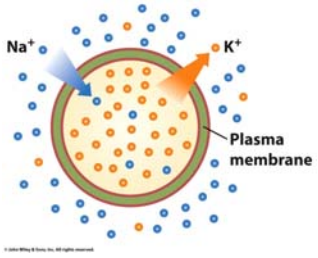
Membrane Transport

Pratt & Cornely, Ch. 9

Thermodynamics

- Membrane potential—volts
- For +1 ion, potential = 0.058V(log$\frac{ion_{in}}{ion_{out}}$)
- If potential is negative, the inside of cell is more negative



$$\Delta\psi = \frac{RT}{Z\mathcal{F}} \ln \frac{[\text{ion}]_{in}}{[\text{ion}]_{out}}$$

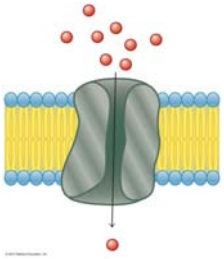
Energetics of Transport

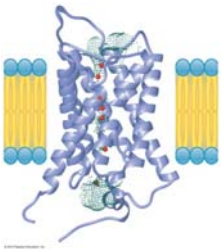
- $\Delta G = RT \ln \frac{[X]in}{[X]out} + ZF\Delta\psi$
  - R = 8.31 J/molK
  - F = 96,485 J/Vmol
  - Z = charge
- Calculate as if X is moving into cell; opposite of DG if moving out
- Negative free energy if
  - Move to lower concentration
  - Move with the charge (be sure potential is written in direction travelled)

- **Problem 6:** Calculate the free energy change at 20°C for the transmembrane movement of Na^+ and K^+ assuming -70 mV potential. (Na^+ is 12 mM in and 150 mM out; K^+ is 140 mM in and 4 mM out.) Which direction is spontaneous for each ion?

Membrane Transport

- Unfacilitated diffusion
- Transporters
  - Pores
  - Channels
  - Transport proteins
- Selectivity
- Thermodynamics

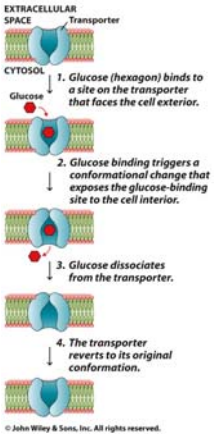


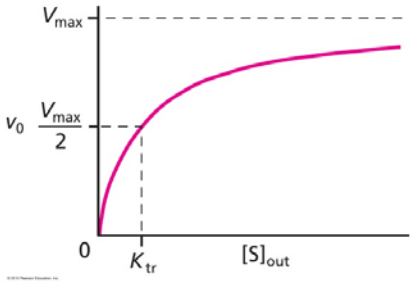


Types of Transport

- Passive Transport—spontaneous
  - with concentration or charge gradient
  - Facilitated diffusion
    - Selectivity
    - regulation
- Active Transport—goes against concentration or charge gradient
  - Requires energy input
  - Never unfacilitated

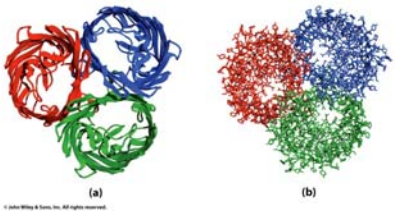
Kinetics of Facilitated Transport

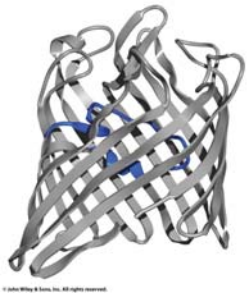




Porins

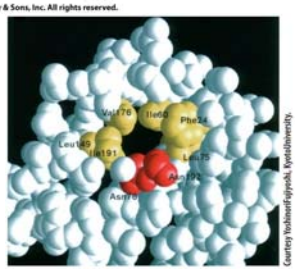
- Beta-barrel trimer
- Always open
- Travel possible in either direction
- But somewhat selective…





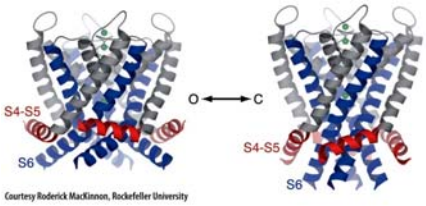
Aquaporins

- Water influx through porins
- Hydronium must be blocked
- Utilization of selective H-bonding through nonpolar cavity

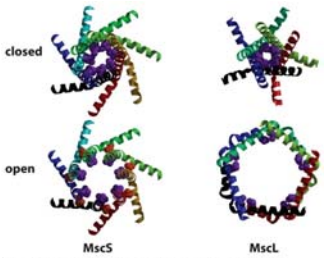


Ion Channels

- Passive
- Gated
  - Specific binding
  - Voltage-gated
  - Mechanicosensitive



Courtesy Roderick MacKinnon, Rockefeller University



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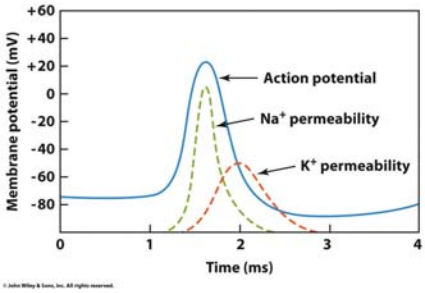
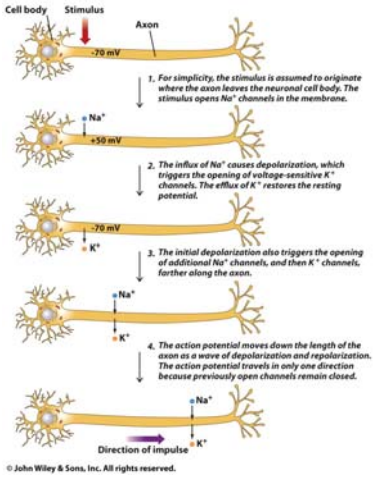
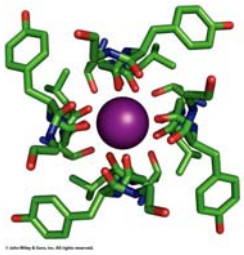
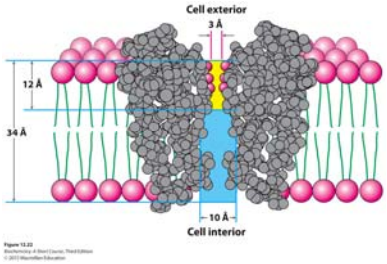
Action Potential





Selectivity





- Potassium ion channels must exclude the smaller sodium ion
- Not a simple “hole”
- Takes into account solvation of ions

Thermodynamics of selectivity

- Difference in solvation energy

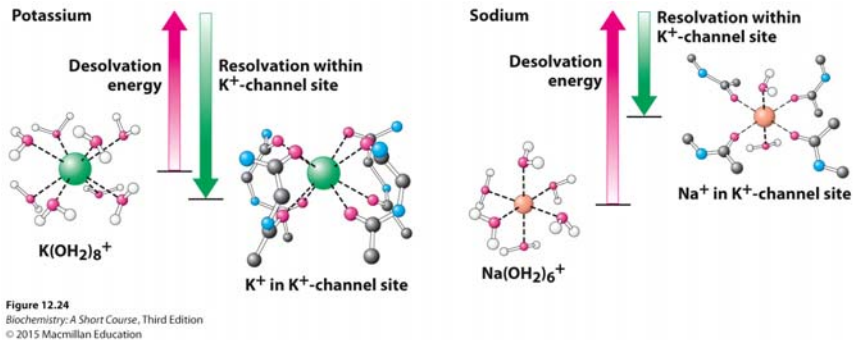


Figure 12.24
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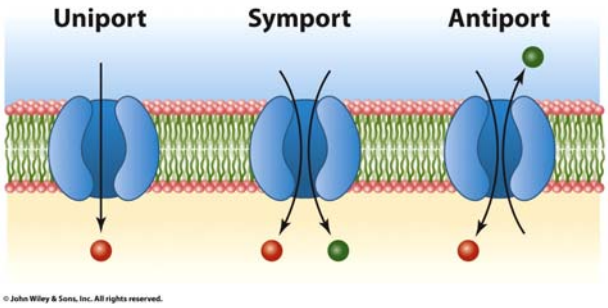
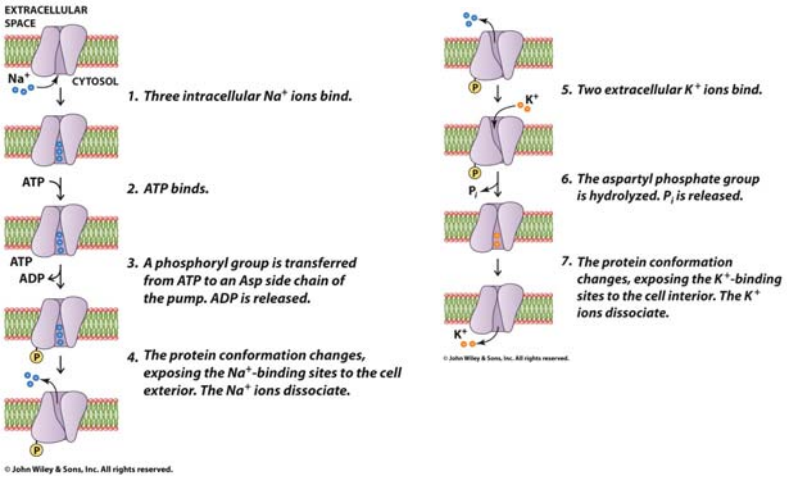
Types of Transport

- Both passive and active transport can be
  - Uniport
  - Symport
  - Antiport



Active Transport: Na^+/K^+ ATPase



ABC Transporters

- ATP-Binding Cassette
- Large transporter family
  - Multidrug resistance
  - Cystic fibrosis
- Different than P-type ATPase family

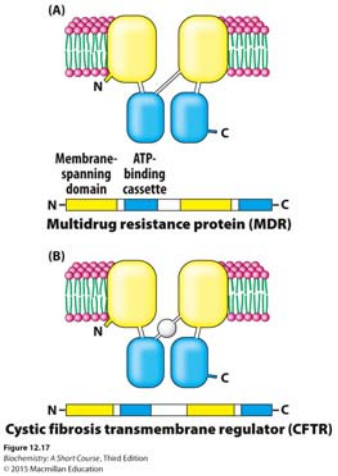


Figure 12.17
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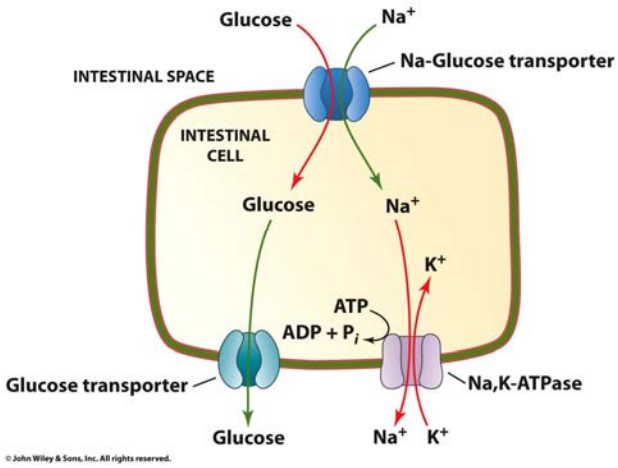
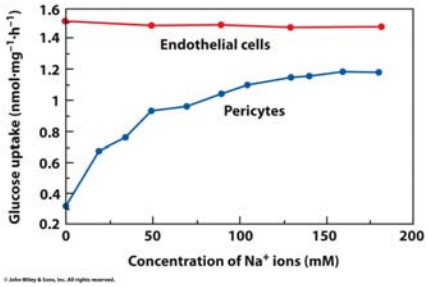
Secondary Transport



Problem 37



- The retina of the eye contains equal amounts of endothelial and pericyte cells. Basement membrane thickening in pericytes occurs during the early stages of diabetic reinopathy. Glucose uptake was measured in both types of cells in culture in the presence of increasing amounts of sodium.
  - What is your interpretation of the graph?
  - What information is conveyed by the shapes of the curbes?
  - By what mechanism might the pericytes use sodium ions to assist with glucose import?