

Problem Set 2 - Action Potentials
(due Monday, Sept 19, 2005)

Imagine that you're teaching an undergraduate neuroscience course, and you'd like to get across a few key concepts about action potential generation to your students. Armed with an action potential simulation program, describe how you would demonstrate these ideas. You can look at the "Experiments" part of the program, but please explore and generate simulations of your own.

Use the action potential simulation program, **APSIM**, to investigate the following questions (1-5). It can be used to study the electrophysiology of neurons under a wide variety of conditions.

For a detailed description of each function consult the extensive help menu. Running the program in DEMO mode to begin with will show you how to use it. It's not hard.

- Begin with "1 pulse" and "active membrane" in the *mode* menu.
- Change the time scale by selecting "time bar" in the *edit* menu.
- To add a second pulse select "2 pulses" in the *mode* menu.
- To change pulse 1, pulse 2 parameters and interpulse interval, press the *pulse #* button.
- Change "ionic concentrations" in the *edit* menu (note: defaults are set for squid axons).
- Examine the currents, conductance and gates by selecting them from the *plot* menu.
- Simulate blocking current with toxins by decreasing the conductance in the *edit* menu.
- Print your results with your favorite screen-capture program or press ALT-Print Screen, and then paste into a program like Microsoft Paint (found under Accessories).

1. *Thresholds*. You would like to demonstrate the concept of threshold in generating an action potential, and in particular that the stimulus is an integral of both current (stimulus strength) and duration. In your own words, define and explain these ideas. After exploring with **APSim**, print at least 2 illustrations of the threshold by changing the stimulus strength, and 2 examples by changing the duration.
2. *Refractory period*. You think your students should really understand refractory period, both absolute and relative. Please define the term and explain how the two differ. To investigate refractory periods, you can go to "Mode" and set the program to "2pulses". Print the illustration you'll use in class to explain each term, complete with labels.
3. *Regulation of peak and repolarization*. Although you have been teaching your students that action potentials are considered all-or-nothing events, various parameters also affect the peak and the duration of the action potential. You'd like to illustrate this by changing some channel parameters. Under the "edit" menu, you can open Maximal Conductances, Ionic Concentrations or Gating Kinetics. If you press "measure" in the menu bar, a window pops up which allows you to measure values in a window; point your mouse pointer over the peak of your action potential, and the time and voltage where your pointer is placed is read out. Explain to your students which factors (Maximal Conductances, Ionic Concentrations and Gating Kinetics) most affect the peak, and why. Do the same for the repolarizing phase.

4. *Drugs and toxins.* Since some of your students will one day write prescriptions for drugs, you'd like to let them know how a toxin or an anesthetic can block action potential propagation. Illustrate how this works, and how it changes the threshold. Explain how they might generalize from this program, which models a stationary action potential, to a propagating action potential.
5. *Variability and constancy among cell types.* The program defaults are set for squid axons, where ion concentrations are much higher because of the high salt concentrations in sea water. Show how the general idea still works for mammalian ion concentrations, if you adjust some parameters. What parameter adjustments are needed, and why? Which parameters can be kept pretty constant? Explain briefly how morphological differences among mammalian neurons might require differences in these parameters for different types of neurons.