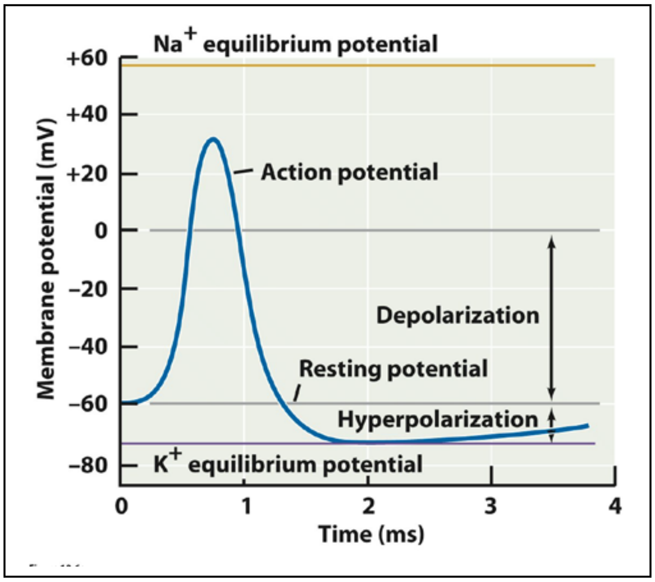
Membrane Transport - Understanding Ion Gradients and Potentials in Action Potentials

1. Examine the image below (Fig 10-6 from your book). This shows us that the equilibrium potential of Na^+ is +60 mV and K^+ is -75 mV. This means that at this potential, the chemical and electrochemical gradients are in balance…so mathematically, $\Delta G = 0$ in the equation below.



$$\Delta G = RT \ln\left(\frac{[A]_{in}}{[A]_{out}}\right) + Z\Im\Delta\Psi$$

   a. Using the resting potential for each ion, determine the ratio of $[A]_{in}$:$[A]_{out}$ (so solve for the term in the ln(x)).

   b. The ratios calculated in part A tell you about the resting chemical gradient for a neuron cell.
      i. Which ion has a higher intracellular concentration?
      ii. Which ion has a higher extracellular concentration?
      iii. For each of the following membrane potentials, identify which direction the ions will flow (in, out, or no net flow) and the sign on ΔG (< 0, > 0, = 0).

Membrane Potential	Na^+ flow	K^+ flow	ΔG
+80 mV			
+ 60 mV			
0 mV			
-60 mV			
-75 mV			
-80 mV			

2. The action potential begins by nerve cell stimulation. This stimulation triggers the Na^+ channel to open.
   a. Which direction will sodium ions flow?

   b. As you see in the graph, this causes the membrane potential to become more positive. Why?

c. Sodium ions quickly rush into the cell but stop after roughly 0.75 ms – this is shown as a peak in the action potential. Why does the ion channel close? Hint, remember that this is a voltage-gated ion channel.

d. The change in membrane potential triggers voltage gated potassium channel to open. At this membrane potential (~30 mV), which direction does the potassium flow?

e. Why does the membrane potential become more negative as the potassium channel is active?

f. How do you think that this action potential is propagated down the neuron?

3. Using the voltage gated potassium channel as a guide, discuss how the voltage-gated sodium channel in a nerve cell might work.