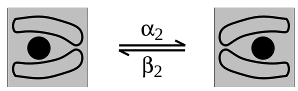
Carrier-Mediated Transport: glucose transporter as example

Distinguishing characteristics of glucose transport:

- facilitated -- i.e., faster than dissolve and diffuse
- structure specific -- different rates for even closely related sugars
- passive -- given a single solute, flow is down concentration gradient
- transport saturates -- solute-solute interactions
- transport can be inhibited -- solute-other interactions
- pharmacology (cytochalasin B)
- hormonal control (insulin)

similar to water channels (Hg, vasopressin)

Translocation

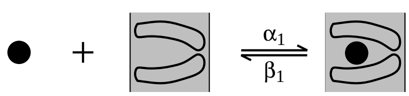


$$ES^i \underset{\beta_2}{\overset{\alpha_2}{\rightleftharpoons}} ES^o$$

$$\frac{dC^o_{ES}}{dt} = \alpha_2 C^i_{ES} - \beta_2 C^o_{ES}$$

$$\frac{dC^i_{ES}}{dt} = \beta_2 C^o_{ES} - \alpha_2 C^i_{ES}$$

Binding

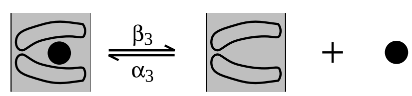


$$S^i + E^i \underset{\beta_1}{\overset{\alpha_1}{\rightleftharpoons}} ES^i$$

$$\frac{dC^i_{ES}}{dt} = \alpha_1 C^i_S C^i_E - \beta_1 C^i_{ES}$$

$$\frac{dC^i_S}{dt} = \frac{dC^i_E}{dt} = \beta_1 C^i_{ES} - \alpha_1 C^i_S C^i_E$$

Unbinding

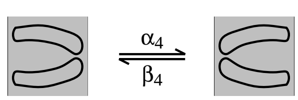


$$ES^o \underset{\alpha_3}{\overset{\beta_3}{\rightleftharpoons}} E^o + S^o$$

$$\frac{dC^o_{ES}}{dt} = \alpha_3 C^o_S C^o_E - \beta_3 C^o_{ES}$$

$$\frac{dC^o_S}{dt} = \frac{dC^o_E}{dt} = \beta_3 C^o_{ES} - \alpha_3 C^o_S C^o_E$$

Translocation

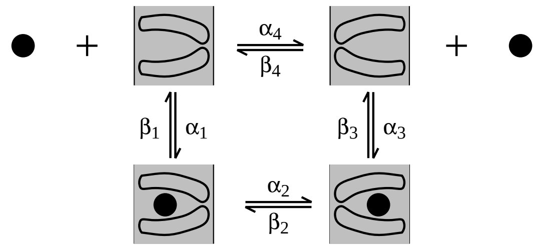


$$E^i \underset{\beta_4}{\overset{\alpha_4}{\rightleftharpoons}} E^o$$

$$\frac{dC^o_E}{dt} = \alpha_4 C^i_E - \beta_4 C^o_E$$

$$\frac{dC^i_E}{dt} = \beta_4 C^o_E - \alpha_4 C^i_E$$

General Four-State Model



$$\frac{dC_{ES}^i}{dt} = \alpha_1 C_S^i C_E^i - \beta_1 C_{ES}^i \qquad \frac{dC_{ES}^o}{dt} = \alpha_3 C_S^o C_E^o - \beta_3 C_{ES}^o$$

$$\frac{dC_S^i}{dt} = \frac{dC_E^i}{dt} = \beta_1 C_{ES}^i - \alpha_1 C_S^i C_E^i \qquad \frac{dC_S^o}{dt} = \frac{dC_E^o}{dt} = \beta_3 C_{ES}^o - \alpha_3 C_S^o C_E^o$$

$$\frac{dC_{ES}^o}{dt} = \alpha_2 C_{ES}^i - \beta_2 C_{ES}^o \qquad \frac{dC_E^o}{dt} = \alpha_4 C_E^i - \beta_4 C_E^o$$

$$\frac{dC_{ES}^i}{dt} = \beta_2 C_{ES}^o - \alpha_2 C_{ES}^i \qquad \frac{dC_E^i}{dt} = \beta_4 C_E^o - \alpha_4 C_E^i$$

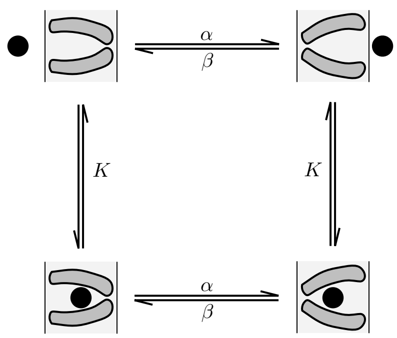
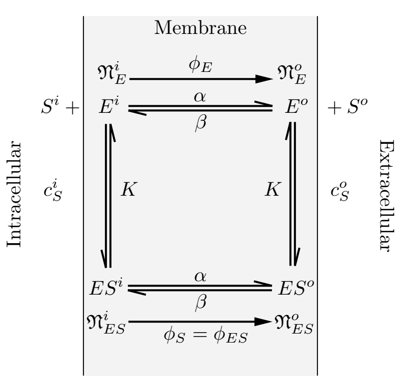


Figure 6.20

Simple Symetric 4-State Carrier Model



1. Conservation of enzyme:

$$\mathfrak{N}_E^i + \mathfrak{N}_E^o + \mathfrak{N}_{ES}^i + \mathfrak{N}_{ES}^o = \mathfrak{N}_{ET}$$

2. Binding is fast (always in steady state):

$$K = \frac{c_S^i \mathfrak{N}_E^i}{\mathfrak{N}_{ES}^i} = \frac{c_S^o \mathfrak{N}_E^o}{\mathfrak{N}_{ES}^o}$$

3. Translocation characterized by fluxes:

$$\phi_{ES} = \alpha \mathfrak{N}_{ES}^i - \beta \mathfrak{N}_{ES}^o$$

$$\phi_E = \alpha \mathfrak{N}_E^i - \beta \mathfrak{N}_E^o$$

4. Net flux of enzyme is zero:

$$\phi_E + \phi_{ES} = 0$$

Simple Symetric 4-State Carrier Model

$$\mathfrak{N}^i_{ES} = \left(\frac{\beta}{\alpha+\beta}\right)\left(\frac{c^i_S}{c^i_S+K}\right)\mathfrak{N}_{ET}$$

$$\mathfrak{N}^i_{E} = \left(\frac{\beta}{\alpha+\beta}\right)\left(\frac{K}{c^i_S+K}\right)\mathfrak{N}_{ET}$$

$$\mathfrak{N}^o_{ES} = \left(\frac{\alpha}{\alpha+\beta}\right)\left(\frac{c^o_S}{c^o_S+K}\right)\mathfrak{N}_{ET}$$

$$\mathfrak{N}^o_{E} = \left(\frac{\alpha}{\alpha+\beta}\right)\left(\frac{K}{c^o_S+K}\right)\mathfrak{N}_{ET}$$

$$\phi_S = \left(\frac{\alpha\beta}{\alpha+\beta}\right)\mathfrak{N}_{ET}\left(\frac{c^i_S}{c^i_S+K} - \frac{c^o_S}{c^o_S+K}\right)$$

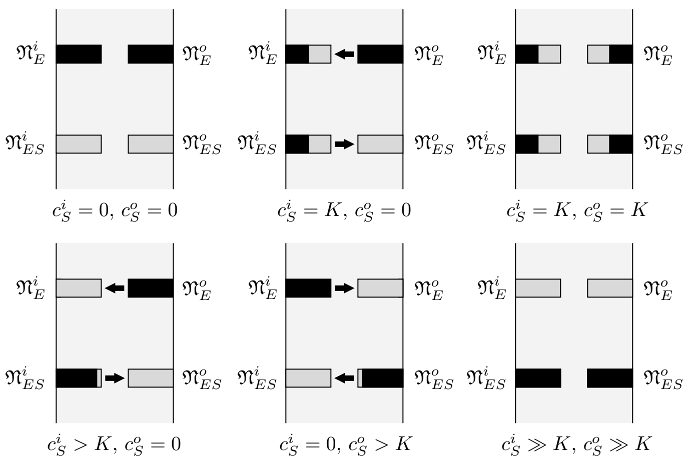
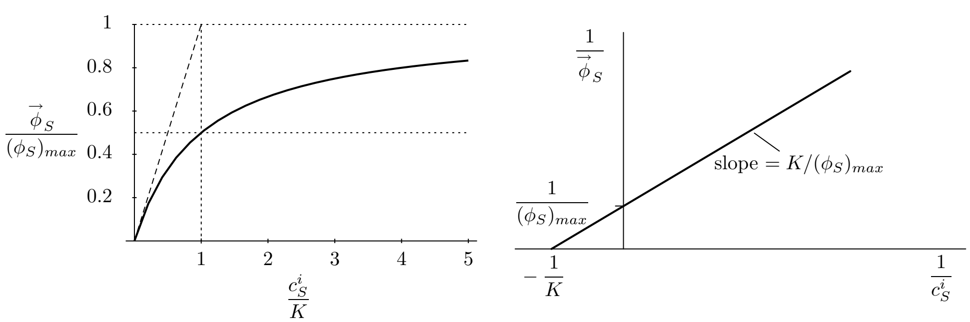


Figure 6.23

Simple Symetric 4-State Carrier Model



$$\phi_S = (\phi_S)_{max}\left(\frac{c^i_S}{c^i_S+K} - \frac{c^o_S}{c^o_S+K}\right)$$

$$(\phi_S)_{max} = \frac{\alpha\beta}{\alpha+\beta}\mathfrak{N}_{ET}$$

$$\overleftarrow{\phi}_S = (\phi_S)_{max}\left(\frac{c^o_S}{c^o_S+K}\right)$$