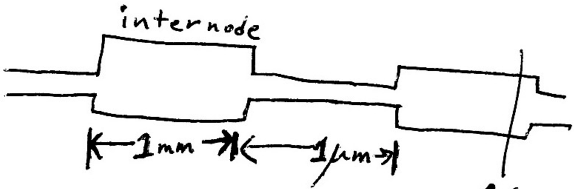
# Problem set #1

1. In Fig. 1 (page 5) the longest "open time" for the ACh-gated channel is approximately 20 msec. How many coulombs of charge cross the membrane during that time? How many $Na^+$ ions does that charge represent (i.e., how many ions are represented by $1.6 \times 10^{-19}$ coulombs)? Using the information in Fig. 1 and its legend, calculate the single channel conductance (in pS) and draw a representation of the Current-Voltage relationship. If the conductance of the whole myotube was 47 mS, how many Ach-gated channels were there?

2. A hypothetical myelinated axon has the following properties:

   a) length of internode = 1.0 mm
   b) length of node of Ranvier = 1.0 $\mu m$
   c) diameter of axon = 1.0 $\mu m$.
   d) number of Schwann-cell membrane Wrappings = 9
   e) resting potential = -70 mV
   f) threshold potential = -60 mV
   g) specific capacitance (axon & schwann-cell membranes) = 1.0 $\mu F/cm^2$
   h) specific resistance (axon & schwann-cell membranes) = 1,000 ohm-$cm^2$



Calculate, for both the nodel and internodal regions,

a) how many charges line the inner face of the axon at the resting potential,
b) how many charges must be neutralized to elicit an action potential,
c) the time constants; and
d) how long it will take an action potential (generated at the node of Ranvier) to decay to the threshold level (assume the peak of the action potential is at +30 mV).

If the action potential propagates at a velocity of 100 m/sec, will the voltage at the next node of Ranvier be sufficient to generate another action potential?

1.3 (pge 12)

3. In Figure 3, the application of symmetric currents (i.e., equal amplitudes of positive and negative current) resulted in asymmetric voltages. How can this effect be explained and how should the circuit diagram in Fig. 3 be corrected? Illustrate possible current-voltage and conductance-voltage relationships that could account for this phenomenon. To determine the "input" resistance of a cell, what range of currents (and therefore voltages) should be used to avoid such complications?

4. If Cl ions are distributed "passively" (i.e., not pumped) across the membrane, what will be the ratio of concentrations across the membrane ($C_o/C_i$) if the resting potential is -50mV and the temperature is 37°C? If only $Na^+$ and $K^+$ are actively transported, use Table 3 to calculate the ratio of $g_K/g_{Na}$ to produce a resting potential of -90 mV. (Hint: $I_K = g_K(V-E_K)$; $I_{Na} = g_{Na}(V-E_{Na})$, and at the resting potential, $I = I_K + I_{Na} = 0$).

5. In the previous problem we assumed that the Na-K pump is a "neutral" pump. In fact, the Na-K pump's stoichiometry is 3 $Na^+$ out : 2 $K^+$ in. Re-calculate $g_K/g_{Na}$ with this new information. Now using the new $g_K/g_{Na}$ ratio, calcute the expected resting potential. What is the contribution to the resting potential from the Na-K pump? (<u>Hint</u> : $I_{Na} = I_{Na(pump)}$ and $I_K = I_{K(pump)}$.)