Box 1: An brief outline of the electro-biology of spike trains.

A: a neuron has three parts, the cell body or soma and two sorts of projections, the dendrites, which carry signals in to the soma and the much longer axons, which carry signals, in the form of spike trains from the soma, on to other neurons. Axon branches terminate at synapses which connected to the dendrites or soma of other neurons. When a spike arrives at a synapse a complex cascade of electrobiological events causes a small change in the potential at the post-synaptic site.

B gives a schematic sketch of two types of ion-selective gated channels. The transition probabilities of these channels have voltage-driven dynamics, this is crucial to the production of spikes. The potassium channel has two configurations, the sodium has three. When the potential inside the neuron approaches a threshold value more and more of the sodium channels open, going from the closed 1 to open configuration. This causes a diffusion-driven influx of positive sodium ions raising the potential further. Next, the potassium channels begin to open and the sodium channels change from the open to the closed 2 configuration, driving the voltage back down. The effect is a spike in the potential. Spikes are largely stereotypical in profile and propagate without dissipation along the axon.

C is a voltage plot for a Hodgkin-Huxley model simulation of a neuron. Rather than modelling the in vivo situation where the neuronal voltage changes in response to incoming spikes, this plot shows the effect of injecting current into the cell, an in vitro experiment commonly used to study cell responses. Here, the current is switched on at 0.01s and off again at 0.04s.

(A is taken from commons.wikimedia.org; B and the code used to produce C can be found at www.maths.tcd.ie/~mnl/rfp2009).

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Box 2: An brief outline of signaling in synapses.

A synapse. Above is the terminal button which terminates the axon; below is the dendritic spine, a small projection from the dendrite. These are separated by a tiny gap called the synaptic cleft. The button contains vesicles: membrane-bound packets of neurotransmitter. An arriving spike causes vesicles to release neurotransmitter into the cleft. Some then binds to receptors in receptor-gated ion-channels on the dendritic spine, opening the channels and changing the potential inside the dendrite. The unbound neurotransmitter in the cleft is re-absorbed. As the concentration falls the bound neurotransmitter unbinds and the ion-channels close again. (This image was modified from one in commons.wikimedia.org and is available at www.maths.tcd.ie/~mnl/rfp2009).