Cell Biology Problem Set: **Membrane Potential** Colin Nichols 10/06

1. Consider the following concentrations (all are given in mM) found in a typical mammalian cell. Complete the table by calculating the equilibrium potential (Nernst Potential) for each ion.

ion	Extracellular	Intracellular	E_{ion} (mV)
Na^+	145	4	
K^+	4	140	
Ca^{+2}	2	1×10^{-4}	
Cl^-	120	4	

2. The relative permeabilities to K^+, Na^+ and Cl^- are as follows (with $PCa^{2+} = 0$) :
   $PK^+ : PNa^+ : PCl^-$ 1 : 0.01 : 2
   Estimate Vm using the GHK equation.

3. If the relative permeabilities suddenly became 0.1 : 5 : 2, how would Vm change?

4. The specific capacitance of most cell membranes is 1 μF / cm^2.
   a) How many K^+ ions must cross the membrane of a spherical cell, 40 μm in diameter, to change the membrane potential by 10 millivolts.
   b) How many millimoles does this represent.
   c) What change in cytoplasmic K^+ concentration will occur?

5. Consider a spherical cell (diameter = 38 μm) with specific membrane capacitance of 1 μF / cm^2. The cell has 80 open channels that have a unitary conductance of 10 pS.
   a) Calculate the capacitance, the cell's input resistance and the membrane time constant.
   b) Draw the change in membrane potential versus time (for 400 msec) that would be recorded in the cell for injection of a 200 msec square current step of 20 pA.

6. If the pH outside of a cell is 7.4 and the pH inside the cell is 7.2
   a) What is the Nernst potential for protons across the cell membrane?
   b) In what direction will the net flow of protons occur through a surface membrane proton channel at the following membrane potentials: -80 mV? 0 mV? +80 mV?