Lecture 7, Jan 31, 2023

Energy Needed for Active Transport

- About 40% of ATP generated by cells is purely dedicated to the sodium-potassium-ATPase pumps

Membrane Potential Continued

- *Depolarization* is when the resting membrane potential becomes less negative than normal (closer to zero), resulting in a positive change
  - After depolarization, the membrane undergoes *repolarization* to return to the normal potential in a negative change
- *Hyperpolarization* is when the resting membrane potential becomes more negative than normal, resulting in a negative change
- Depolarization/repolarization/hyperpolarization occurs due to gated ion channels; these are normally closed, but when ligands attach to them, they allow ions to flow through
  - The gated channels are all over the cell body
  - Ligands are also known as neurotransmitters
- These gated channels and ligands allow graded potentials to propagate
  - When a ligand attaches to a gated channel, sodium ions are able to come into the cell; due to the positive ions coming in, there is a little bit of depolarization around the channel
  - When the ligand is gone, positive ions on the outside of the cell move to fill the holes on the outside, and the sodium on the inside move to the negative potential
  - The result is that the depolarization spreads out in a gradient; the potential returns to normal about 1 mm away
- Voltage-gated ion channels respond to voltage differences
  - Sodium channels have 3 different states: closed but capable of opening, open (active, happens rapidly), or closed and not capable of opening for some time
  - Potassium channels are either closed or open (takes some time to close)
  - These are located on the axon hillock (the trunk), and not everywhere over the cell like ligand-gated channels
- If graded potentials transmit to the axon hillock, they will cause a small depolarization followed by a repolarization at the voltage-gated channels; more neurotransmitters cause a larger depolarization
  - If we have enough neurotransmitters to cause a depolarization above the *threshold*, all these voltage-gated ion channels open quickly
  - First the sodium channels open and cause rapid depolarization; then they close and the potassium channels open and cause rapid repolarization and a little hyperpolarization; then finally both channels are closed and everything returns to normal
  - The duration where the channels are inactive is called the *absolute refractory period*
    * This starts at where the potential crosses the threshold for the first time and ends where the potential is below the threshold again
    * In this period stimulation cannot occur
  - Once the potential is below the threshold again and until the potential returns to normal from hyperpolarization, this is called the *relative refractory period*
    * In this period it is difficult to stimulate the cell, but not impossible

Neuron Structure

- Dendrites are branch like structures coming out of the neuron
- The soma is where the nucleus lives
- The axon is the long cable part
- The axon branches out into terminal end bulbs
- The membrane is along the axon and there are voltage gated sodium and potassium channels along it
  - A signal would start at the axon hillock, and travel along the axon
  - A signal that travels one step at a time this is referred to as *contiguous*

  - *Saltatory* signals travel instead in big leaps – this is possible due to myelin sheaths in the neuron
    * The myelin sheaths wraps around the axon; there are bare spots where the axon is exposed (*nodes*), and in every other spot the axon is enclosed
    * The voltage gated sodium and potassium channel are at the nodes
    * Saltatory conduction travels from one node to another, which makes the signal travel much faster
- The factors that affect the speed of propagation are the degree to which myelin sheaths cover the axon, the axon diameter and the temperature