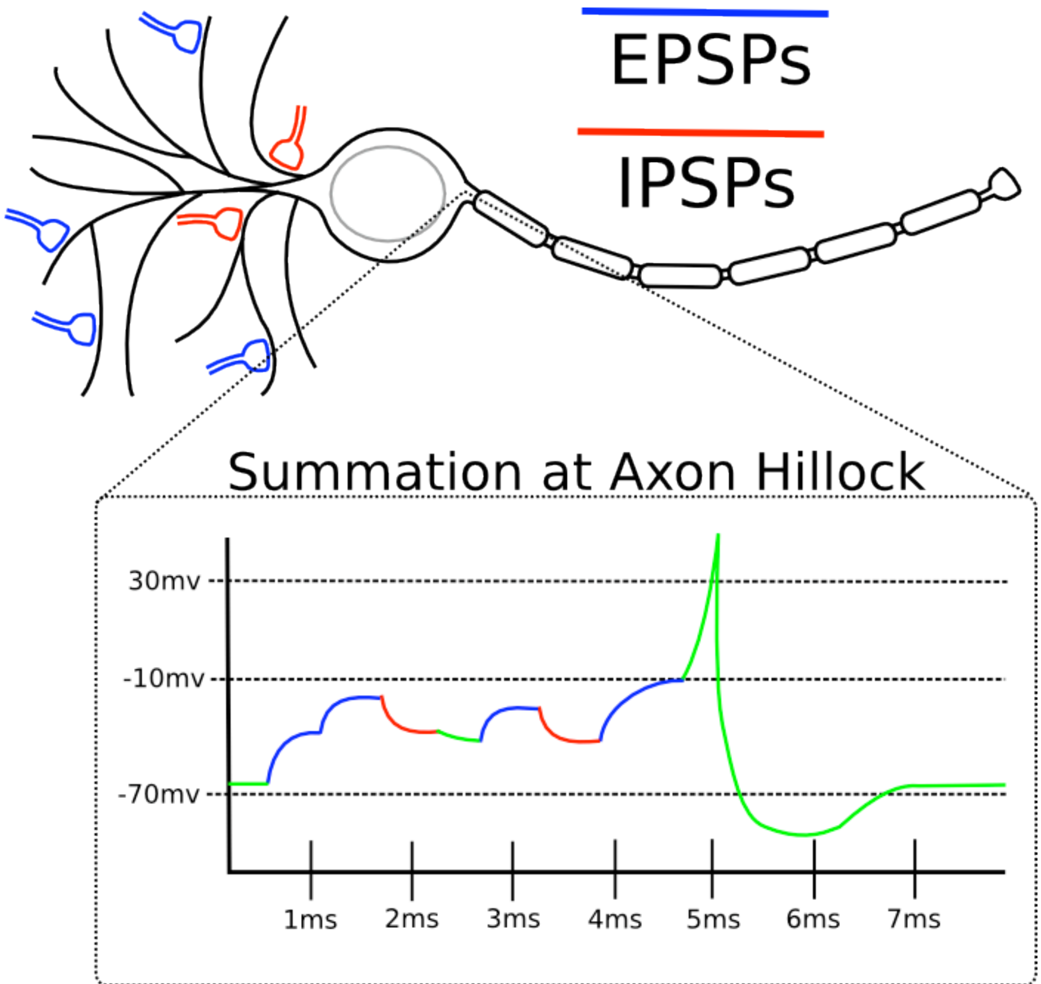

[Top] A diagram of the neuron with the dendrite on the left, the soma in the middle and the axon on the right. The red (IPSP) and blue (EPSP) inputs to the dendrites represent axon terminals from other neurons. The EPSP and IPSP signals propagate down the dendrites to the soma. The axon hillock is the anatomical part of the neuron that connects the cell body to the axon. It is the location where the summation of IPSPs and EPSPs occurs. [BOTTOM] The summation of inhibitory and excitatory postsynaptic potentials. The excitatory inputs cause the membrane potential to increase (blue) and the inhibitory inputs cause the membrane potential to decrease (red). Once the membrane reaches threshold (-10mV) the cell will produce an action potential (4.7 msec).

Excitatory Postsynaptic Potentials (EPSP)

An excitatory postsynaptic potentials (EPSP) is a temporary depolarization of postsynaptic membrane caused by the flow of positively charged ions into the postsynaptic cell as a result of opening of ligand-sensitive channels. An EPSP is received when an excitatory presynaptic cell, connected to the dendrite, fires an action potential. The EPSP signal is propagated down the dendrite and is summed with other inputs at the axon hilllock. The EPSP increases the neurons membrane potential. When the membrane potential reaches threshold the cell will produce an action potential and send the information down the axon to communicate with postsynaptic cells. The strength of the EPSP depends on the distance from the soma. The signal degrades across the dendrite such that the more proximal connections have more of an influence.

Inhibitory Postsynaptic Potentials (IPSP)

An inhibitory postsynaptic potentials (IPSP) is a temporary hyperpolarization of postsynaptic membrane caused by the flow of negatively charged ions into the postsynaptic cell. An IPSP is received when an inhibitory presynaptic cell, connected to the dendrite, fires an action potential. The IPSP signal is propagated down the dendrite and is summed with other inputs at the axon hilllock. The IPSP decreases the neurons membrane potential and makes more unlikely for an action potential to occur. A postsynaptic cell typically has less inhibitory connections but the connections are closer to the soma. The proximity of the inhibitory connections produces a stronger signal such that fewer IPSPs are needed to cancel out the effect of EPSPs.

Spiking Dynamics

The membrane potential and spiking rate are dependent on a cells biophysical mechanism and the interaction of the cells internal and external voltage. Hodgkin and Huxley (1952) have introduced a standard model to describe the dynamics of cell's membrane potential. That model, described in terms of differential equations, tends to be computationally slow. Over the years, several other simplified spiking models have been designed. Although the later models are faster, they are less accurate than the Hodgkin and Huxley model. In this demonstration the Izhikevich resonate-and-fire model is used. This spiking model is used because it is faster than quadratic firing models and more biologically accurate than integrate and fire models.