Exercise 4:
Ball-and stick neuron: Rall versus Eccles

In this exercise you will use `NEURON`[1], together with its `Python` interface. You will be given an example file, `exercise_4.py` containing a ball-and-stick neuron, and a (virtual) patch clamp electrode that is used to inject a pulse current into the soma of the cell.

(i) We have (what we will pretend to be) experimental data from current injection into the soma of a neuron. The current injection starts at t=10 ms, and is held constant throughout the recording (200 ms). In Figure 1 you can see the *charging curve*, i.e. how the voltage responds to the injected current, and moves from its initial resting state of -65 mV, towards its new resting state at a more depolarized potential. This type of recording has been used to estimate the membrane time constant of neurons, and a dispute in neuroscience in the 1950s, was whether the dendrites of the neuron had a substantial impact on this charging curve. The group of John Eccles (`http://en.wikipedia.org/wiki/John_Eccles_(neurophysiologist)`) used a lone soma model to fit the charging curve, while Wilfred Rall (Figure 2, `http://en.wikipedia.org/wiki/Wilfrid_Rall`) argued for using a ball-and-stick model. In this exercise you will try to solve the dispute by comparing the normalized charging curves from our virtual 'experimental data' both to predictions from a lone soma model and from a ball-and-stick model. For more background information see Box 2.7 in Sterratt.

Use and modify the code in `exercise_4.py` to explore by visual inspection of the results whether the lone-soma model or the ball-and-stick model fit the (virtual) experimental data best.

(ii) Dendrites filter the incoming currents from other neuron, that is, *synaptic currents*. Here we will look at how synaptic currents, modeled here as a square current pulse with a duration of 5 milliseconds, are filtered by the ball-and-stick neuron.

Modify the stimulation duration in `exercise_4.py` and explore how the voltage response in the soma to this stimulus depends on the position of the current stimulation along the ball-and-stick dendrite. What happens to the somatic response as the input is moved farther away?

[1] If you are not familiar with `NEURON` and `Python` it might help to have a look at this site, which contains quite similar code to what we will be using: http://paedia.info/quickstart/pyneuron.html

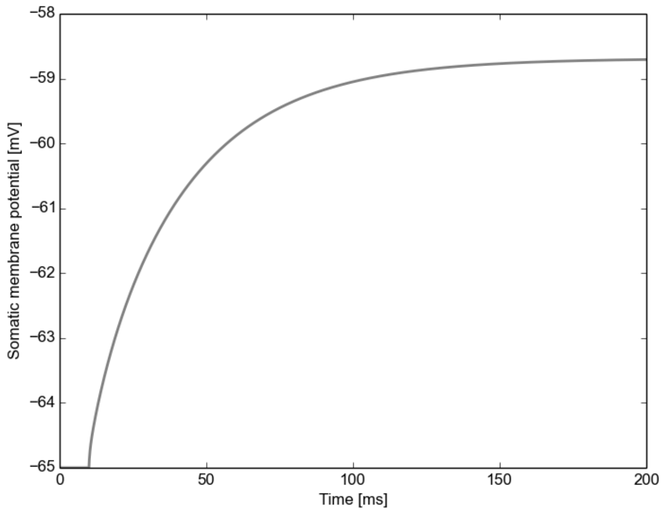

Figure 1: The charging curve of the soma in our (virtual) experimental neuron, following the injection of a constant current starting at $t = 10$ ms.

Figure 2: Gaute and his hero Wilfred Rall at the SfN meeting in Washington DC in 2014.

(iii) [**Optional**] If you would like to get more familiar with the Hodgkin-Huxley model, you can insert these conductances by simply writing `insert(''hh'')` instead of the already present `insert(''pas'')` (The `''hh''` contains its own passive mechanism). You should now be able to make the model spike.