Lecture 7.2 Exercises: Dopamine Pacemaker Model

See the text file 'readme.txt' for useful installation and setup information.

The point of these exercises is to show that this model dopamine neuron is an endogenous pacemaker due to a low threshold calcium current, but that the calcium dynamics do not control the firing rate. The spike rate is controlled instead by the net current during the interval prior to reaching spike threshold.

The model is based on

Kuznetsova AY, Huertas MA, Kuznetsov AS, Paladini CA and, Canavier CC. Regulation of Firing Frequency in a Computational Model of a Midbrain Dopaminergic Neuron, J. Computational Neuroscience 2010 Jun;28(3):389-403.

which is available as a NEURON implementation with a more realistic morphology at

https://senselab.med.yale.edu/modeldb/ShowModel.asp?model=127507

Run the interactive version by typing

>> interactiveDA

You will get the following prompts:
'Type a value in microS if you want a gNa value different than the default 550, otherwise hit return';
'Type a value in pA for Istim if you want to change it from the default 0, otherwise hit return';
'Type a value for fCa if you want to change it from the default 0.05, otherwise hit return';
'Type a value in seconds- hit return for default value 2 s ';
'Type R or r to restart from the end of the last simulation- hit return for default initial conditions';

Hitting return for each option will for the default settings reproduce control pacemaking observed in Figure 2a1 of Kuznetsova et al. 2010. You should see two windows appear, one showing the somatic membrane potential and the other showing the concentration of free calcium ions in the cytosol

1. Type interactiveDA again and set gNa to 0 and leaving the other settings at their default values to produce the slow oscillatory potential (SOP) in Figure 2f1 of the same paper.

2. In order to reproduce Figure 7.3 in this chapter, set fCa =0.02 and Istim= 100. First run the simulation with the default gNA, then set it to zero to reproduce the figure in its entirety. You will note that there will be an initial transient before the oscillation settles down to its steady waveform. This can be avoided by running the simulation twice, and the second time choosing the restart option.

3. Changing fCa at a given Istim value affects the frequency of the SOP, but does not affect the spiking rate much. Try comparing fCa=0.02 and 0.05 at Istim = 100, where the spike frequency is around 6 spikes per second, or at Istim =0 where the frequency is close to 2 spikes per second.

   Alternately you can edit dopamine.m and type

>> dopamine