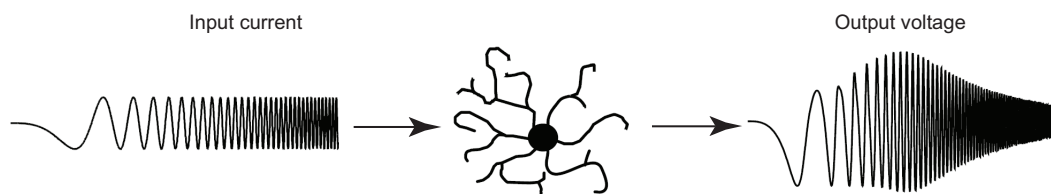


## Filtering properties of resonant dendrites

Dendrites form the major component of many neural cell types and provide contact area for synaptic inputs from other neurons. A large variety of different dendritic geometries combined with the biophysical properties of the dendritic membrane endow the cell with rich computational abilities. Dendritic integration of synaptic signals is believed to be an important process by which nerve cells encode synaptic input into spike output. Interestingly, the variety of active membrane conductances can not only boost or attenuate individual synaptic signals, but can also provide neural cells with the ability to respond selectively to inputs at preferred frequencies and support resonance. Neurons *in vivo* are bombarded with signals of both fast and slow frequency components due to synaptic background activity in the surrounding neural network, but often such complexity has to be omitted in experimental studies *in vitro*. As a result the nature of the dendrite-to-soma relationship in response to time-varying inputs is largely unknown.

The main goal of this project is to study the response properties of dendrites with resonant membranes to time-varying inputs (of periodic and chirp current waveforms). A theoretical model of the neuron based on cable theory will be used, consisting of a system of partial differential equations with appropriate boundary conditions (obeying Kirchoff's laws). Both uniform and nonuniform distributions of ion channels responsible for resonance (such as  $I_h$  channels) will be considered. The nonlinearity of such channel kinetics usually restrains the mathematical analysis in such models, however, under subthreshold conditions the resonant dynamics of the cell membrane can be adequately described by linearised currents. This will allow a more direct attack on the problem using a recently developed theoretical framework for calculating the Green's function for resonant dendrites. The study will focus particularly on the effect of dendritic geometry and heterogeneous distribution of active channels on the spatio-temporal filtering properties of such dendrites. Both idealised and more realistic geometry of the cell will be considered and the project will incorporate both theoretical and numerical components. It will be possible although not necessary to use the NEURON software (<http://www.neuron.yale.edu/neuron/>) which is a simulation environment widely used in the neuroscience community. The outcome of the project will be of interest to computational and experimental neuroscientists alike.



### Relevant papers:

- B Hutcheon and Y Yarom (2000) Resonance, oscillation and the intrinsic frequency preferences of neurons, *Trends in Neurosciences* 23, 216–222.
- D Ulrich (2002) Dendritic resonance in rat neocortical pyramidal cells, *Journal of Neurophysiology* 87, 2753–2759.
- S Coombes, Y Timofeeva, C-M Svensson, G J Lord, K Josic, S J Cox and C M Colbert (2007) Branching dendrites with resonant membrane: A “sum-over-trips” approach”, *Biological Cybernetics* 97, 137–149.