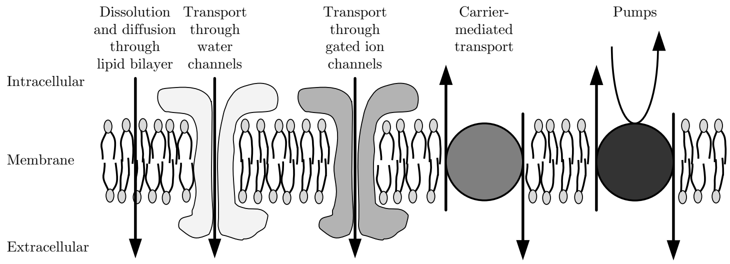


Figure 2.19

Sugar	K_{eq} (mmol/L)
D-glucose(6)	4-10
D-mannose(6)	14
D-galactose(6)	40-60
D-xylose(5)	60
L-arabinose(5)	250
D-ribose(5)	2000
L-sorbose(6)	3100
D-fructose(6)	9300

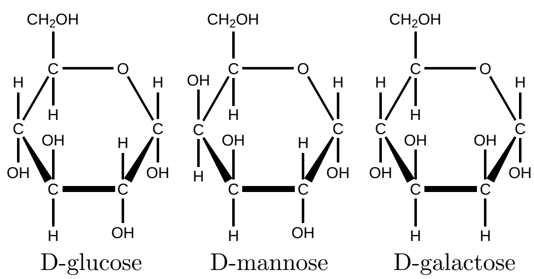


Figure 1.7

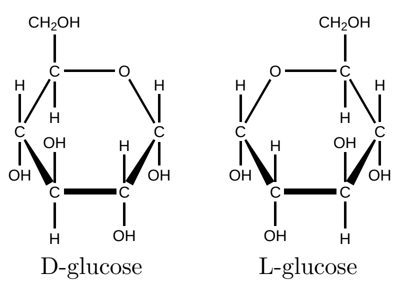


Figure 1.8

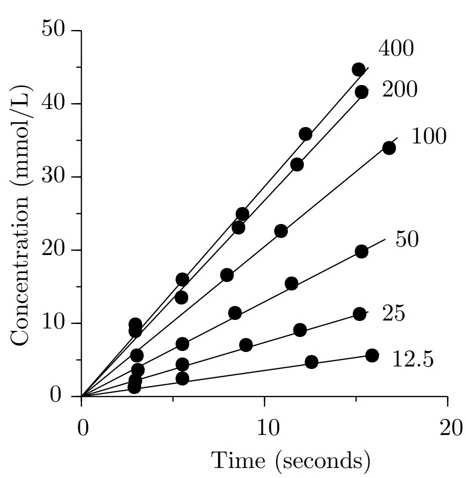


Figure 6.1

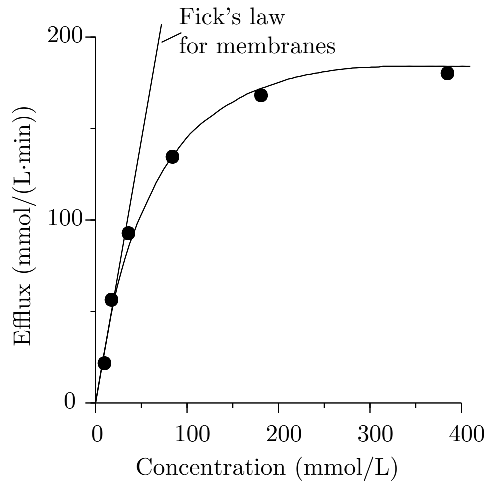


Figure 6.2

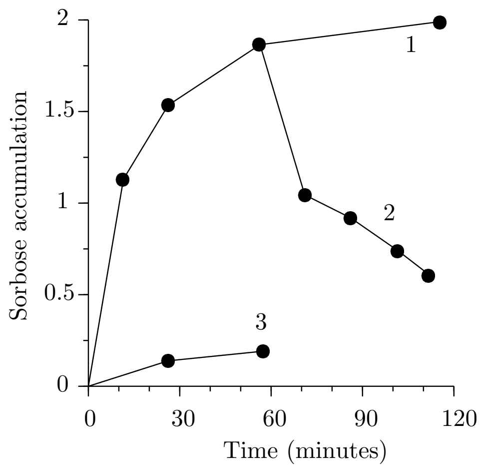


Figure 6.3

First-order, reversible reaction

$$R \underset{\beta}{\overset{\alpha}{\rightleftharpoons}} P$$

$$\frac{dc_R(t)}{dt} = \beta c_P(t) - \alpha c_R(t) \quad \text{AND} \quad \frac{dc_P(t)}{dt} = \alpha c_R(t) - \beta c_P(t)$$

Equilibrium:

$$\frac{dc_R(t)}{dt} = \frac{dc_P(t)}{dt} = 0 \quad \rightarrow \quad \beta c_P(\infty) = \alpha c_R(\infty)$$

$$\frac{c_P(\infty)}{c_R(\infty)} = \frac{\alpha}{\beta} = K_a \quad \left(\begin{array}{c}\text{association, equilibrium, affinity,}\\ \text{stability, binding, formation constant}\end{array}\right)$$

Kinetics: assume total amount of reactant and product is conserved

$$c_R(t) + c_P(t) = C$$

$$\frac{dc_R(t)}{dt} = \beta\left(C - c_R(t)\right) - \alpha c_R(t)$$

$$\frac{dc_R(t)}{dt} + (\alpha + \beta)c_R(t) = \beta C$$

First-order linear differential equation with constant coefficients

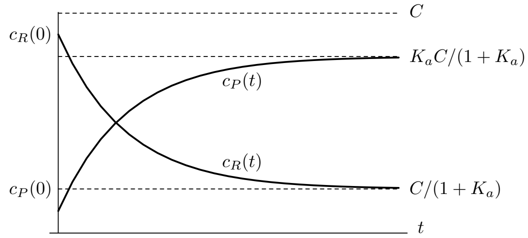
$$c_R(t) = c_R(\infty) - \left(c_R(\infty) - c_R(0)\right)e^{-t/\tau}, \text{ for } t > 0$$

$$c_R(\infty) = \frac{\beta}{\alpha+\beta}C = \frac{1}{1+K_a}C \quad \text{AND} \quad \tau = \frac{1}{\alpha+\beta}$$

$$c_P(t) = C - c_R(t)$$

First-order, reversible reaction

$$R \underset{\beta}{\overset{\alpha}{\rightleftharpoons}} P$$



$$\tau = \frac{1}{\alpha+\beta}$$

Second-order reversible (binding) reaction

$$S + E \underset{\beta}{\overset{\alpha}{\rightleftharpoons}} ES$$

$$\frac{dc_{ES}(t)}{dt} = \alpha c_S(t)c_E(t) - \beta c_{ES}(t),$$
$$\frac{dc_S(t)}{dt} = \frac{dc_E(t)}{dt} = \beta c_{ES}(t) - \alpha c_S(t)c_E(t),$$

Equilibrium:

$$\frac{dc_{ES}(t)}{dt} = \frac{dc_S(t)}{dt} = \frac{dc_E(t)}{dt} = 0$$
$$\alpha c_S(\infty)c_E(\infty) - \beta c_{ES}(\infty) = 0$$
$$\frac{c_{ES}(\infty)}{c_S(\infty)c_E(\infty)} = \frac{\alpha}{\beta} = K_a \quad \text{(association constant)}$$
$$\frac{1}{K_a} = \frac{c_S(\infty)c_E(\infty)}{c_{ES}(\infty)} = K \quad \text{(dissociation constant)}$$

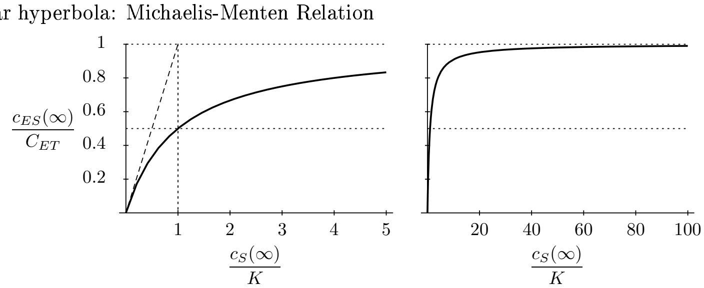
Assume enzyme conserved: $c_E(t) + c_{ES}(t) = C_{ET}$
How does c_{ES} depend on c_S? Eliminate c_E.

$$C_{ET} = c_E(\infty) + c_{ES}(\infty)$$
$$C_{ET} = \frac{Kc_{ES}(\infty)}{c_S(\infty)} + c_{ES}(\infty) = \left(\frac{K}{c_S(\infty)} + 1\right) c_{ES}(\infty)$$
$$c_{ES}(\infty) = \left(\frac{c_S(\infty)}{K + c_S(\infty)}\right) C_{ET}$$

Second-order reversible (binding) reaction

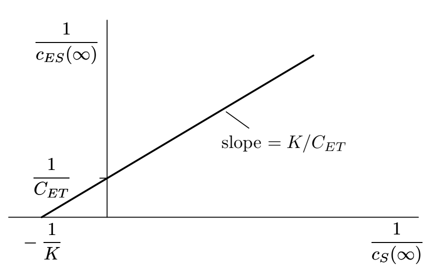
$$S + E \underset{\beta}{\overset{\alpha}{\rightleftharpoons}} ES$$

Rectangular hyperbola: Michaelis-Menten Relation

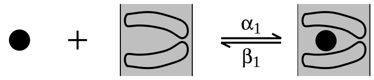


Doubly-reciprocal coordinates: Lineweaver-Burk plot

$$\frac{1}{c_{ES}(\infty)} = \left(1 + \frac{K}{c_S(\infty)}\right)\frac{1}{C_{ET}} = \left(\frac{K}{C_{ET}}\right)\frac{1}{c_S(\infty)} + \frac{1}{C_{ET}}$$



Binding

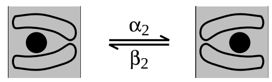


$$S^i + E^i \underset{\beta_1}{\overset{\alpha_1}{\rightleftharpoons}} ES^i$$

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

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

Translocation

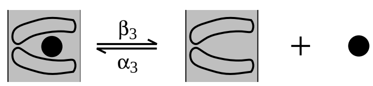


$$ES^i \underset{\beta_2}{\overset{\alpha_2}{\rightleftharpoons}} ES^o$$

$$\frac{dC_{ES}^o}{dt} = \alpha_2 C_{ES}^i - \beta_2 C_{ES}^o$$

$$\frac{dC_{ES}^i}{dt} = \beta_2 C_{ES}^o - \alpha_2 C_{ES}^i$$

Unbinding

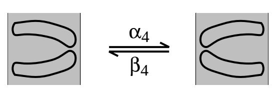


$$ES^o \underset{\alpha_3}{\overset{\beta_3}{\rightleftharpoons}} E^o + S^o$$

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

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

Translocation

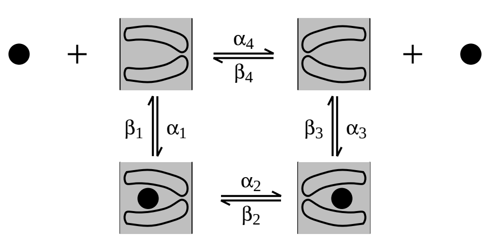


$$E^i \underset{\beta_4}{\overset{\alpha_4}{\rightleftharpoons}} E^o$$

$$\frac{dC_E^o}{dt} = \alpha_4 C_E^i - \beta_4 C_E^o$$

$$\frac{dC_E^i}{dt} = \beta_4 C_E^o - \alpha_4 C_E^i$$

General Four-State Model



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

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

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

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

$$\frac{dC_{ES}^o}{dt} = \alpha_2 C_{ES}^i - \beta_2 C_{ES}^o$$

$$\frac{dC_{ES}^i}{dt} = \beta_2 C_{ES}^o - \alpha_2 C_{ES}^i$$

$$\frac{dC_E^o}{dt} = \alpha_4 C_E^i - \beta_4 C_E^o$$

$$\frac{dC_E^i}{dt} = \beta_4 C_E^o - \alpha_4 C_E^i$$