Computer Lab Worksheet - **RESTING MEMBRANE POTENTIAL**

Purpose :
To illustrate how the concentrations of the major ionic species inside and outside a cell determine its resting membrane potential.

Directions :
1) Double click on "**nernst.rt**" (Mac) or "**nernst.exe**" (Wintel) icon to load the program.
2) Click on the ARROW symbol or select "**run**" from the "operate" menu to begin.
3) Change the internal and external concentrations of any of the 4 major ions by moving the analog slide controls up / down. For fine adjustments, click on the small up / down arrows next to the digital displays, or double-click on the number inside the digital display (when the number is highlighted, enter a new number from the keyboard then hit return to enter it).
4) As an ion's concentrations are changed, the program continually recalculates the new equilibrium potential for that ion (using the Nernst equ.) and then recalculates the membrane potential (using the Chord conductance equ.). The changes are instantly updated on the driving force diagram. The horizontal slide controls at the bottom control the permeability of the cell to Na^+, Ca^{++}, Cl^- and K^+. The initial values approximate those for a spinal motor neuron.
5) To reset all parameters to their default values (similar to those of a mammalian spinal neuron), go to the "**operate**" menu and select "**reinitialize all to default**".

Problems :
1) Determine how a 5-fold elevation in external [K_+] alters:
a) the K_+ equilibrium potential (E_k),
b) the Na_+ equilibrium potential (E_{Na}),
c) the membrane potential (E_m),
d) the electrochemical driving force on K_+,
e) the electrochemical driving force on Na_+,
f) the electrochemical driving force on Cl_-,

(to avoid confusion, **specify a change in potential as a move "toward zero" or "toward a more hyperpolarized value" rather than an "increase" or "decrease"**)

2) Reset all variables to their default values (and restart if you stopped the program). Estimate how a 5-fold elevation in internal [Na_+] alters each and explain why.

a) E_{Na},
b) E_K,
c) E_m.
d) Repeat c) after setting $g_{Na} = 3.0$. Explain the difference:

3) Reset all variables to their default values.
a) at what value of $[Na_+]_{in}$ does $E_{Na} = 0$? Why?
b) at what value of $[Cl_-]_{out}$ does $E_{Cl} = 0$?

4) Reset all variables (and you must reset them after each step).
a) What happens to E_m as g_K is increased 10-fold? decreased 10-fold?
b) What happens to E_m as g_{Na} is increased 100-fold?
c) What happens to E_m as g_{Cl} is increased to max? Why?
d) Set gK=1.0; Now what happens to E_m as g_{Cl} is increased? Why?

5) a) Reset. By changing only ionic conductances, figure out under what conditions Na^+ will flow out of the cell.

b) Reset. Changes in which ionic conductances would cause membrane depolarization?

6) Reset. a) Set gCl to its minimum value. Now change gNa to bring E_m close to -40 mV. gNa=____? What value of $[Cl^-]_i$ will make E_{Cl} equal to the new E_m? ______

b) Reset and repeat after E_m is adjusted to -20 mV by initially changing gNa. gNa=____; $[Cl^-]_i$ =_____.

c) This procedure approximates what happens to Cl^- distribution in a damaged axon; why might that be?

7) Use the Nernst model to work the two problems at the end of the Resting Membrane Potential lecture. (remember, the calculations assume only Na and K are permeable)

a. Assuming a normal E_K and E_{Na} , what will E_m be if gK = 2 • gNa?

b. Assuming a normal E_K and E_{Na} , what will E_m be if gNa = 10 • gK?