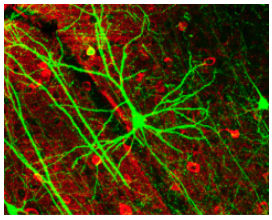
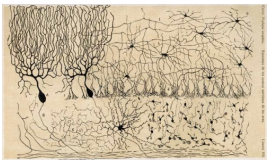
Notes: Neuron

Stained Florescent Microscopy	Hand Drawing (Ramon y Cajal)	Computer Graphic
		
Source: http://phys.org/news175417796.html	Source: http://nobelprizewatch.wordpress.com/2011/12/06/	Source: http://thetechjournal.com/science/neuron-implantation-can-rewire-brain-itself.xhtml

Background

Functional unit of nervous system

A cell specialized for the _____ and _____ of signals

____ billion in adult human brain (source)

Uses _____ and _____ systems to communicate

	In central nervous system	In peripheral nervous system
clusters of cell bodies		
bundles of axons		

Cell basics

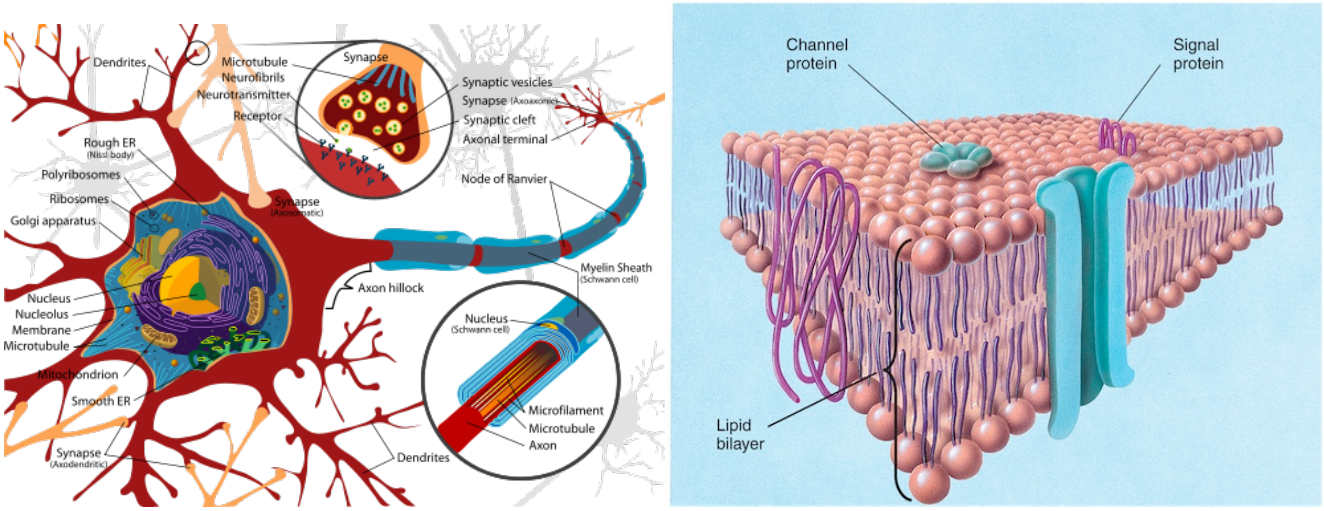
Nucleus & DNA

Membrane

Organelles

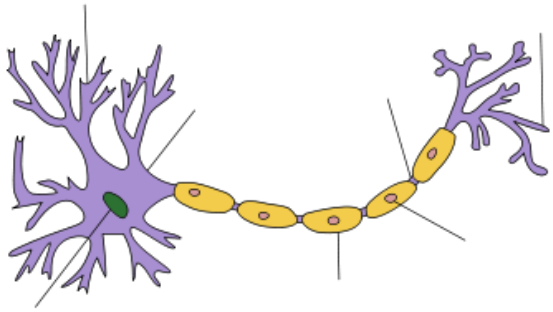
Mitochondria

Energy metabolism: constant need for _____ and _____



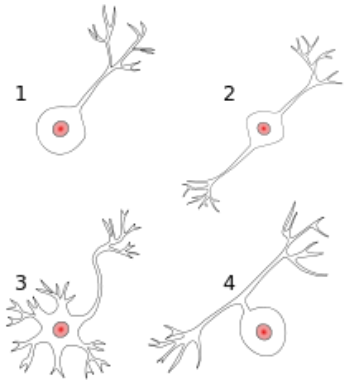
Sources: http://en.wikipedia.org/wiki/Neuron#Anatomy_and_histology (left), Pinel (right)

Structures for communication



Source: http://en.wikipedia.org/wiki/Neuron

Types of neurons



http://en.wikipedia.org/wiki/Neuron#Functional_classification

Glial Cells

Support cells
Generally outnumber neurons (as much as 10:1 in some parts of the brain)

Oligodendrocytes
- myelin extensions wrap around axons in central nervous system
- provides myelin to multiple neurons

Schwann cells
- provides myelin in peripheral nervous system
- 1 Schwann cell per axon
- can aid in regeneration

Microglia
- aid in recovery, part of inflammation process

Astrocytes
- historically seen as "glue" or support cells
- increasingly recognized for communication abilities
- part of blood-brain-barrier and may regulate blood flow
- recycle neurotransmitters

Resting Potential

Where is this going:
- The neuron is going to rapidly move ions across its membrane
- It spends the energy in advance to setup for this action

Potential

Energy that is available to do work
Ball at top of slope, spring, laptop battery

Chemical gradients

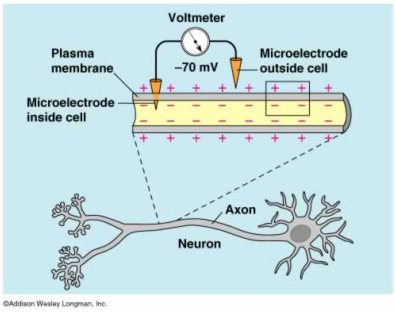
Example of non-charged particles diffusing across barrier to reach equilibrium

Concentration gradient - the "downhill" change in concentration

Electrical gradients

Ions - molecules that carry a negative or positive charge

Electrostatic pressure - the force pushing molecules down the gradient (space below is intentionally blank for drawing)

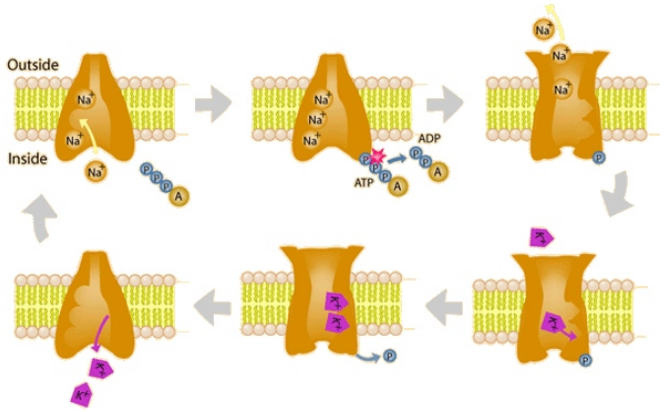


Source: http://www.anselm.edu/homepage/jpitocch/genbio/nervousnot.html

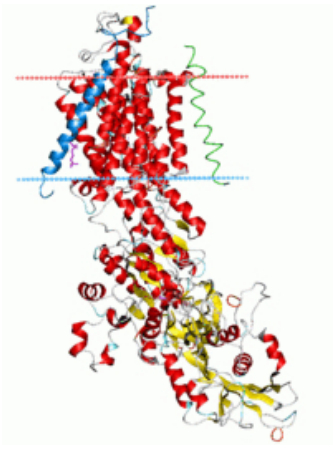
Sodium-Potassium Pump

A pump that moves _____ out and _____ in by using _____

(The brain uses about 20% of your daily calories, this is a major component)



Source: http://hyperphysics.phy-astr.gsu.edu/hbase/biology/nakpump.html



Not really a pump, but just a _____

Source: http://en.wikipedia.org/wiki/Na%2B/K%2B-ATPase

Channels

Proteins embedded in the membrane that allow molecules to _____ diffuse through

Voltage-gated channels - open and close in response to _____

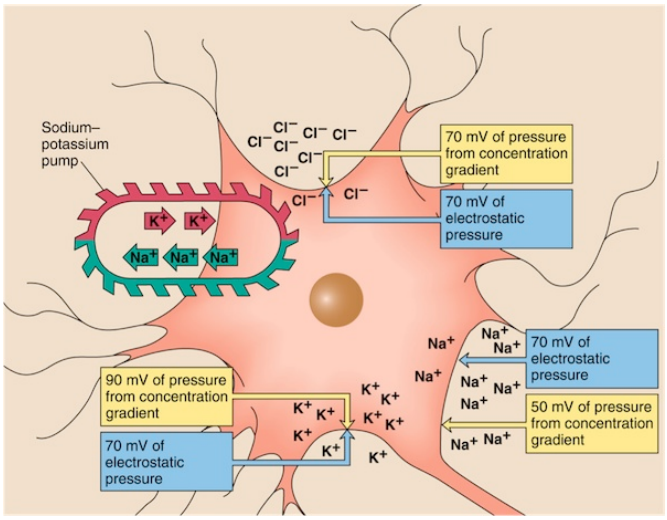
Ligand gated - open and close in response to _____

Na+ channel - _____ at negative potentials, slower/faster to respond

K+ channels - _____ at negative potentials, slower/faster to respond

Neuron's Resting Potential

Typical resting potential is _____



Sodium (Na+)

Potassium (K+)

Chloride (Cl-)

Organic anion (A-)

Source: http://academic.uprm.edu/~ephoebus/id81.htm

Action Potential

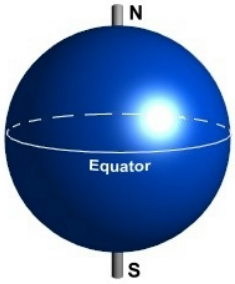
Where we are going:

- How does a signal get passed down the neuron (along the axon)
- A sequence of events that disrupts the resting potential

Post-synaptic potentials

- Axon terminals release neurotransmitters
- These neurotransmitters react with receptors on the next neuron
- Can cause the neuron to depolarize or hyperpolarize

Polarization



Source: http://www.polaris.iastate.edu/NorthStar/Unit1/activity1.htm

Depolarization

Hyperpolarization

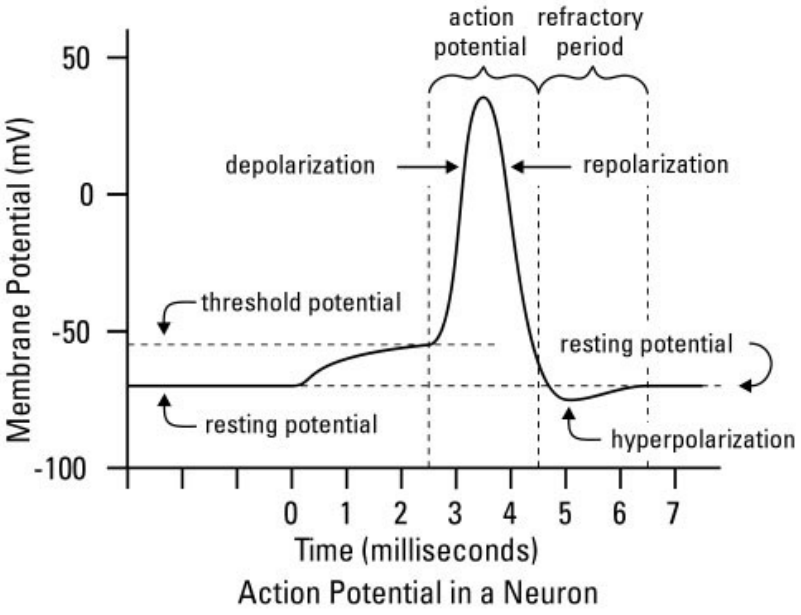
Sub-threshold depolarization

Does NOT make membrane potential more positive than threshold (typically -65 mV)
A little Na+ comes in, making the potential more positive
K+ is pushed out by the incoming Na+ and the NaK pump is still working, so returns to resting potential

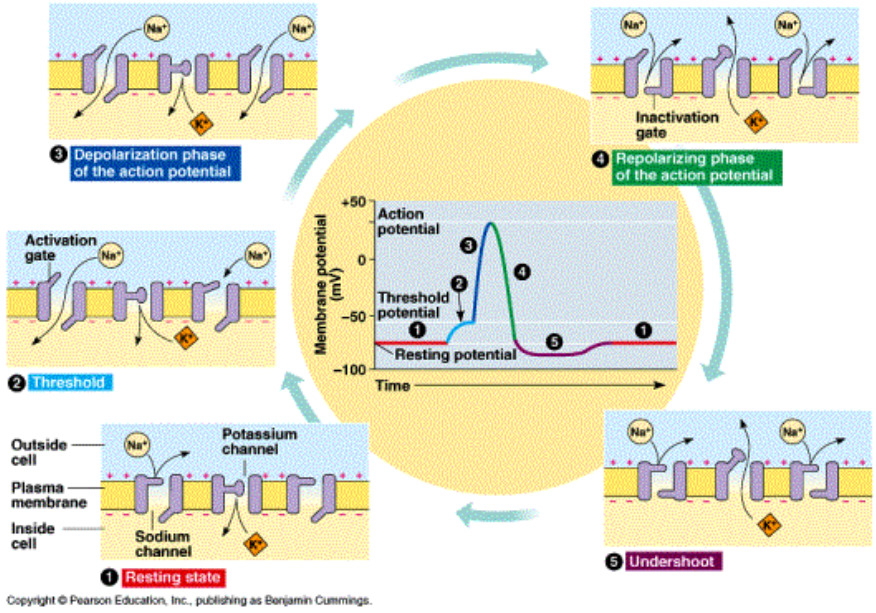
Above-threshold depolarization

DOES make membrane potential more positive than threshold (typically -65 mV)
As it depolarizes, more and more sodium channels open
Na+ starts coming in faster and faster, creating positive feedback
Full action potential occurs
Total number of ions flowing through membrane is relatively small, so concentrations do not change much

Stages



Source: http://www.dummies.com/how-to/content/understanding-the-transmission-of-nerve-impulses.html



Source: http://www.msdellasantina.com/Files%20AP/Ch%2048%20Neurons%2006_files/slide0078_image046.gif

Depolarization / rising phase

becoming more positive as Na+ channels open

with all channels open, Na+ pushes potential up to +50 mV

Repolarization

at maximum positive voltage, Na+ channels close & no-longer voltage sensitive

K+ channels eventually fully open

K+ pushes out until voltage goes negative

Undershoot

With K+ fully open, potential goes more negative than resting

Once K+ go back to mostly-closed-but-leaky, returns to resting potential

Refractory Period

Immediately after firing, another depolarization will not trigger an action potential

absolute refractory period - no action potential possible

relative refractory period - action potential requires stronger depolarization

a few milliseconds long

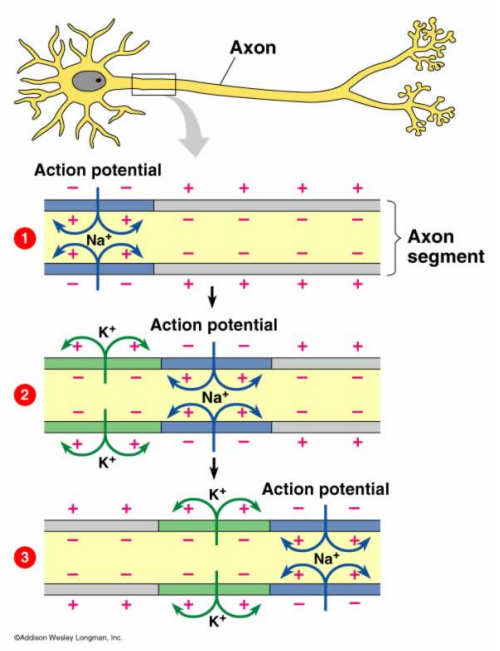
Where in the neuron

Starts at axon hillock (typically)

Travels down axon

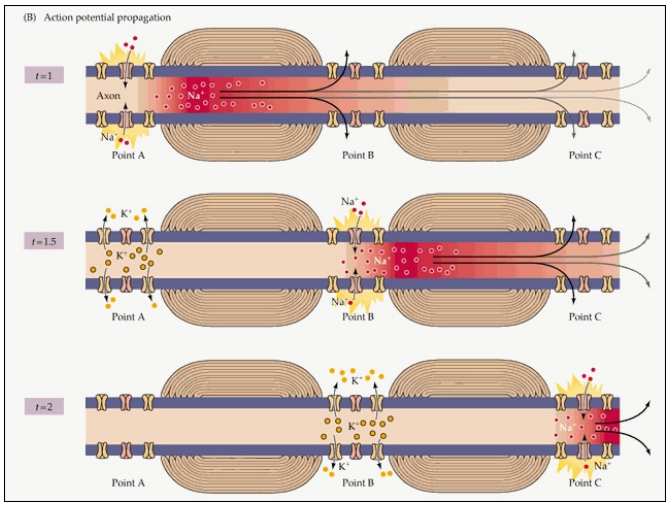
Triggers events at axon terminals

Does not automatically pass into next neuron



Source: http://www.anselm.edu/homepage/jpitocch/genbio/nervousnot.html

Saltatory conduction



Source: http://psych.hanover.edu/classes/sensation/WebNotes/Class04-2010.html

Myelin covers most of neuron with a few gaps
Ions only exchange across membrane at these gaps
For reasons related to particle diffusion, this is faster than continuous conduction

Myelinated neurons (e.g. motor neurons) - 100 m/s
Unmyelinated neurons - 1 m/s

Principles

All-or-none

One directional

Electrical

Fast

Active vs. Passive