**How is the action potential produced?**

All cellular membranes are electrically charged due to the concentration of ions present in the extracellular and intracellular space. For neurons, sodium ions (Na+) and chlorine ions (Cl+) exists in large quantities in the extracellular space while the intracellular space contains many potassium ions (K+) and other organic anions (A+). The cell membrane contains ion channels that regulate the passing of these various ions between the inside and outside of the cell. When the cell is at the resting potential (-70mV), the intracellular space is more negative relative to the extracellular space and the voltage-dependent Na+ and K+ channels are closed (see picture below).

The opening of Na+ channels is triggered by the reduction of the membrane potential (depolarization) to the threshold of excitation. Once the ion channels open, the action potential begins as electrostatic pressure and the force of diffusion drive Na+ into the cell. The entry of positively-charged ions into the cell actually reverses the electrical potential from a negative potential to a positive one, (i.e., the inside becomes positive). This depolarization is produced by the entry of Na+, which subsequently causes the K+ channels to open. The force of diffusion drives K+ out of the cell. In about 1 millisecond, the membrane potential reaches +40mV because of the many Na+ ions entering the cell.

The entry of positively charged ions into the cell reduces the membrane potential to an extent that causes the inside to become positive. The depolarization caused by the entry of Na+ causes the K+ channels to open and the force of diffusion drives K+ out of the cell. In about 1 millisecond, the membrane potential reaches +40mV because of the Na+ entering the cell. At this point, the Na+ channels become blocked (refractory) and Na+ cannot enter the cell anymore. But the K+ channels remain open and are continually pumping K+ out of the cell. The outflow of K+ helps to bring the membrane potential back to its resting value. Once the resting potential is reached, the K+ channels close. As you can see from picture below, the membrane actually overshoots the resting potential (hyperpolarization) and there is an excess of K+ outside of the membrane. The resting potential returns to -70mV as the excess K+ diffuses away (repolarization).

<http://www.macalester.edu/academics/psychology/whathap/ubnrp/meth08/biochemistry/neurotransmission.html>

A more general understanding of this process is that at 1. **resting potential**: sodium ions are on the outside of the axon and potassium ions on on the inside. The overall charge inside the axon is (-) compared to the outside of the axon which is (+); during

2. **action potential**: segments of the axon switch charges in a wave-like fashion; going from a negative to positive charge; 3. during the **refractory period** new sodium ions cannot enter the cell and potassium ions flow out in order to help bring the neuron back to resting potential. (So the inside of the axon goes from from a negative charge (resting) to a positive charge sequentially (action); then back to negative again (refractory, then resting)).

