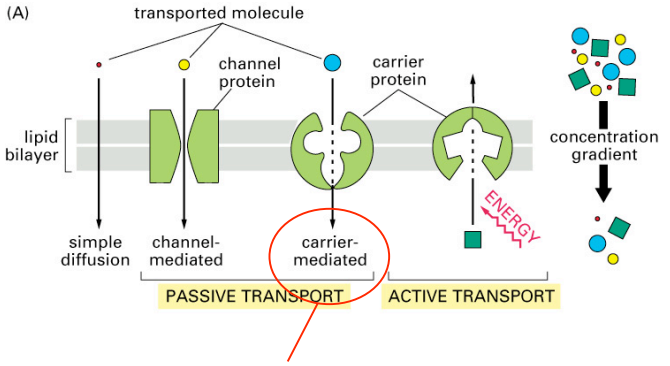
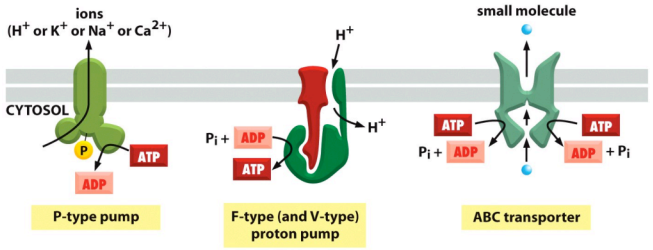




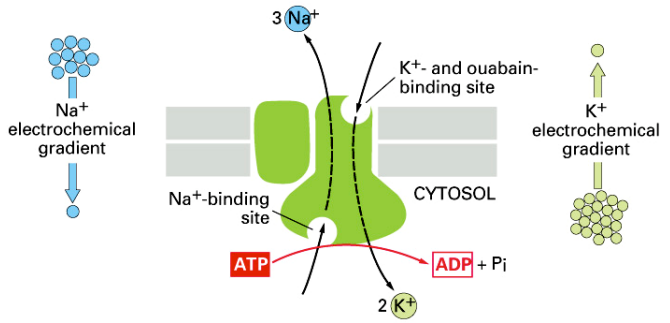
Na^+/K^+ ATPase
Ca^{2+} ATPase

F_0/F_1 ATPase

flippases
MDR proteins

Figure 11-12 *Molecular Biology of the Cell* (© Garland Science 2008)

Sodium-Potassium (Pump) ATPase



3 Na^+ out & 2 K^+ in per 1 ATP hydrolyzed
Pump is "electrogenic"
Pump is Reversible !!

Table 11–1 A Comparison of Ion Concentrations Inside and Outside a Typical Mammalian Cell

COMPONENT	INTRACELLULAR CONCENTRATION (mM)	EXTRACELLULAR CONCENTRATION (mM)
Cations		
Na^+	5–15	145
K^+	140	5
Mg^{2+}	0.5	1–2
Ca^{2+}	10^{-4}	1–2
H^+	7×10^{-5} ($10^{-7.2}$ M or pH 7.2)	4×10^{-5} ($10^{-7.4}$ M or pH 7.4)
Anions*		
Cl^-	5–15	110

*The cell must contain equal quantities of positive and negative charges (that is, it must be electrically neutral). Thus, in addition to Cl^-, the cell contains many other anions not listed in this table; in fact, most cell constituents are negatively charged (HCO_3^-, PO_4^{3-}, proteins, nucleic acids, metabolites carrying phosphate and carboxyl groups, etc.). The concentrations of Ca^{2+} and Mg^{2+} given are for the free ions. There is a total of about 20 mM Mg^{2+} and 1–2 mM Ca^{2+} in cells, but both are mostly bound to proteins and other substances and, for Ca^{2+}, stored within various organelles.

Table 11-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Ion Channels

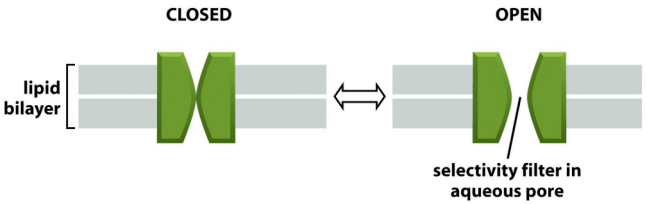


Figure 11-20 *Molecular Biology of the Cell* (© Garland Science 2008)

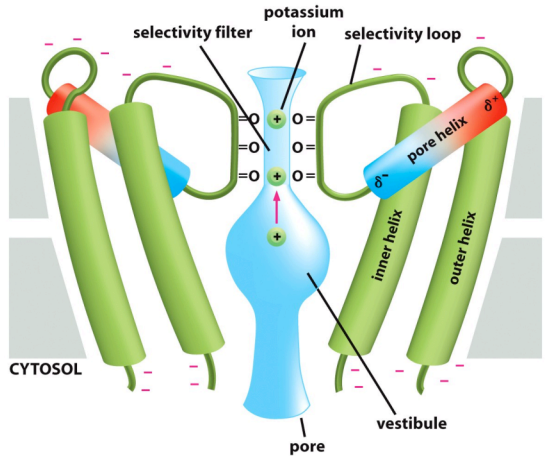


Figure 11-23a *Molecular Biology of the Cell* (© Garland Science 2008)

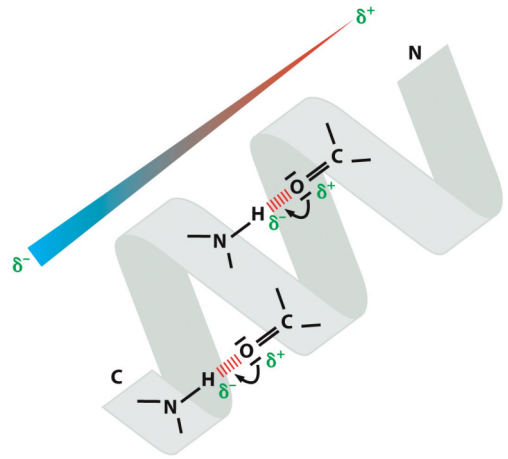
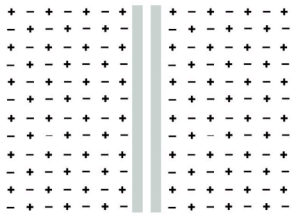
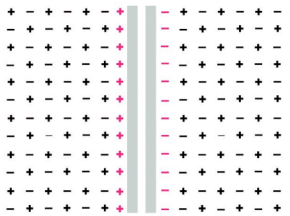


Figure 11-23b *Molecular Biology of the Cell* (© Garland Science 2008)

Resting Membrane Potential



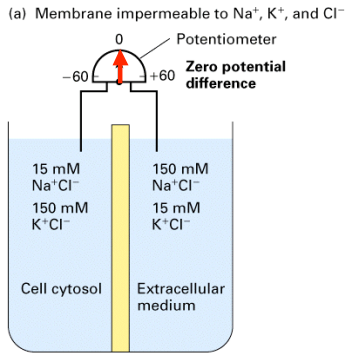
exact balance of charges on each side of the membrane; membrane potential = 0



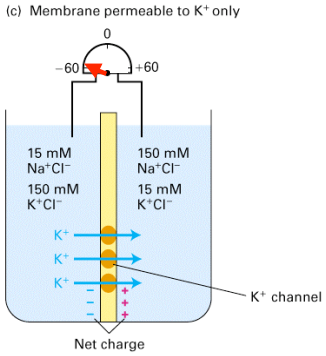
a few of the positive ions *(red)* cross the membrane from right to left, leaving their negative counterions *(red)* behind; this sets up a nonzero membrane potential

Figure 11-22 *Molecular Biology of the Cell* (© Garland Science 2008)

Ion gradients and membrane potential



Ion gradients and membrane potential



Nernst Equation

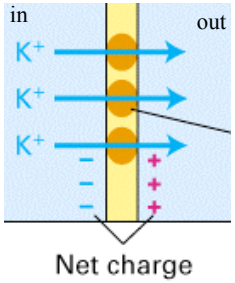
$$E_K = \frac{RT}{ZF} \ln \frac{[Kr]}{[K_l]}$$

$$E_K = 0.059 \log \frac{[K_r]}{[K_l]}$$

E_K = - 0.059 V (@ 20°C)

- 59 mV

Ion gradients and membrane potential



Selective permeability of the cell membrane to potassium ions through passive potassium channels gives rise to the resting membrane potential = -70 mV

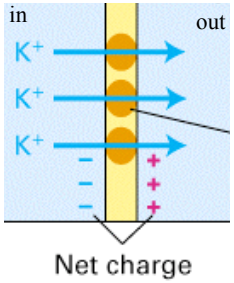
This "electrochemical potential gradient" is equal to nearly 200,000 V/cm !!

High voltage lines utilize a potential gradient of roughly 200,000 V/ km

10000 times smaller

There lipid bilayer is an excellent electrical insulator.

Ion gradients and membrane potential



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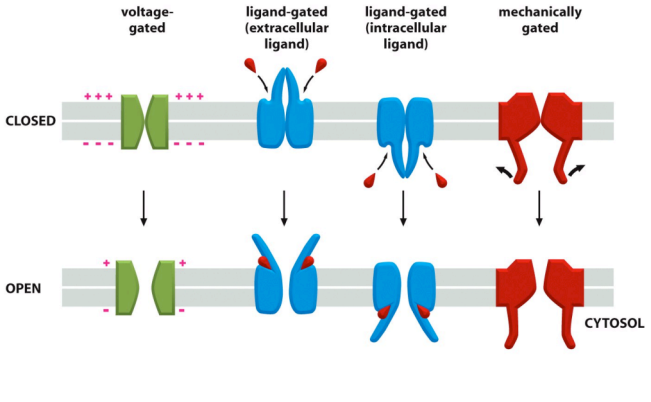
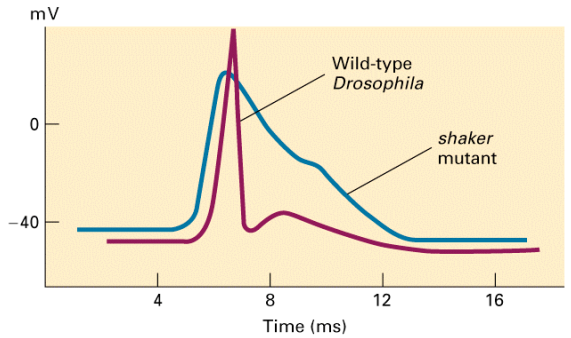


Figure 11-21 *Molecular Biology of the Cell* (© Garland Science 2008)

Shaker Mutant

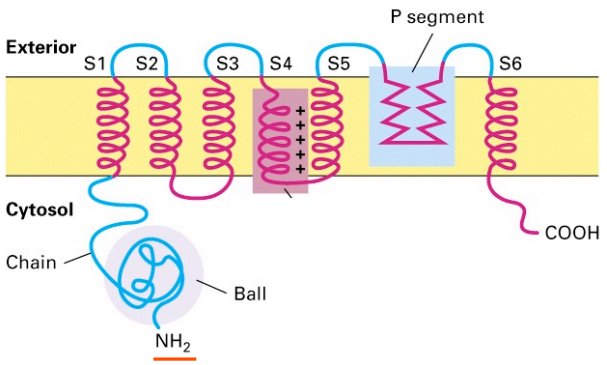
Mutated K+ Channel: First of over 100 to be cloned.



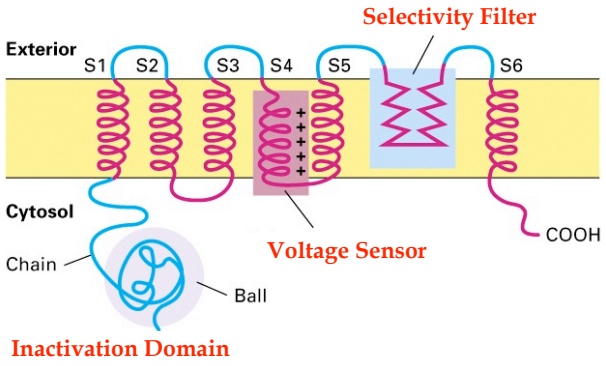
Properties of Voltage-Gated Ion Channels

1. Ion Selectivity
2. Voltage Dependence
3. Inactivation (+/-)

Voltage-gated Potassium Channel – 1 of 4 subunits

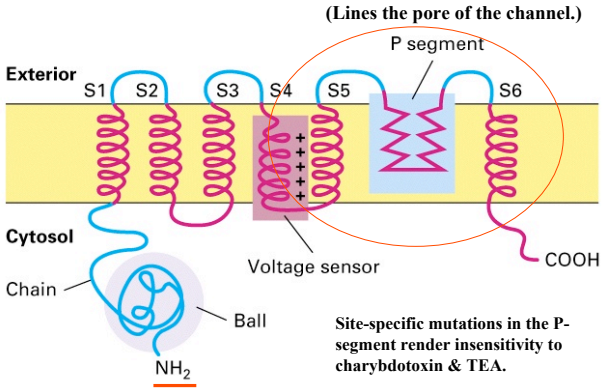


Voltage-gated Potassium Channel – 1 of 4 subunits



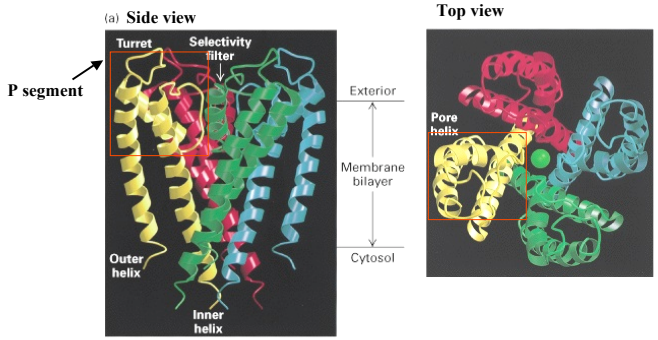
Voltage-gated Potassium Channel – 1 of 4 subunits

(Lines the pore of the channel.)

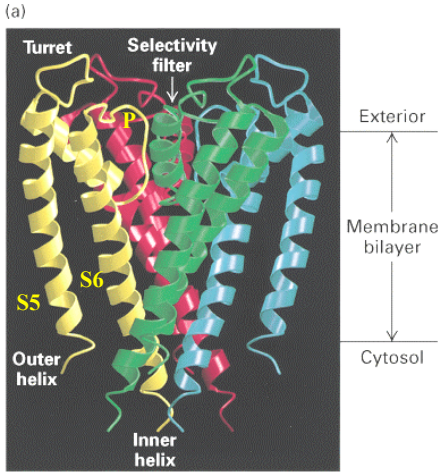


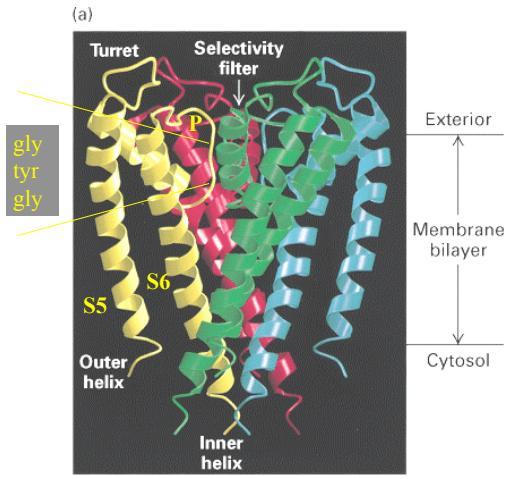
Site-specific mutations in the P-segment render insensitivity to charybdotoxin & TEA.

Voltage-gated Potassium Channel



Selectivity arises from carbonyl oxygens on conserved glycines (Gly-Tyr-Gly) in each of the four P segments, which coordinate with de-hydrated K+ ions.





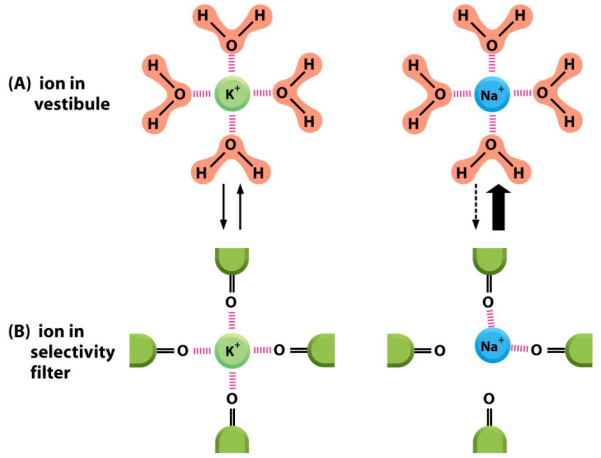


Figure 11-24 *Molecular Biology of the Cell* (© Garland Science 2008)

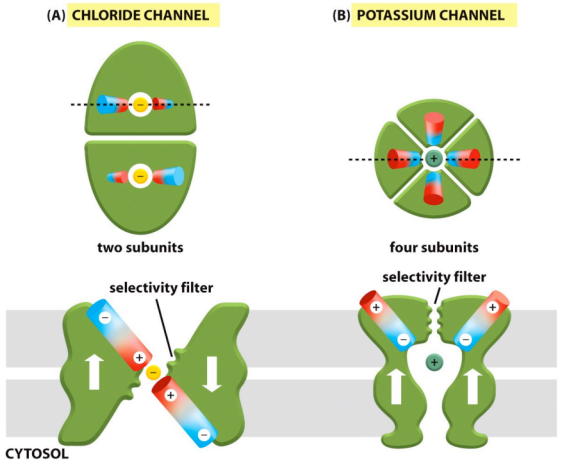


Figure 11-26 *Molecular Biology of the Cell* (© Garland Science 2008)

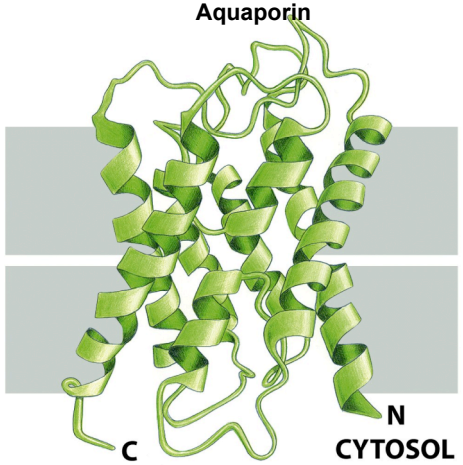
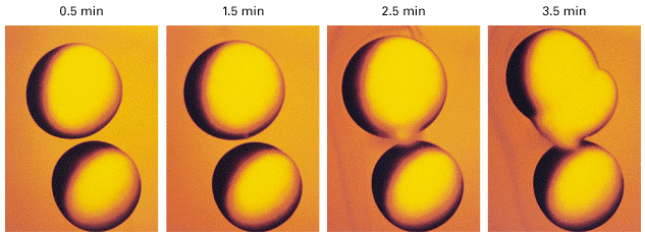


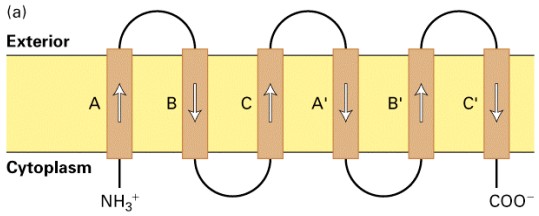
Figure 11-27a *Molecular Biology of the Cell* (© Garland Science 2008)

Aquaporin Channels



Expression of aquaporin in frog oocytes renders them sensitive to osmotic swelling

Aquaporin



1. 28 kDa polypeptide with 3 homologous pairs of transmembrane spanning α helices
2. Isolated from erythrocytes
3. Transports water according to osmotic pressure

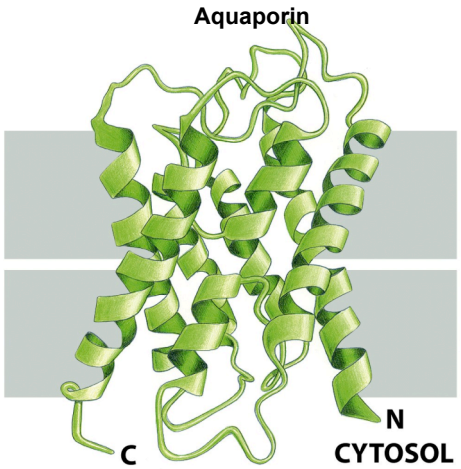
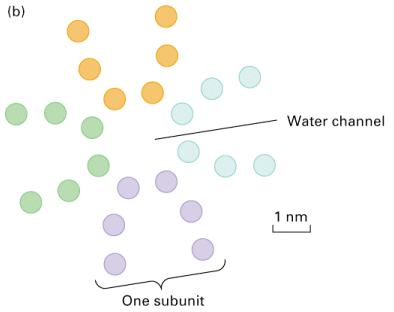


Figure 11-27a *Molecular Biology of the Cell* (© Garland Science 2008)

Aquaporin Channel



1. Homotetrameric protein complex
2. Water channel is probably formed by 8 α helical segments in antiparallel configuration

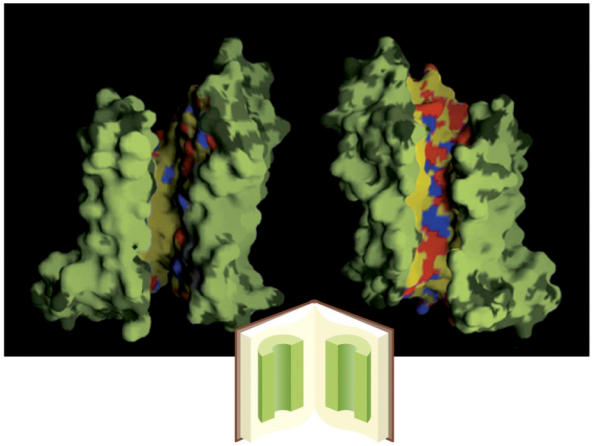


Figure 11-27b *Molecular Biology of the Cell* (© Garland Science 2008)

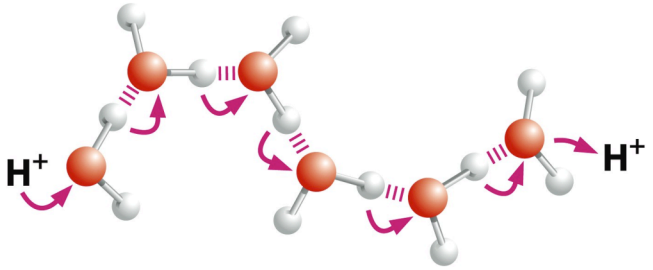


Figure 11-27c *Molecular Biology of the Cell* (© Garland Science 2008)

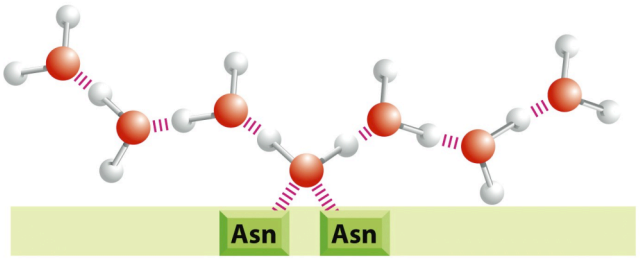
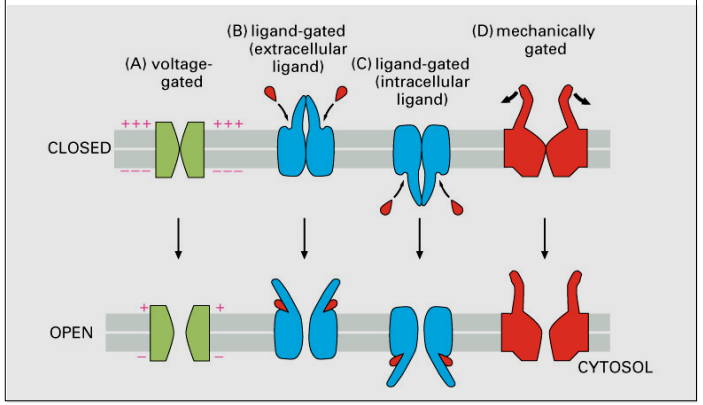
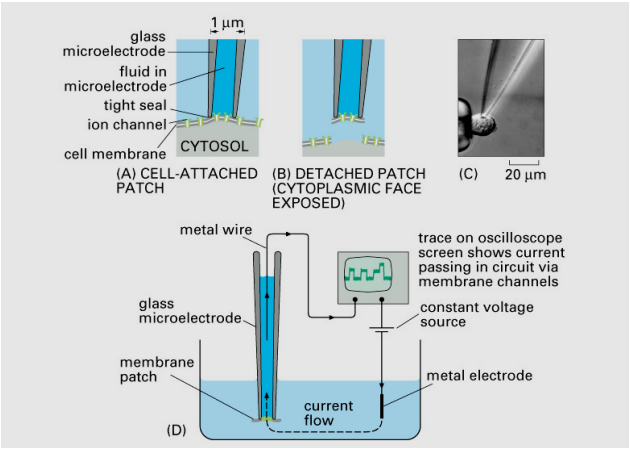


Figure 11-27d *Molecular Biology of the Cell* (© Garland Science 2008)

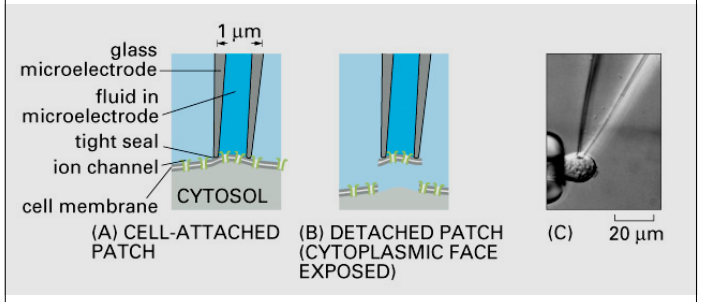
Types of Gated Ion Channels



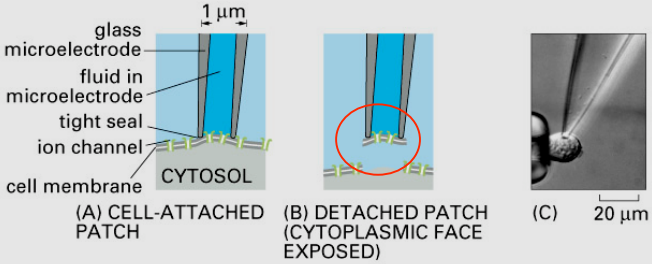
Patch Clamp Current Recording Technique

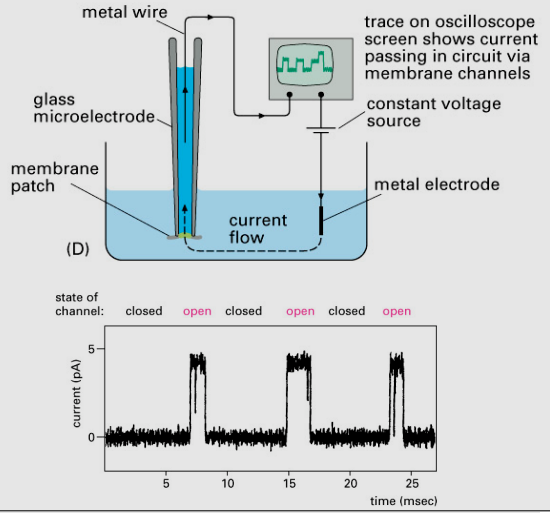


Patch Clamp Current Recording Technique



Patch Clamp Current Recording Technique





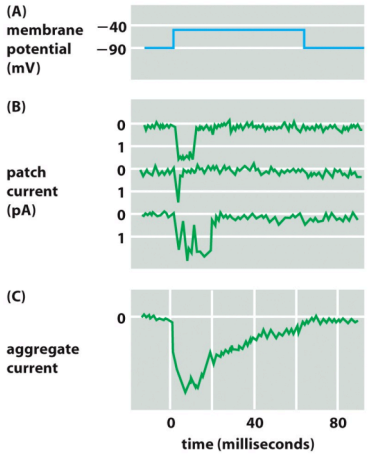


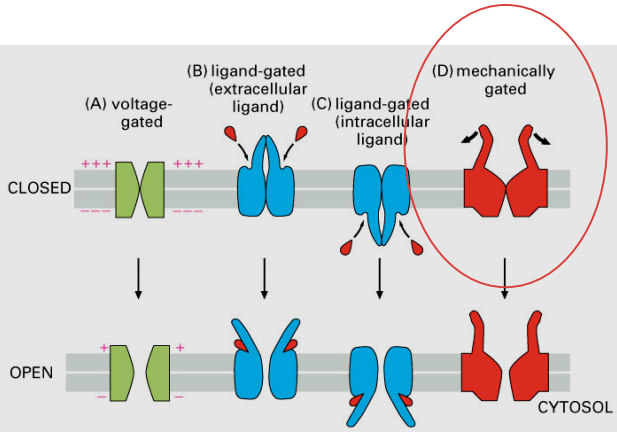
Figure 11-34 *Molecular Biology of the Cell* (© Garland Science 2008)

Properties
Open probablility
Activation kinetics
Current
Open time
Inactivation kinetics
Small molecule dependence

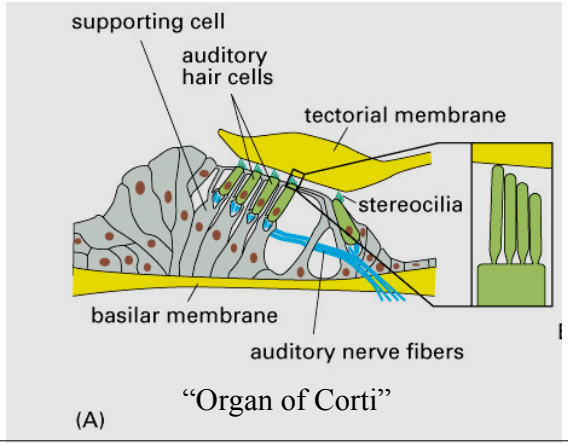
K+ Channels are Tremendously Diverse

- More than 100 different K channel subunits have been cloned.
- Channels reconstituted in Xenopus oocytes have different reversal potentials, conductances, second messenger regulation, and degree of inactivation
- Hybrid channels have hybrid characteristics
- Expression patterns can vary with developmental stage, exposure to growth factors and hormones, environment, etc, etc, etc

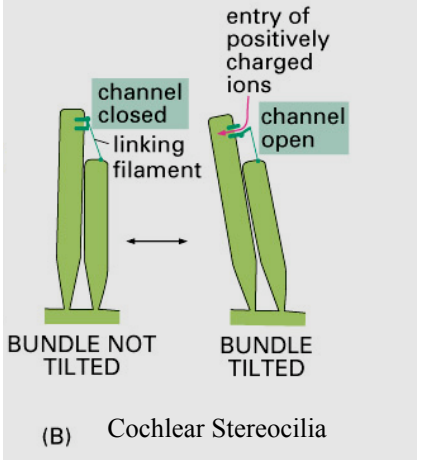
Types of Gated Ion Channels



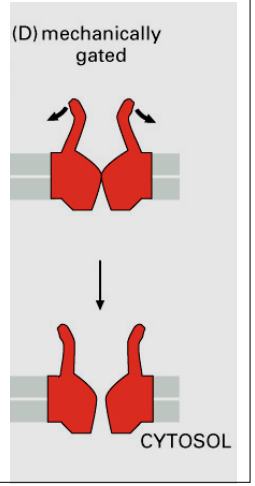
Auditory and Vestibular Systems Rely on Mechanically Gated Ion Channels for Signal Generation



"Organ of Corti"



Cochlear Stereocilia



Rapid Movement in Plants is Activated by Mechanically Gated Ion Channels

Venus Fly Trap

Mimosa