Bio 365L Fall 2009

Wednesday 1-6 pm. Dr. Markham

Homework Assignment #2: Equilibrium Potentials & Action Potentials

Internal (Pipette) solution, in millimoles per liter (mM):		ACSF (external saline), in mM:	
Potassium gluconate	130	NaCl	130
Sodium phosphocreatine (sodium salt)	20	Glucose	20
EGTA tetrasodium salt	0.5	KCl	3
HEPES sodium salt	10	$MgSO_4$	1
$MgCl_2$	2	$NaHCO_3$ (pH buffer)	10
MgATP	2	$CaCl_2$	2
NaGTP	2	NaH_2PO_4	2

1. Calculate the equilibrium potentials for Na+ and K+ in our experimental preparation given the composition of the internal and external solutions given in the above table. For all equilibrium potential calculations, assume room temperature of 25 °C. NOTE: Sodium phosphocreatine is a disodium salt and NaGTP is a monosodium salt.

2. Based on the resting potentials you recorded earlier in your neurons, is the resting potential likely determined by either of these ions alone? Why?

3. Using the GHK equation, calculate the predicted resting membrane potential, assuming a relative permeability of K:Na of 1.0 : 0.09. Is this a better approximation of the resting potentials you recorded in your neurons? Why or why not?

4. What is the maximum peak voltage of the action potential in normal saline?

5. If the afterhyperpolarization (AHP) is determined by potassium conductance, what is the minimum membrane potential that could be reached during the AHP?

6. Given the composition of our external and internal solutions, the Goldman-Hodgkin-Katz equation, and Ohms law expressed in terms of voltage, current, and conductance, make three graphs by whatever means is most convenient to depict the time series of 1) the membrane voltage, 2) the Na^+ and K^+ ionic conductances, and 3) the Na^+ and K^+ currents, given the following sequence of ionic conductances. (You can use a spreadsheet, computer code, or brute force calculations; just explain your methods, and provide formulas/source code where appropriate).

Time (ms)	gNa (µs/cm2)	gK (µs/cm2)	INa	IK	V_M
0.1	0.0009	0.017			
0.2	0.0009	0.017			
0.3	0.0009	0.017			
0.4	0.0012	0.017			
0.5	0.002	0.017			
0.6	0.004	0.017			
0.7	0.01	0.018			
0.8	0.05	0.019			
0.9	0.2	0.025			
1	0.5	0.028			
1.1	0.2	0.022			
1.2	0.02	0.023			
1.3	0.003	0.023			
1.4	0.002	0.023			
1.5	0.0015	0.022			
1.6	0.0013	0.022			
1.7	0.001	0.021			
1.8	0.0009	0.021			
1.9	0.0009	0.019			
2	0.0009	0.017			
2.1	0.0009	0.017			

1) Plot membrane potential on one graph, 2) plot the sodium current and the potassium current together on a single graph [Na^+ current is inward and therefore negative; K^+ current is outward and therefore positive], 3) plot the sodium conductance and the potassium conductance on the same graph, remembering that conductance is always a positive number.

7. Why are the plots of the ion conductances so different from the plots of the ion currents?

8. How do the sodium and potassium conductances interact with the equilibrium potentials for sodium and potassium to produce the action potential?