Computer Lab Worksheet - ACTION POTENTIAL

Purpose:
To demonstrate some of the unique physiological properties of the neuronal action potential.

General Information:
Program name = **"AP7.rt" or "AP7.exe"**
Location = Shared on Wintel computers in LRU and MSL rm. 180; or downloaded from Davis webpage link.

Directions:
1) Double click on the "**ap7.rt**" (Mac) or "**ap7.exe**" (Wintel) icon to load the program.
2) Click on the ARROW button or select "**run**" from the "operate" menu to begin execution. You may **let the program continue to run** throughout the exercise.
3) Any of the parameters (e.g. the stimulator or ionic concentrations) can be altered "on the fly" to test their effects on the action potential.
4) To reset all parameters to their default values, go to the "**operate**" menu and select "**reinitialize all to default**".

Problems:
1) Threshold. This exercise will illustrate the all-or-none property of the action potential.

a) Reset all variables and start the program (stimulator set for a single pulse, DURATION1 = 1 ms, START1 = 4 ms). Incrementally increase AMPLITUDE1 (from 0) to find the minimum stimulus amplitude that will trigger an AP = _____. Identify the various phases of the AP: _______________ _______________ _________________ _________________.
Describe the sequence of current changes that underlie the AP: _________________________________.
Decrease AMP1 until the AP disappears; what term describes the membrane potential at the the point where an AP is first produced? __________. What happens to the AP as AMP1 is increased well above this point? ____.
Set AMP1= 5.0 ma. Now progressively decrease $[Na]_{out}$ and describe the effects on E_m, I_{Na} and I_K:
(note: the selector on the right side of the current trace (iMem) allows you to view total current, Na^+ current, or K^+ current)
____.

b) Reset AMP1 to the point where the AP first fires. Now set DUR1 = 0.5 ms; note that the AP no longer fires but that amp1 has to be increased further to trigger the AP; write the new value down in the Table to the right. Then complete the Table for other values of DUR1 (numbers <0.5 need to be typed in).

Duration1	Amplitude1
0.1	
0.2	
0.5	
1.0	
1.5	
2.0	
2.5	
3.0	

Finally, sketch a rough plot of the Amplitude (y) vs Duration (x). (This is a well-described relationship that is used clinically to assess recovery of nerve function).

2) Accomodation.

a) Reset all variables. Set DUR1 = 15 ms, what is the minimum value of AMP1 required to fire an AP? ____.

b) Keep these settings the same but switch from a pulse to a ramp stimulus. What happens to the AP? Why? ____.
Now what is the minimum value of AMP1 required to fire an AP? ______.
Is the AP identical to that in question **2a** (switch between pulse and ramp to compare)?____________.

What is the mechanism behind this phenomenon? ____.

3) Refractory Periods.

a) Reset all variables (DUR1 = DUR2= 1ms, START1 = 4 ms, START2 =20 ms).Set the stimulator switch for 2 pulses. Set AMP1 and AMP2 to the value in question **1a** that first produced an AP. Compare the second AP to the first: _________________. Why?_____________________________.
Now set START2 = 11 ms (i.e. so the second pulse is delivered during the after-hyperpolarization phase of the first AP). Increase the value of START2 until another AP is fired. START2 = ____. What is the term for the difference between START2 and START1? ______________________________________.

b) Set START2 = 11.0 ms. At what value of AMP2 will an AP first fire? _______. Is the AP identical to the first one? ___ Why or why not? ____.

c) Set START2 = 10.0 ms. At what AMP2 does an AP fire? _______. Why is this value different from that in **4b**? ____.

d) Set AMP2 = 400 ma (a maximal stimulus). Now incrementally decrease START2 from 10 ms until a distinct second AP is not fired. START2 = ______. What is the term for the difference between START2 and START1? _______________. What is the maximum firing rate of this cell? ___.

4) Spontaneous Depolarization.

a) Reset all variables. Keep AMP1=0 and increase $[K]_{out}$ until an AP is fired. $[K]_{out}$ = __? How is the AP different than in **1a**? ______________________. What is E_{rest} at this point? _____.

b) Increase $[K]_{out}$ to 14.2 mM; what happens? ___________________________________.
How does the AP shape change? Why? ____.

c) Increase $[K]_{out}$ to > 16.8 mM; what happens? __________________________________.
Why are subsequent AP's spaced at consistent intervals? ____________________________________.
Why do all the secondary AP's have the same amplitude? ____________________________________.

d) Reset all variables. Set DUR1= 25 ms and AMP1 = 14.6 ma. Discuss similarities and differences between this result and that in **4c**: ____
____.

5) Anodal break.

Reset all variables. Progressively decrease AMP1 below zero. Describe the changes in E_m when AMP1 pulses are positive or negative: ____.
Can an AP ever be fired using a hyperpolarizing stimulus pulse? ___Why or why not? ____________
____
____.

6) Changes in external [Ca^{2+}].

Reset all variables. Increase AMP1 to 2.0 ma. This produces a subthreshold depolarization, but record what happens as $[Ca]_{out}$ is progressively decreased from 1.5 from 0.5 mM: _______________
_______Can you guess why this happens? ____
__________________________. What happens as $[Ca]_{out}$ is further decreased to 0.2 mM:____________
____________.