Homework Assignment – Module 1

1. [5 points] With reference to the fluid mosaic model of the cell membrane, which of the following statements is the most correct?
   A. Only electrically charged molecules can move through the membrane.
   B. The positions of various channels with respect to each other is fixed within the membrane.
   C. A particular protein that at a given time is located at the outer surface of the membrane can migrate to the inner surface of the membrane.
   D. The lipids that make up the outer membrane layer are always identical to those that make up the inner membrane layer.

2. [5 points] Which of the following statements about channels in mammalian cell membranes is the most correct?
   A. Polar molecules do not pass through channels of any type.
   B. Some channels are selective for a class of molecules (e.g., singly charged molecules); other channels are selective for only one molecular species (e.g., Na^+).
   C. As a general rule, it is easier for larger, as compared to smaller, molecules to pass through channels.
   D. VHF channels, due to their lower frequency, allow the passage of larger molecules than UHF channels (channel width is inversely proportional to frequency; $c = f\lambda$).

3. [15 points[1]]Using the concentrations provided in the table (below) calculate the Nernst potential at T = 24° C for Na^+, K^+, and Cl^-. SHOW YOUR WORK

Ion	Intracellular, mM	Extracellular, mM
Cl^-	2.0	80
K^+	120	4.0
Na^+	10	127
Ca^{2+}	110 μM	2.4
HCO_3^-	12.4	29

4. [20 points] In our derivation of the Nernst potential we made several assumptions, one of which was that the concentration of the permeant ion(s) on each side of the cell membrane did not change as the problem went to completion.

   Assume a cylindrical cell of radius R meters and length L meters, having a membrane capacitance C_a farads/m^2, one singly-charged permeant species, X, with an intracellular concentration of $[X]_i$ mol/L and an extracellular concentration of $[X]_o$ mol/L (assume that $[X]_i > [X]_o$ so that some X moves out of the cell to

[1] 5 points for each ion in question.

Rev 1, 08/03/2015 – provide units for concentrations in problem 4.
Rev 2, 07/16/2018 – re-write equations (choices A – D) in Q4 and update to 601.
Rev 3, 08/13/2019 – add SHOW YOUR WORK to Q4.
Rev 4, 01/27/20 – various changes to Q3 and Q4

establish electrochemical equilibrium) and a membrane potential (= Nernst; assume no membrane ion pumps) of V_m volts.

Derive an expression for the ratio of the amount (in mol) of ion X moved (to establish the Nernst potential, V_m, of the cell) to the initial amount (in mol) of ion X inside the cell.

5. [10 points] With reference to slide 5 of video 7 explain why $[Cl]_i$ appears in the numerator and $[Cl]_o$ appears in the denominator of the GHK equation.

6. [20 points] Using the intracellular and extracellular concentrations of Na^+ and K^+ and their calculated Nernst potentials as given in slide 8 of video 7, calculate the ratio of g_{Na} to g_K.

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