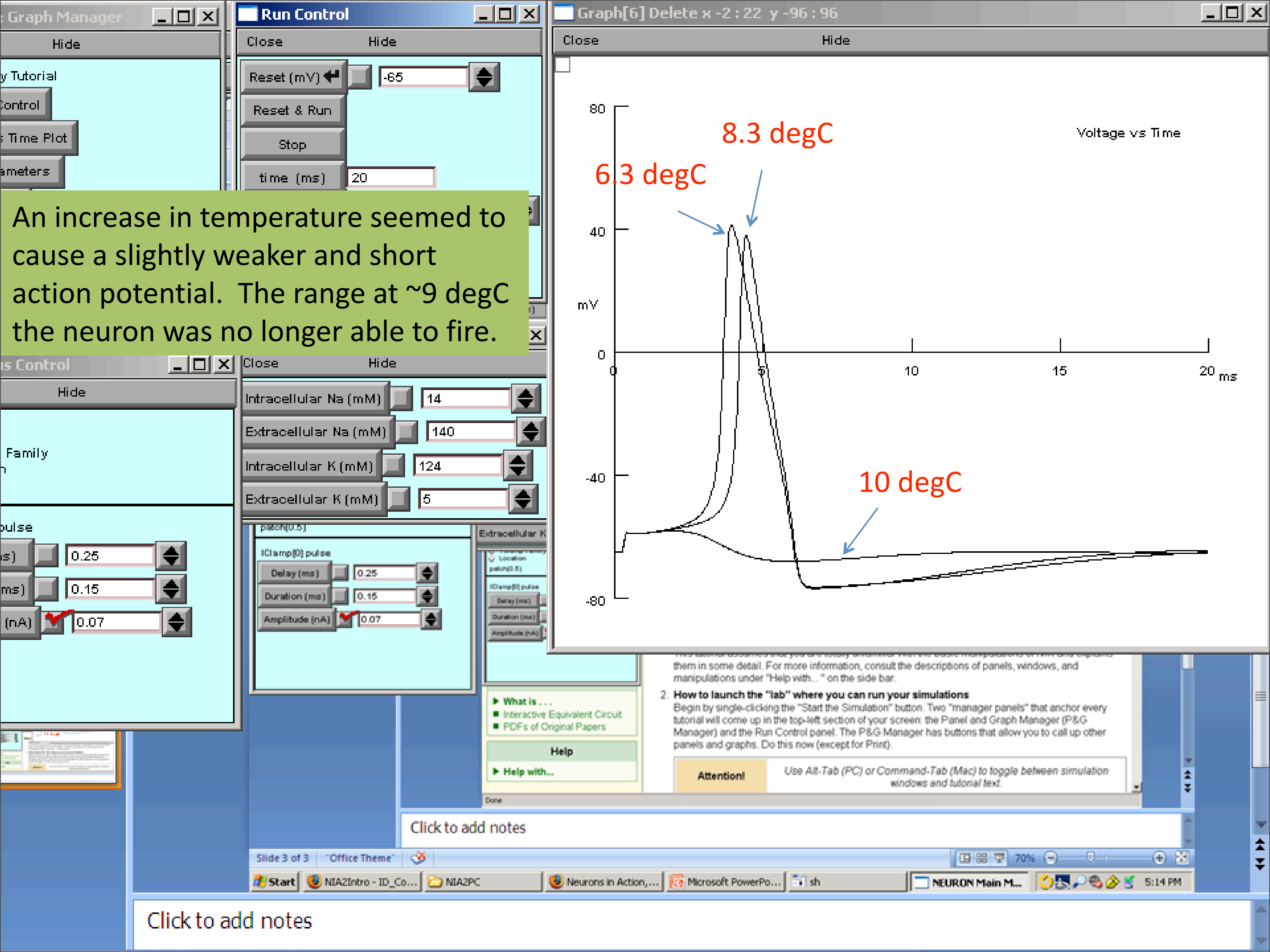
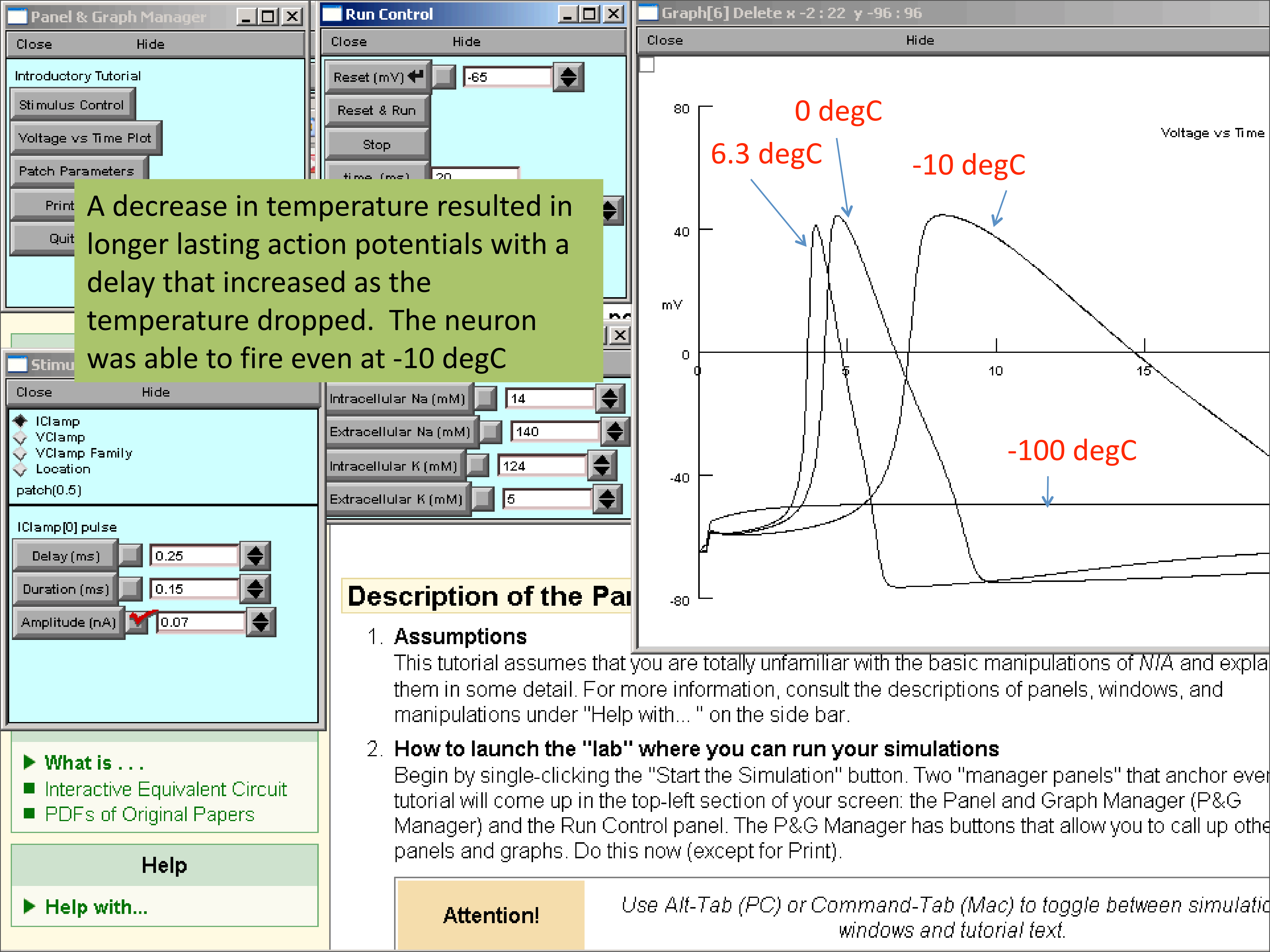
Completed Lab D

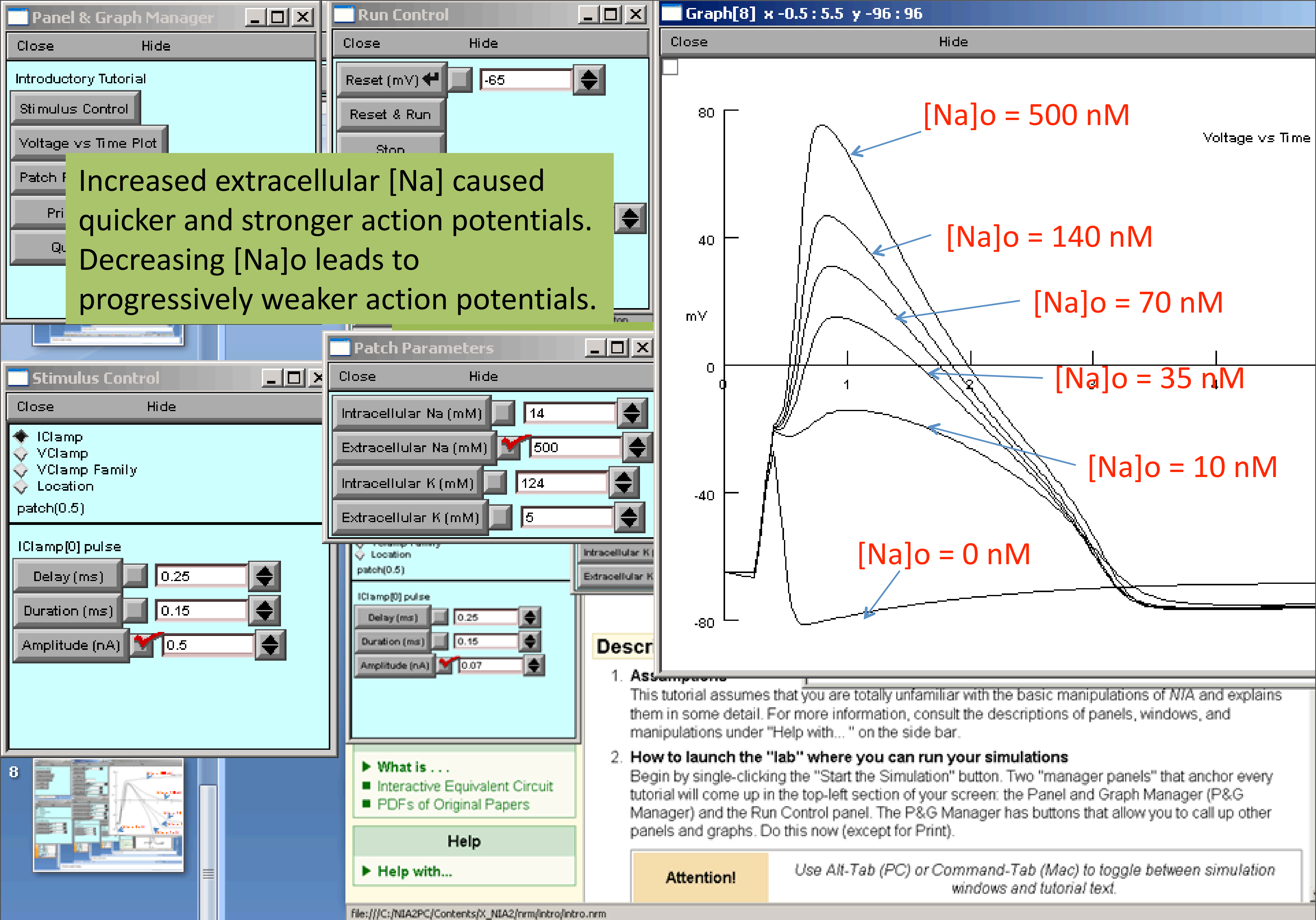
With Bonus



An increase in temperature seemed to cause a slightly weaker and short action potential. The range at ~9 degC the neuron was no longer able to fire.
Graph Manager
Run Control
Close
Hide
Reset (mV)
-65
Reset & Run
Stop
time (ms)
20
Intracellular Na (mM)
14
Extracellular Na (mM)
140
Intracellular K (mM)
124
Extracellular K (mM)
5
0.25
0.15
0.07
Graph[6] Delete x -2 : 22 y -96 : 96
Voltage vs Time
8.3 degC
6.3 degC
10 degC
mV
ms
80
40
0
-40
-80
0
5
10
15
20
Click to add notes
Slide 3 of 3
"Office Theme"
Start
NEURON Main M...
5:14 PM
Click to add notes

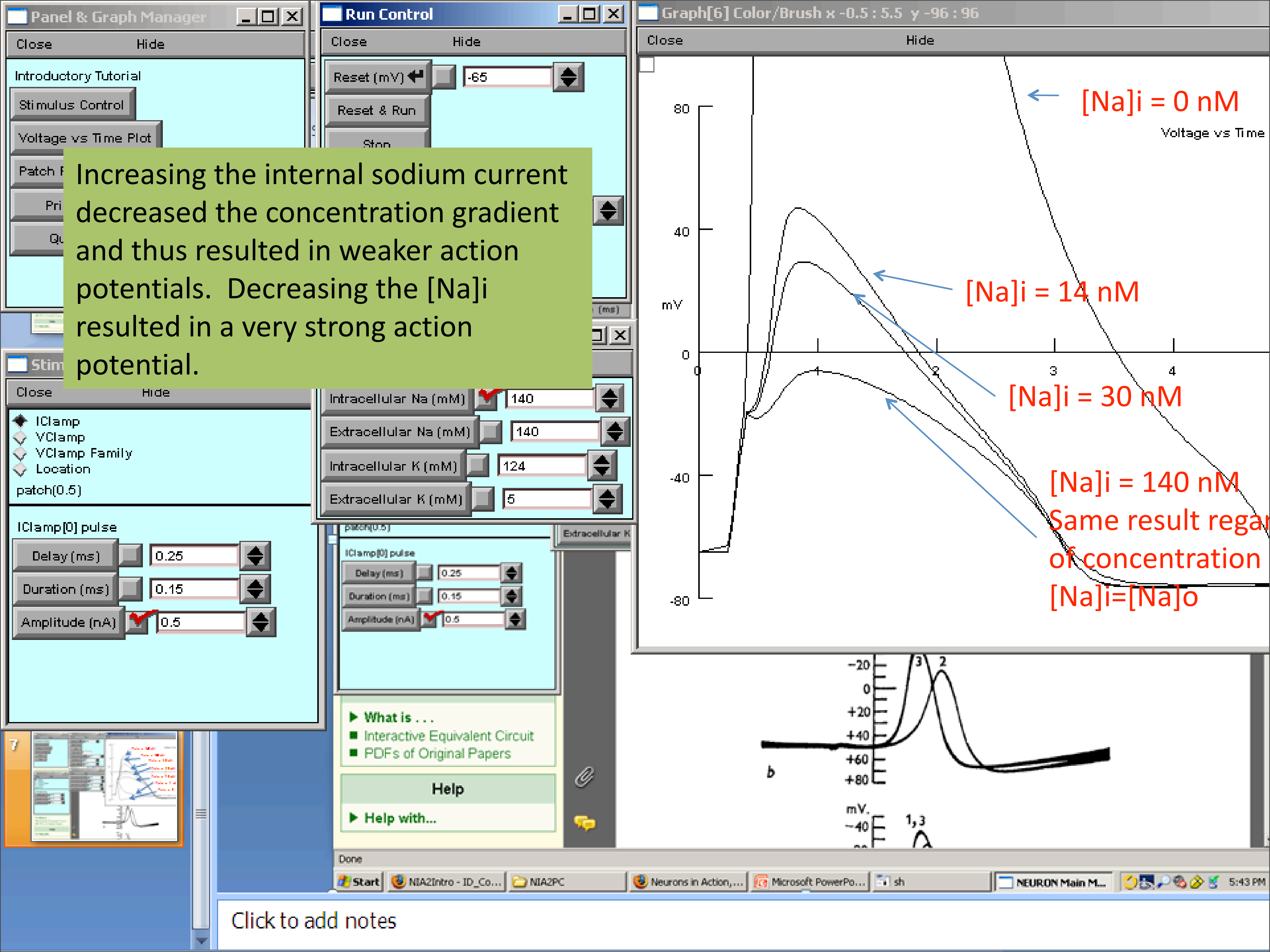

A decrease in temperature resulted in longer lasting action potentials with a delay that increased as the temperature dropped. The neuron was able to fire even at -10 degC
Panel & Graph Manager
Close
Hide
Introductory Tutorial
Stimulus Control
Voltage vs Time Plot
Patch Parameters
Print
Quit
Run Control
Reset (mV)
-65
Reset & Run
Stop
Graph[6] Delete x -2 : 22 y -96 : 96
Voltage vs Time
mV
80
40
0
-40
-80
0
5
10
15
0 degC
6.3 degC
-10 degC
-100 degC
Intracellular Na (mM)
14
Extracellular Na (mM)
140
Intracellular K (mM)
124
Extracellular K (mM)
5
IClamp
VClamp
VClamp Family
Location
patch(0.5)
IClamp[0] pulse
Delay (ms)
0.25
Duration (ms)
0.15
Amplitude (nA)
0.07
What is . . .
Interactive Equivalent Circuit
PDFs of Original Papers
Help
Help with...
Description of the Pa
1. Assumptions
This tutorial assumes that you are totally unfamiliar with the basic manipulations of NIA and expla
them in some detail. For more information, consult the descriptions of panels, windows, and
manipulations under "Help with... " on the side bar.
2. How to launch the "lab" where you can run your simulations
Begin by single-clicking the "Start the Simulation" button. Two "manager panels" that anchor ever
tutorial will come up in the top-left section of your screen: the Panel and Graph Manager (P&G
Manager) and the Run Control panel. The P&G Manager has buttons that allow you to call up othe
panels and graphs. Do this now (except for Print).
Attention!
Use Alt-Tab (PC) or Command-Tab (Mac) to toggle between simulatio
windows and tutorial text.

Increased extracellular [Na] caused quicker and stronger action potentials. Decreasing [Na]o leads to progressively weaker action potentials.

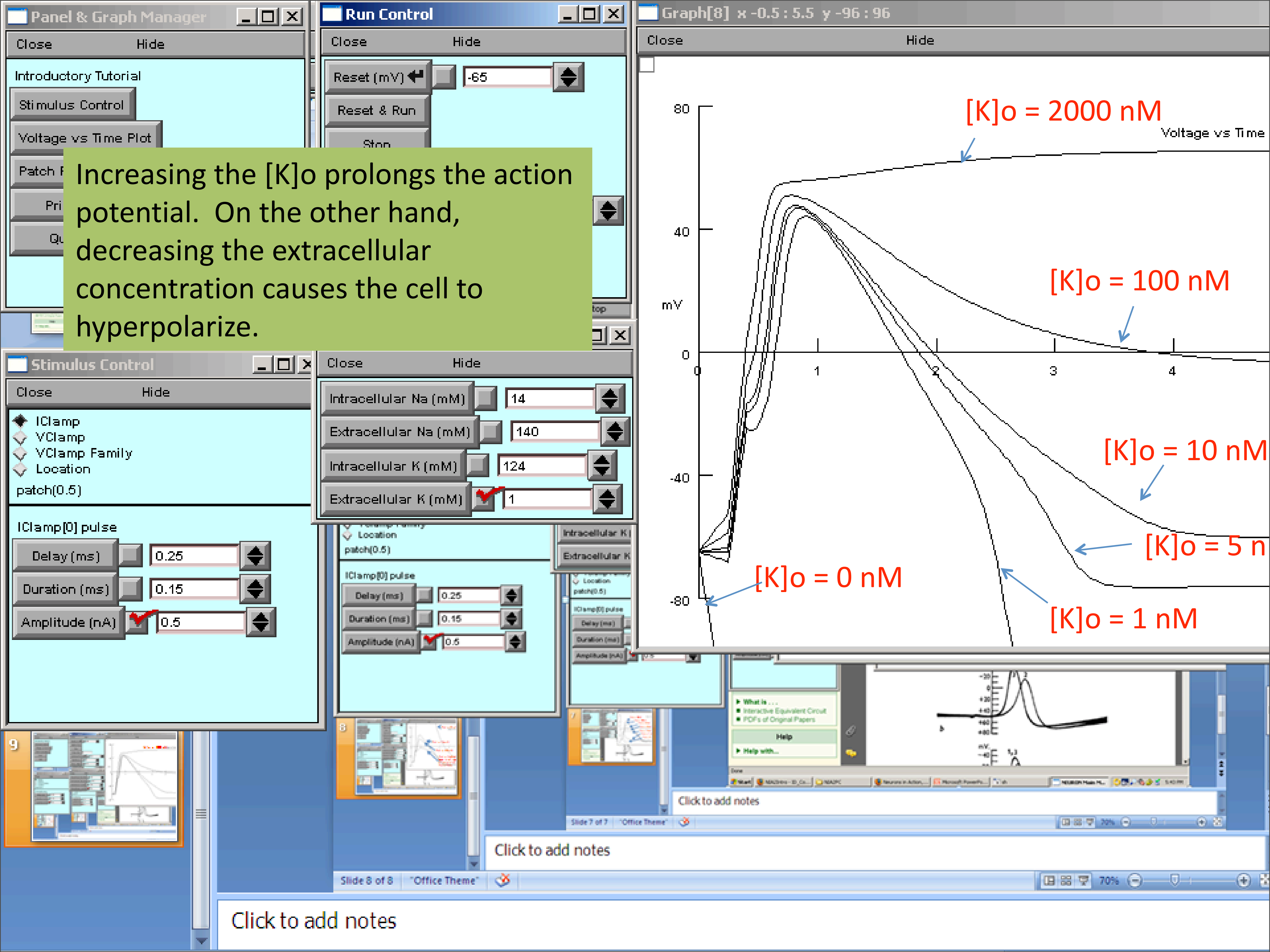


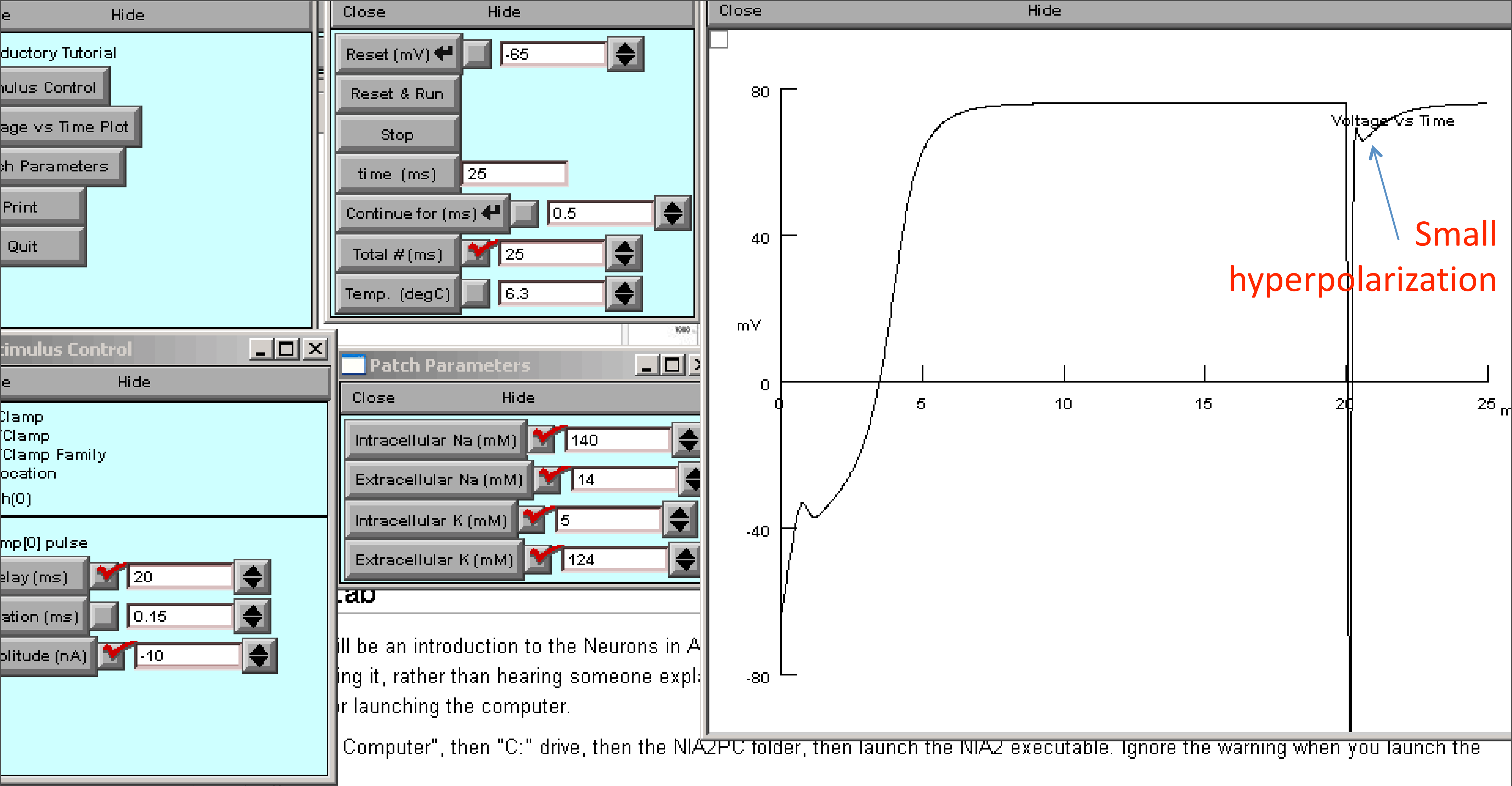
Click to add notes

Increasing the internal sodium current decreased the concentration gradient and thus resulted in weaker action potentials. Decreasing the [Na]i resulted in a very strong action potential.



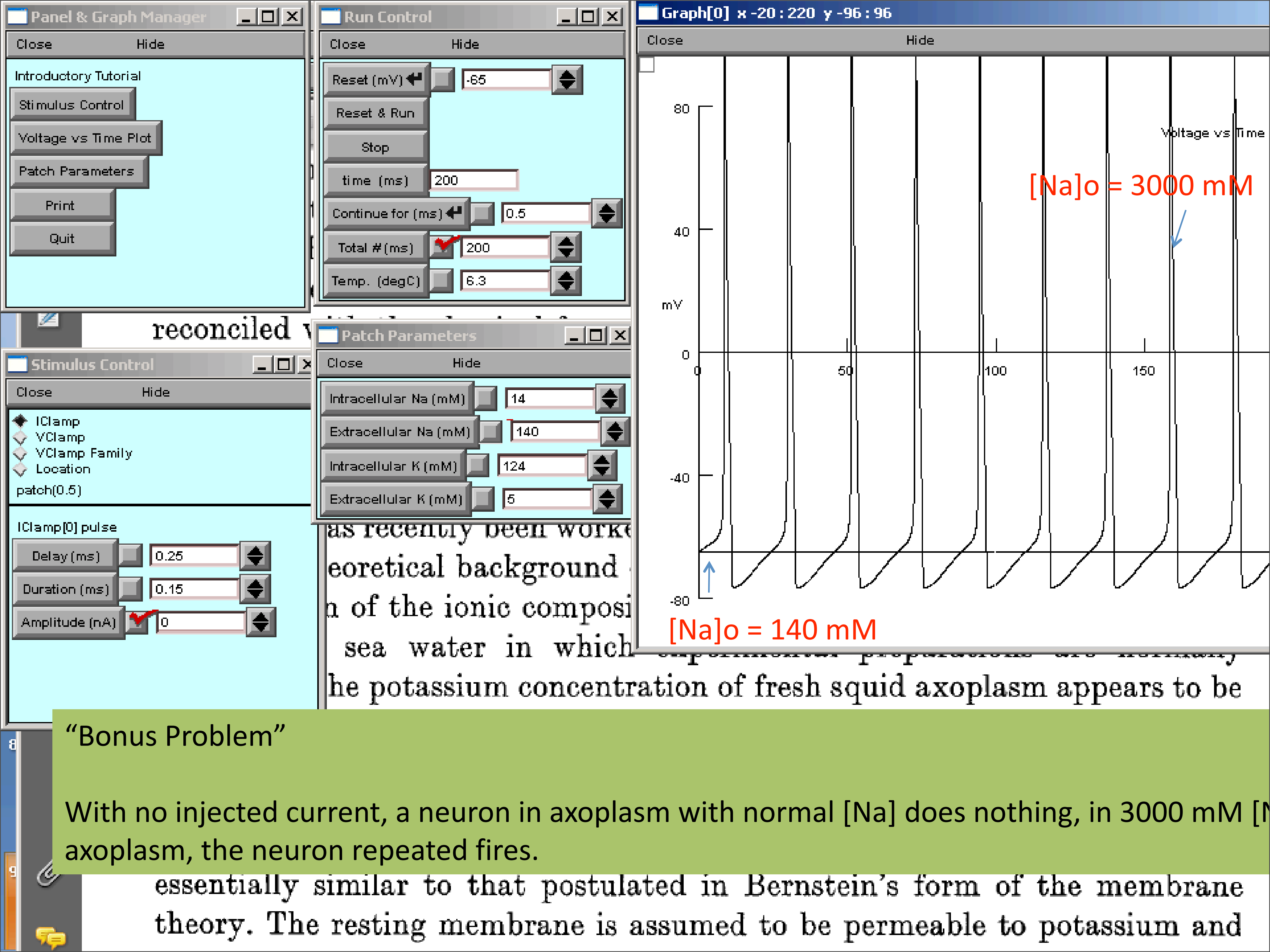
Increasing the [K]o prolongs the action potential. On the other hand, decreasing the extracellular concentration causes the cell to hyperpolarize.





"Bonus Problem"

Reversed the intracellular and extracellular [Na] and [K] and tried to create a "reverse action potential". Because of the voltage gated channels, this should not work.

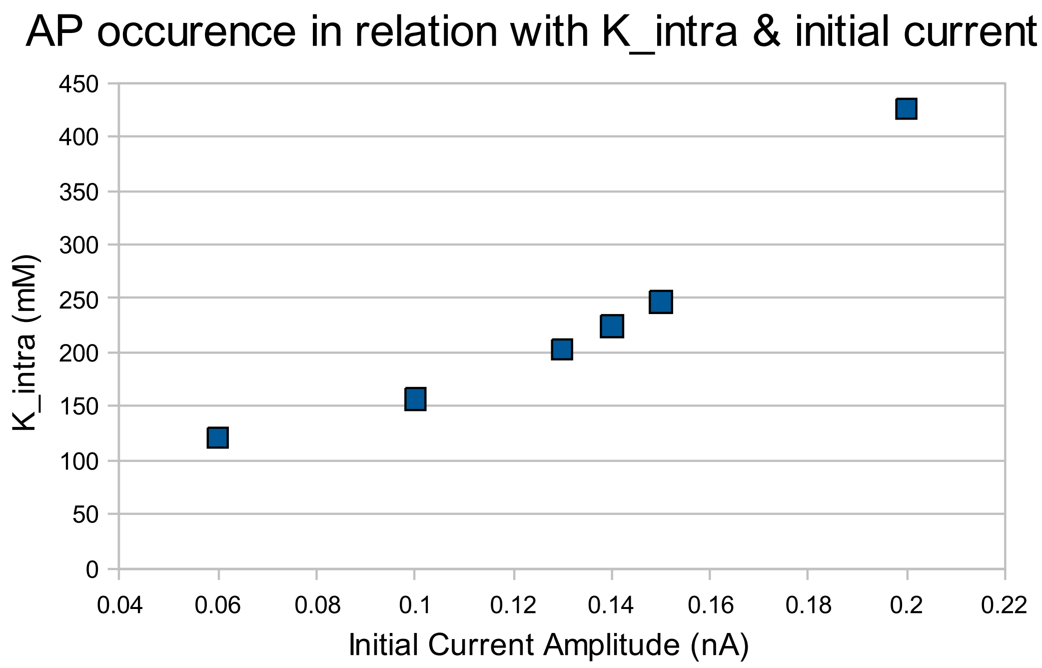


"Bonus Problem"

With no injected current, a neuron in axoplasm with normal [Na] does nothing, in 3000 mM [N
axoplasm, the neuron repeated fires.

Bonus

I_Clamp Amplitude	K_intra
0.2	426
0.15	247
0.14	224
0.13	203
0.1	157
0.06	121

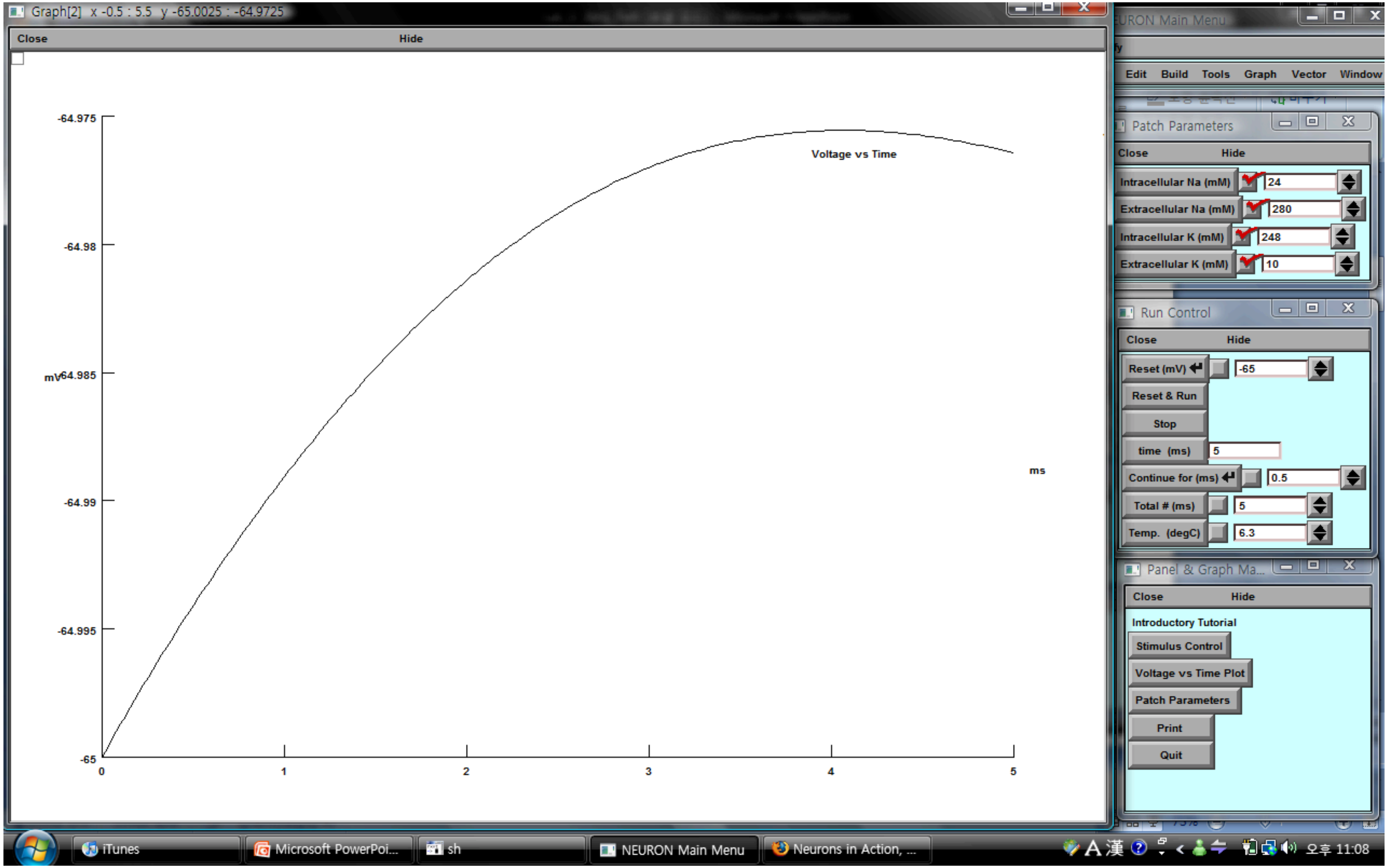


I plotted the threshhold of AP for different pairs of intracellular K+ and Initial Current.
According to the plot, it looks like K+_AP threshold = k * I^2 .
If this assumption is right, the threshold K+ value increases as a function of I^2.

Extra Credit Problem: Would Doubling Every Concentration Change the Shape of the Graph?

Hypothesis: No the shape would remain more or less similar to the original setting because the voltage is determined by driving force, so given same ratio, the voltage should remain constant.

The Graph



Graph[2] x -0.5 : 5.5 y -65.0025 : -64.9725
Close
Hide
-64.975
-64.98
mV-64.985
-64.99
-64.995
-65
0
1
2
3
4
5
ms
Voltage vs Time
Edit
Build
Tools
Graph
Vector
Window
Patch Parameters
Close
Hide
Intracellular Na (mM)
24
Extracellular Na (mM)
280
Intracellular K (mM)
248
Extracellular K (mM)
10
Run Control
Close
Hide
Reset (mV)
-65
Reset & Run
Stop
time (ms)
5
Continue for (ms)
0.5
Total # (ms)
5
Temp. (degC)
6.3
Close
Hide
Introductory Tutorial
Stimulus Control
Voltage vs Time Plot
Patch Parameters
Print
Quit
iTunes
Microsoft PowerPoi...
sh
NEURON Main Menu
Neurons in Action, ...
오후 11:08

Conclusion

The graph looks significantly different from the one with initial setting and here's why.

$$V_m = \frac{RT}{F} \ln\left(\frac{p_K[K]_o + p_{Na}[Na]_o + p_{Cl}[Cl]_i}{p_K[K]_i + p_{Na}[Na]_i + p_{Cl}[Cl]_o} \right)$$

Although the driving force of each ion is determined by its own concentration, the overall voltage is determined by concentration of all three ions.

Bonus

Nernst Equation with Noise

The Na^+ concentration outside the cell is large and probably does not change much. Even if it does, we saw from the lab the enormous range of Na^+_o over which neurons can still fire action potentials. But what about the intercellular concentration? There are of course mechanisms that keep this very stable, but one would imagine that this smaller concentration that changes drastically during an action potential may often not be exactly at 14 mM. So to see the affects of this, I added a uniformly distributed noise parameter with standard deviation N that made the intercellular concentration somewhat random in the Nernst equation. I then plotted the resulting equation as a function of the extracellular concentration for different noise levels, as well as took a look at how much the E_{Na} could vary when the extracellular Na concentration was constant at an optimal 140 mM. The MATLAB code and plots are on subsequent slides.

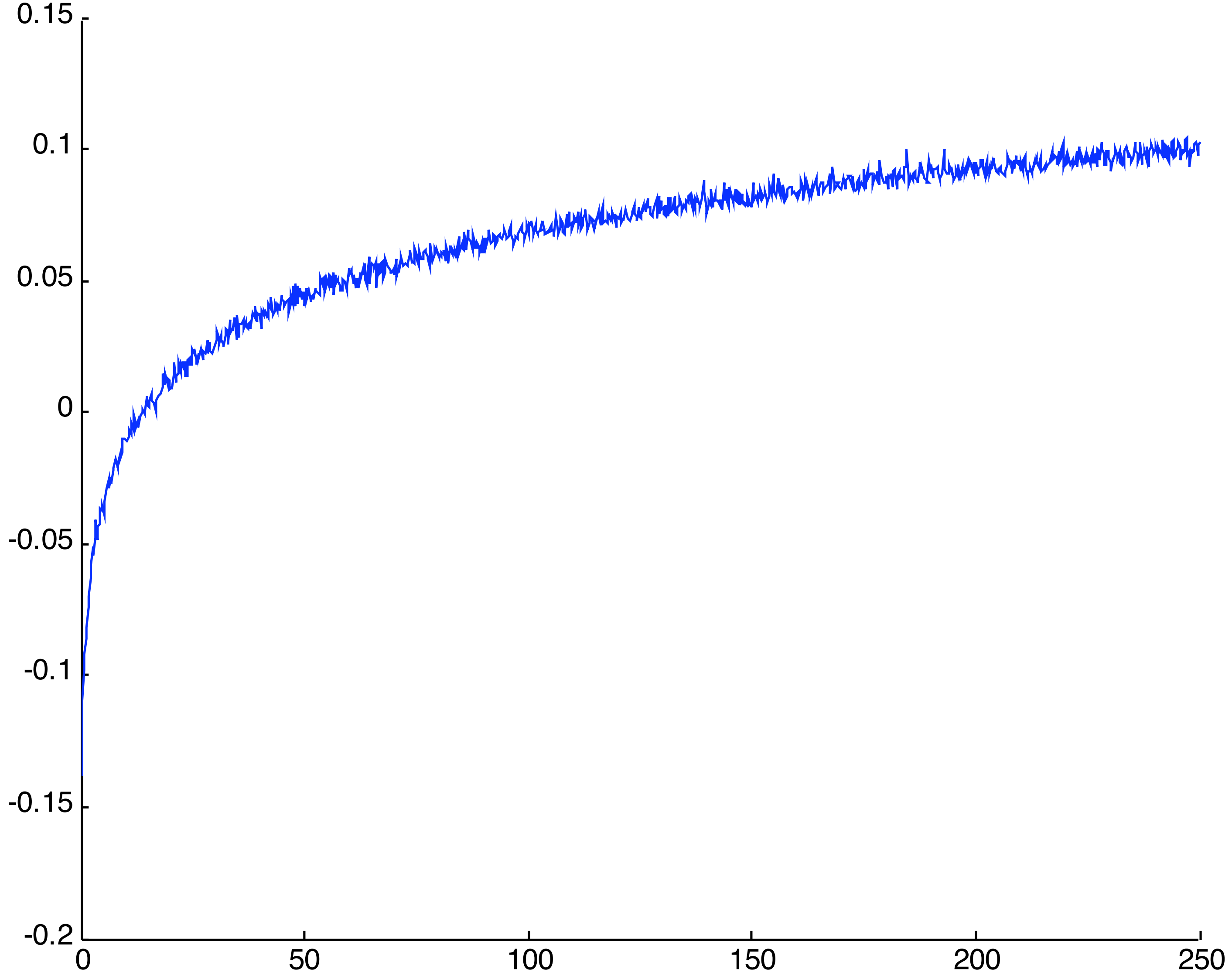
Bonus

```
function nernst(N)

R= 8.314;
T= 6.3 + 273.15;
z= 1;
F= 96485.339;
Nai = 14;
Na0 = 140;
X = (.25:.25:250);
D = zeros(1, 1000);
for i = 1:1000
    D(i) = ((R*T)/(z*F))*log(X(i)/(14 + (N*randn)));
end
hold on
plot(X, D)
```

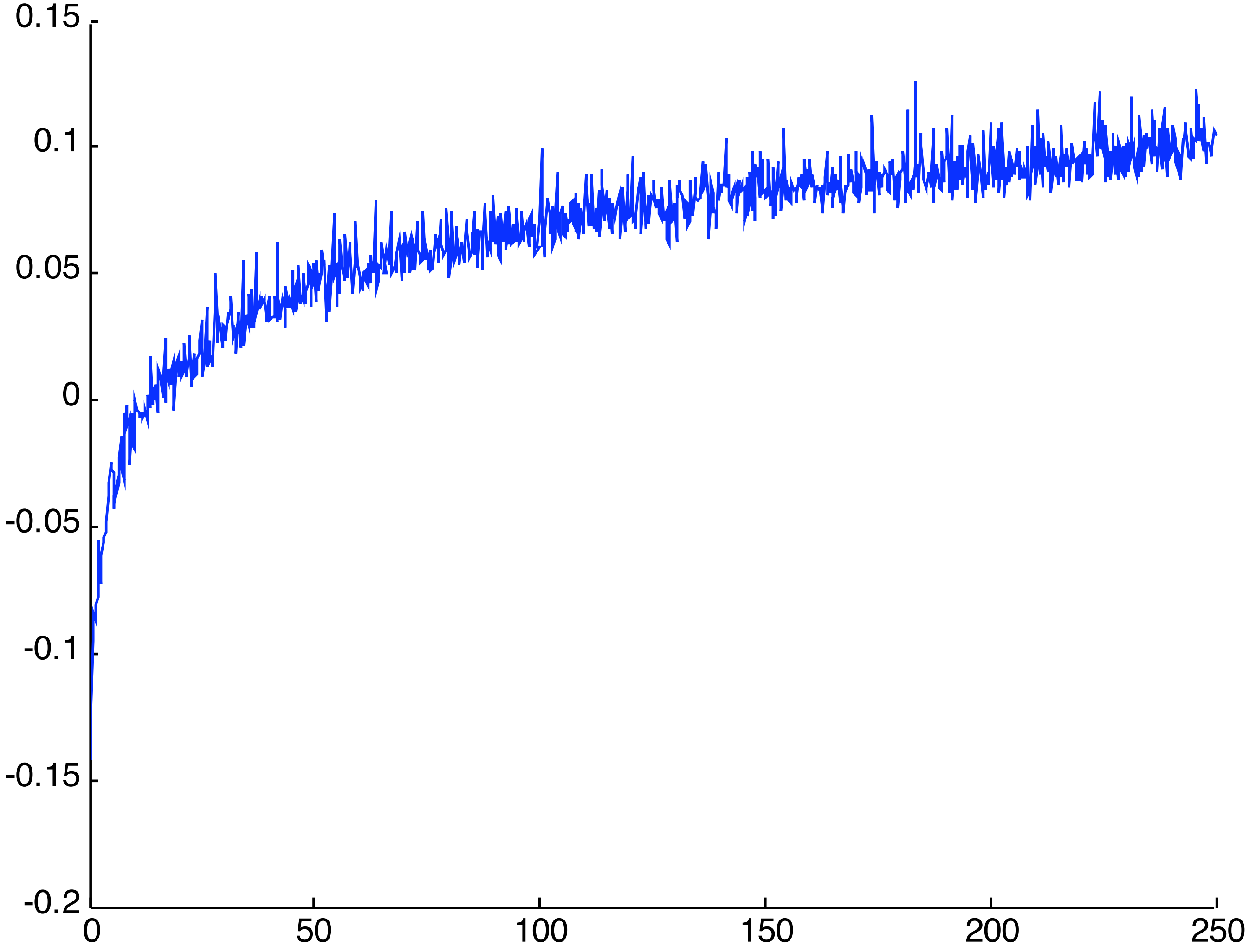
Bonus

N = 1



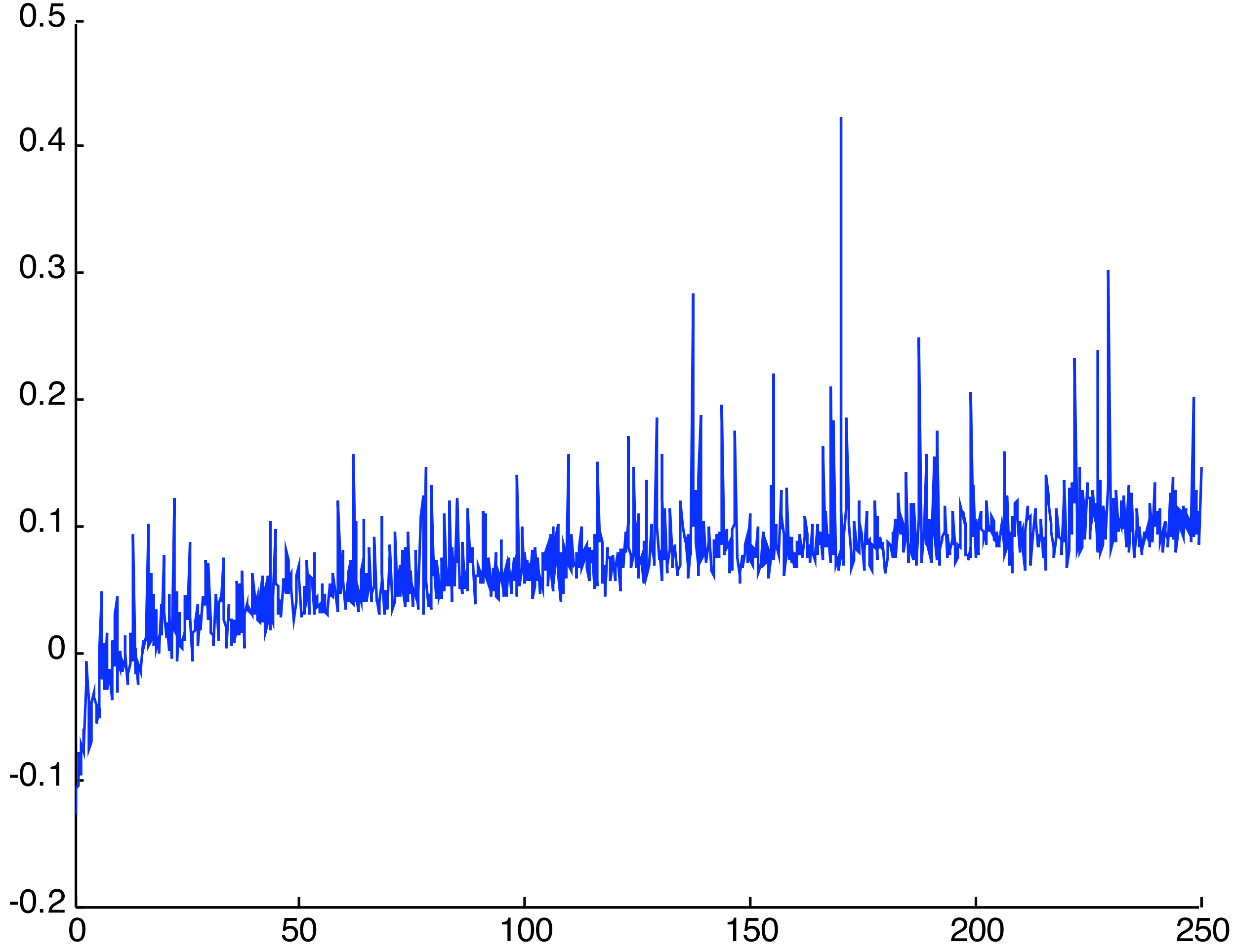
Bonus

N = 5



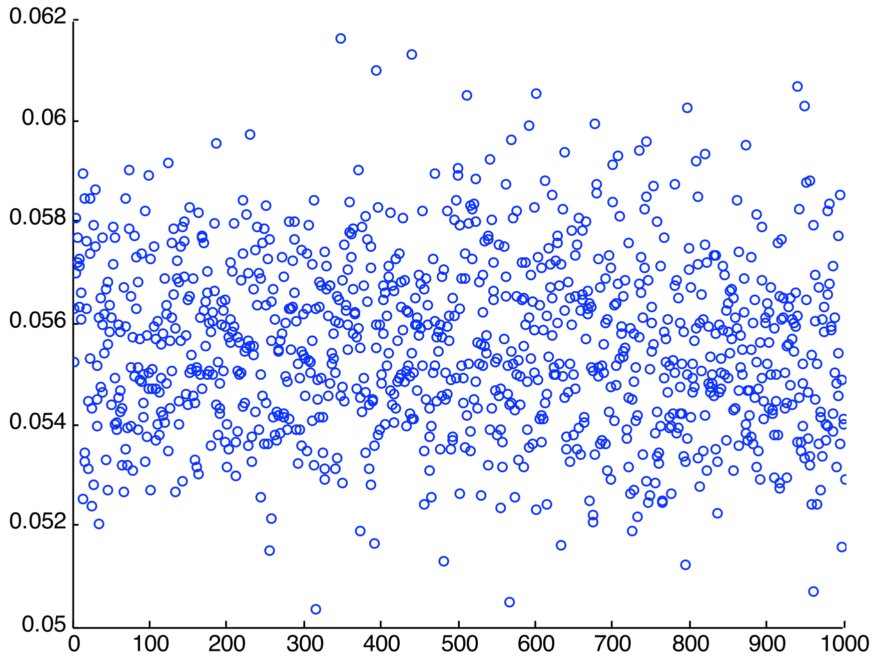
Bonus

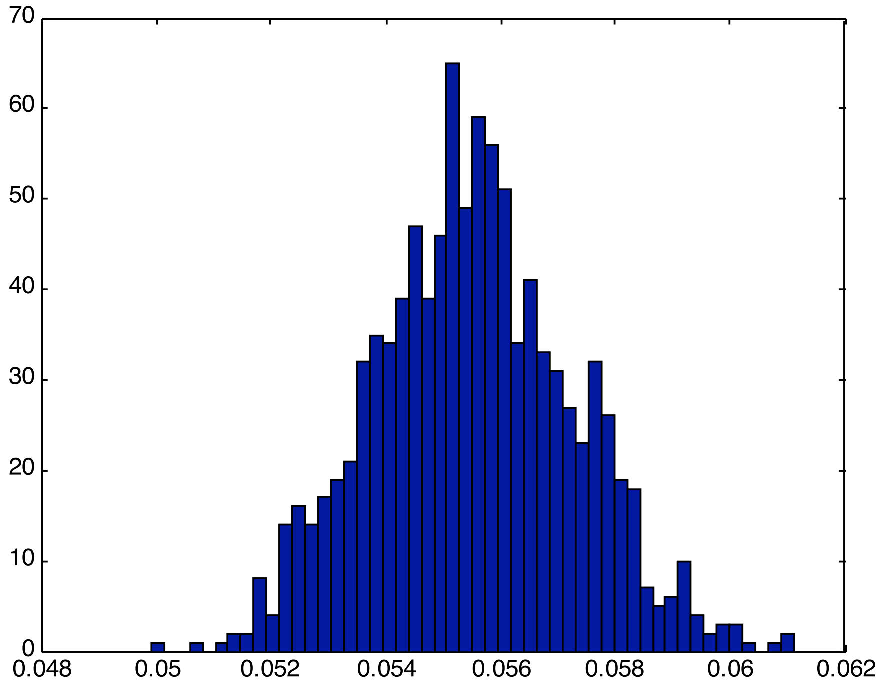
N = 10



Bonus

Variation when Na^+_o is held constant at 140mM and N=1





There seems to be a plus or minus 10% effect. Subsequent questions include how the intercellular concentration of Na^+ changes in vivo, especially during a train of action potentials.