Lights, Camera, Action Potential

https://faculty.washington.edu/chudler/ap.html

Much of what we know about how neurons work comes from experiments on the giant axon of the squid. This giant axon extends from the head to the tail of the squid and is used to move the squid’s tail. How giant is this axon? It can be up to 1 mm in diameter - easy to see with the naked eye.

Neurons send messages **electrochemically**. This means that chemicals cause an electrical signal. Chemicals in the body are “electrically-charged” -- when they have an electrical charge, they are called **ions**. The important ions in the nervous system are sodium and potassium (both have 1 positive charge, +), calcium (has 2 positive charges, ++) and chloride (has a negative charge, -). There are also some negatively charged protein molecules. It is also important to remember that nerve cells are surrounded by a membrane that allows some ions to pass through and blocks the passage of other ions. This type of membrane is called **semi-permeable**.

**Resting Membrane Potential**

When a neuron is not sending a signal, it is “at rest.” When a neuron is at rest, the inside of the neuron is negative relative to the outside. Although the concentrations of the different ions attempt to balance out on both sides of the membrane, they cannot because the cell membrane allows only some ions to pass through channels (ion channels). At rest, potassium ions ($K^+$) can cross through the membrane easily. Also at rest, chloride ions ($Cl^-$) and sodium ions ($Na^+$) have a more difficult time crossing. The negatively charged protein molecules ($A^-$) inside the neuron cannot cross the membrane.
In addition to these selective ion channels, there is a **pump** that uses energy to move three sodium ions out of the neuron for every two potassium ions it puts in. Finally, when all these forces balance out, and the difference in the voltage between the inside and outside of the neuron is measured, you have the **resting potential**. The resting membrane potential of a neuron is about -70 mV (mV=millivolt) - this means that the inside of the neuron is 70 mV less than the outside. **At rest, there are relatively more sodium ions outside the neuron and more potassium ions inside that neuron.**

![Graph showing Resting Potential](image)

**Action Potential**

The resting potential tells about what happens when a neuron is at rest. An **action potential** occurs when a neuron sends information down an axon, away from the cell body. Neuroscientists use other words, such as a "spike" or an "impulse" for the action potential. The action potential is an explosion of electrical activity that is created by a **depolarizing current**. This means that some event (a stimulus) causes the resting potential to move toward 0 mV. When the depolarization reaches about -55 mV a neuron will fire an action potential. This is the **threshold**. If the neuron does not reach this critical threshold level, then no action potential will fire. Also, when the threshold level is reached, an action potential of a fixed sized will always fire...for any given neuron, the size of the action potential is always the same. There are no big or small action potentials in one nerve cell - all action potentials are the same size. Therefore, the neuron either does not reach the threshold or a full action potential is fired - this is the "ALL OR NONE" principle.

![Graph showing Action Potential](image)

Action potentials are caused when different ions cross the neuron membrane. A stimulus first causes sodium channels to open. Because there are many more sodium ions on the outside, and the inside of the neuron is negative relative to the outside, sodium ions rush into the neuron. Remember, sodium has a positive charge, so the neuron becomes more positive and becomes depolarized. It takes longer for potassium channels to open. When they do open, potassium rushes out of the cell, reversing the depolarization. Also at about this time, sodium channels start to close. This causes the action potential to go back toward -70 mV (a repolarization). The action potential actually goes past -70 mV (a hyperpolarization) because the potassium channels stay open a bit too long. Gradually, the ion concentrations go back to resting levels and the cell returns to -70 mV.
And there you have it...the Action Potential...be sure you can DRAW, LABEL and DESCRIBE these models!