Notes: Neuron

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

<table>
<thead>
<tr>
<th>In central nervous system</th>
<th>In peripheral nervous system</th>
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</thead>
<tbody>
<tr>
<td>clusters of cell bodies</td>
<td></td>
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<tr>
<td>bundles of axons</td>
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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**
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)
**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 _______________


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**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 ___________

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

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**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**
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
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

Saltatory conduction
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