ABOUT THE LAB:

The lab will examine two models of how the membrane potential changes due to the action of an ion channel.

1. "Standard" model of membrane potential – Leak current.
The differential equation

$$\frac{dV}{dt} = -\frac{g_L}{C}(V - E_L) \qquad V(0) = -20mV$$

describes the change in the membrane potential due to a leak current. Explain what the equation means. Make sure to touch on the following: Why is it appropriate to use a differential equation to describe the changes in the membrane potential? What happens if the membrane potential, V exceeds the reversal potential, E_L. What about if the two are equal?

2. Numerical solution.
Solve the differential equation (using either the built-in Matlab solver or the Euler method) with the following parameters: $g_L = 19mS, C = 10\mu F, E_L = -67mV$ and $V(0) = -20mV$. Show a (labeled) figure in your lab report and describe the solution. What happens if you change the initial condition? Show the solutions using 5 different initial conditions.

3. Analytical solution.
Using separation of variables, the equation can be solved. The solution is given by: $V(t) = E_L + (V_0 - E_L)e^{g_L t\ C}$. Plot the solution on the same figure as the numerical solution. What does the model predict about changing the conductance, g_L and the capacitance, C? Explain in words, then create a figure using Matlab that demonstrates your point. (ie create a figure where you change the capacitance or the conductance).

4. Persistent sodium channel – Gating variable. Assume that the channel you are considering has the following voltage-dependent gating variable, $m_\infty(V) = \frac{1}{1 + e^{(V_a - V)/k}}$. Let $V_a = 1.5mV$ and $k = 16mV$. Plot $m_\infty(V)$ versus V and describe in words how the gating variable behaves as the voltage changes. Why do you think the channel is called the "persistent" sodium channel?

5. Model of the persisent sodium channel.
Solve the differential equation

$$\frac{dV}{dt} = -\frac{g_{Na}}{C} m_\infty(V)(V - E_{Na}) \qquad V(0) = -20mV.$$

Use the parameters $g_{Na} = 74mS$, $C = 10mF$, $E_{Na} = 60mV$. Show a figure with the solution, using a number of different initial conditions. Compare the solutions to this model with the model of the leak channel. How is the behavior similar and how is it different in the two cases?