Diffusion Potential – Nernst Equation Assumptions

- Membrane
  - Constant thickness ✓
  - Homogeneous ✗, but ✓
  - Infinite extent in transverse plane
    - Allows one dimensional solution ✓
- Solutions
  - Well mixed (uniform in space, temperature, etc.) ✓
  - Concentrations do not change as problem moves forward ✓

Diffusion Potential – Nernst Equation Assumptions, continued

- Ionic mobility and activity coefficient are constant
  - Over time (as problem goes forward) ✓
  - Same in both solutions and in membrane ✗, but ✓
- No net flow of solvent through membrane
  - Osmotic pressure gradient negligible ✓
  - Hydrostatic pressure gradient negligible ✓

$$V_{Nernst} = \frac{R \cdot T}{z \cdot F} \cdot \ln\left(\frac{[S]_{out}}{[S]_{in}}\right)$$

Observations regarding Nernst equation

- $V_{membrane, measured} = V_{Nernst, calculated}$
  - Ion is in electro-chemical equilibrium across membrane
    - No net flux of ion across membrane
- $V_{membrane, measured}$ is same sign as $V_{Nernst, calculated}$ but is of larger magnitude
  - Electrical force "larger" than chemical force
    - Ion will move in direction of electrical force
- $V_{membrane, measured}$ is same sign as $V_{Nernst, calculated}$ but is of smaller magnitude
  - Chemical force "larger" than electrical force
    - Ion will move in direction of chemical force
- $V_{membrane, measured}$ is of opposite sign to that of $V_{Nernst, calculated}$ calculated
  - Chemical and electrical forces acting in same direction
    - Ion is not in equilibrium; it will move, driven by both chemical and electrical forces

$$V_{GHK,Na,K,Cl} = \frac{R \cdot T}{F} \cdot \ln\left(\frac{P_{Na} \cdot [Na]_o + P_K \cdot [K]_o + P_{Cl} \cdot [Cl]_i}{P_{Na} \cdot [Na]_i + P_K \cdot [K]_i + P_{Cl} \cdot [Cl]_o} \right)$$

$$I = g(E_m - E_N)$$

$$I_K = g_K(E_m - E_K)$$

$$I_{Na} = g_{Na}(E_m - E_{Na})$$

$$I_{Cl} = g_{Cl}(E_m - E_{Cl})$$

$$I_K + I_{Na} + I_{Cl} = 0$$

$$g_K(E_m - E_K) + g_{Na}(E_m - E_{Na}) + g_{Cl}(E_m - E_{Cl}) = 0$$

$$E_m(g_K + g_{Na} + g_{Cl}) = g_K E_K + g_{Na} E_{Na} + g_{Cl} E_{Cl}$$

$$E_m = \frac{g_K}{\Sigma g} E_K + \frac{g_{Na}}{\Sigma g} E_{Na} + \frac{g_{Cl}}{\Sigma g} E_{Cl}$$

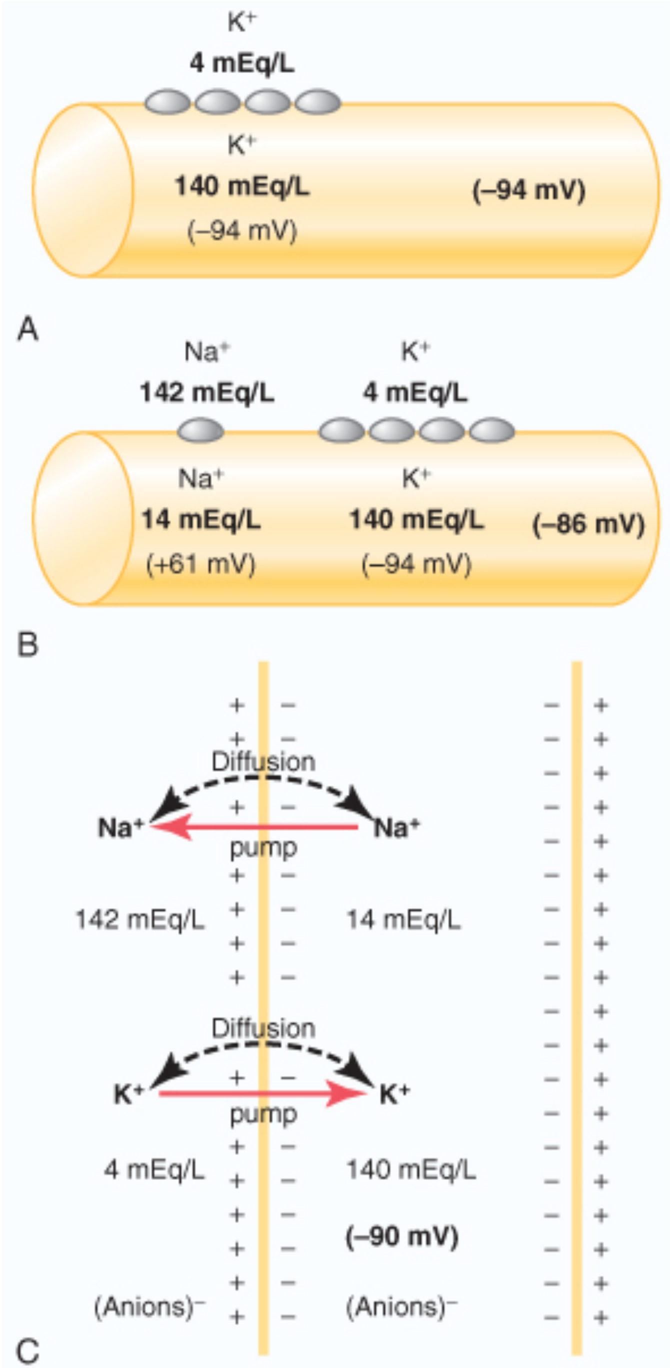

Figure 5-5 Establishment of resting membrane potentials in nerve fibers under three conditions: A, when the membrane potential is caused entirely by potassium diffusion alone; B, when the membrane potential is caused by diffusion of both sodium and potassium ions; and C, when the membrane potential is caused by diffusion of both sodium and potassium ions plus pumping of both these ions by the Na^+-K^+ pump.

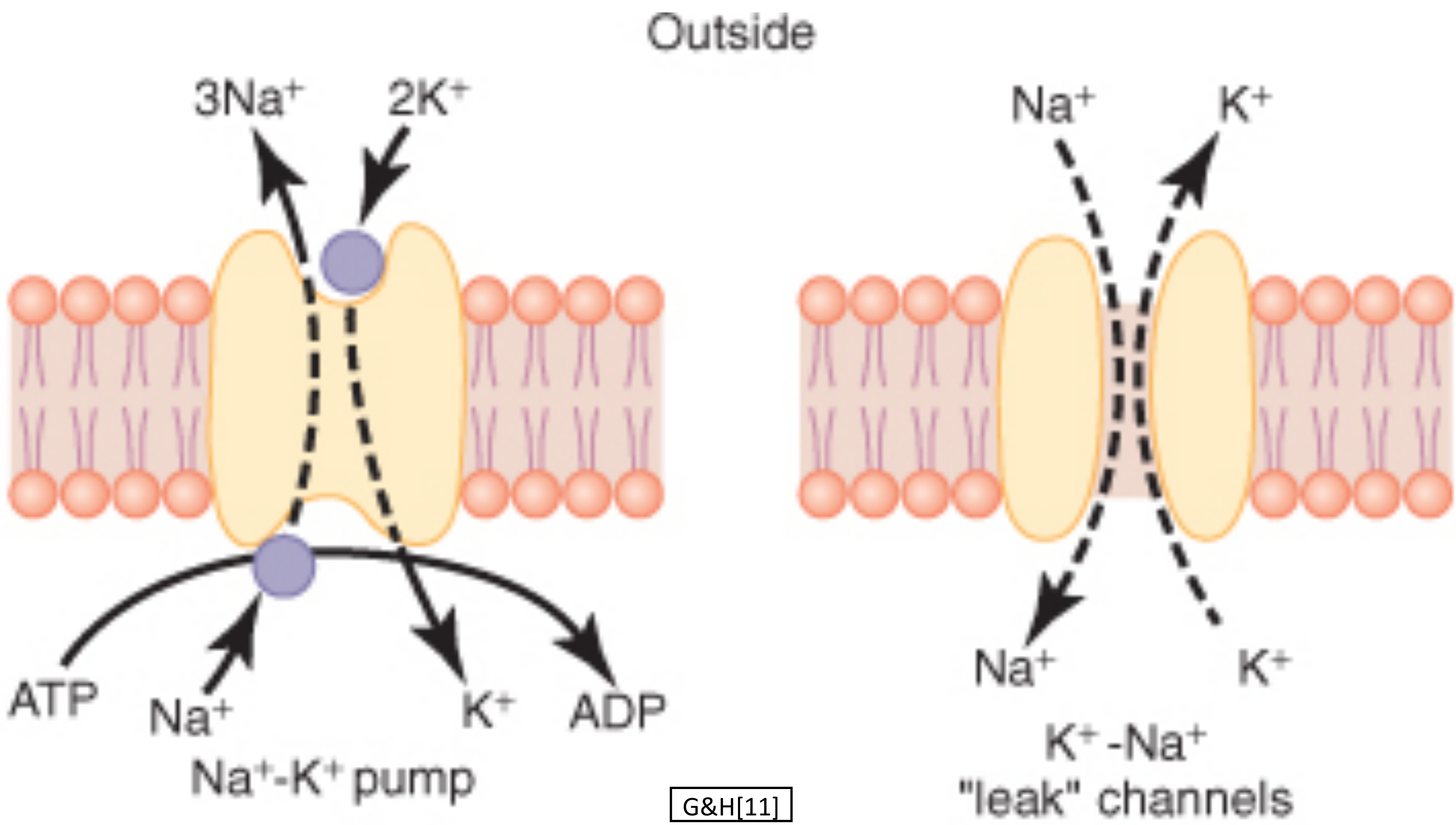

Figure 5-4 Functional characteristics of the Na+-K+ pump and of the K+-Na+ "leak" channels. ADP, adenosine diphosphate; ATP, adenosine triphosphate.

END

Video 7, Module 1