ABOUT THE LAB:

The lab will show you how (1) the opening and closing of a single channel can be modeled stochatically, (2) the long-term observation of a single channel or the average activity of many channels can be described deterministically.

1.Introduction to ion channels.

A brief introduction to ion channels and their role. You can read the introduction to the book chapter on moodle for this lab. We will define the following terminology: deterministic and stochastic models; open and closed probability; Monte Carlo methods.

2. Running the stochastic simulation

Use the code 'mc_trial.m' to get 3 instantiations of the ion channel dynamics. (Save a figure with 3 panels, each showing one instantiation.) Explain how the three trials you got are similar and how they are different.

3. Finding the equilibrium open and equilibrium closed probability.

Find the overall fraction of time the channel spent in the open state and the fraction of time it spent in the closed state over a 1, 10 and 100 second simulation. Run each length simulation 5 times (eg run 5 simulations for 1 s) and record the fraction in the open and closed state for all lengths of simulations in a table. Compare the values you get to the fractions $\frac{k_1}{k_1+k_2}$ and $\frac{k_2}{k_1+k_2}$. What can you conclude?

4. Numerical experiments with the stochastic single channel. Vary the values of k_1 and k_2. (Hint: you should only vary one parameter at a time.) Look at the time series of the channel states and the equilibrium open probability. Summarize your findings in a few sentences and include any figures or tables that might be helpful to make your point.

5. Deterministic simulation of a single channel.

We will look at the derivation of the differential equation

$$\frac{dP_o}{dt} = k_2(1 - P_0) + k_1 P_0.$$

Explain in a few sentences what this equation means. Use 'open_prob_det.m' to look at the solution of the differential equation. Describe what the solution means. Include a figure and make sure to explain how the equilibrium open probability we found in question 3. relates to the 'steady state value' in our determininstic simulation.

5. Numerical experiment with the open probability.

Vary k_1 and k_2 and the initial condition. How do these changes effect the solution of the differential equation? Explain in a few sentences and include any figures or tables that may be helpful.

6. A collection of a large number of channels.

The book chapter derives the differential equation for the average number of open channels,

N_0 if there is a large collection, N of independent channels. The equation is given by

$$\frac{dN_0}{dt} = k_2(N - N_0) + k_1 N_0.$$

Explain in a few sentences how this relates to the differential equation we have seen above. (Hint: read the bottom of pg 296 in the book chapter an focus your attention on the fraction of open channels.) Create a new matlab code that solves the differential equation here for $N = 200$ channels.

7. Relating the stochastic single channel model to the deterministic models. In the next couple of weeks of the course, we will be talking about ion channel dynamics and, typically, we will be describing them using a deterministic model - a differential equation. Based on today's lab, explain under what conditions this is reasonable.