1. Intro Nervous System Fn
   (slides 32-60 from Mon 28 Jan; Ch10)
2. Neurons & Action Potentials (Ch11)
   (slides in this file)

http://eebweb.arizona.edu/eeb_course_websites.htm
**Nervous System**

- **Synapse**
  - Presynaptic
  - Postsynaptic

1. **Sensory Neurons**
   - receive stimuli
2. **Interneurons**
   - entirely in CNS
3. **Motor Neurons**
   - effector organs incl. muscle, gland
   - Presynaptic
   - Postsynaptic

**Action Potential**

- All-or-None from spike-initiating zone
- Changes in ion permeability...
- Changes in membrane potential

- Voltage-gated ion channels vs. ligand-gated
- Na⁺, K⁺, (Ca²⁺)

**Frequency and number**

- Moves information; high-speed communication
- Thoughts, Sensations, Memories, Movements etc.
- Moves SIGNAL without decrement
- AP possible because:
  1. Ionic gradients across membrane
  2. Creates electrochemical gradient and therefore source of potential energy
  3. When ion channels open, ions move down their electrochemical gradients and rapidly change the membrane potential (V_m)
- Na⁺ and K⁺ responsible for AP character...

**Lambda** = length constant
(distance at which 37% voltage change)
- Threshold
- Voltage gated
- Many channels for Na+
- Then many channels for K+

+60 vs. -100 emf

Membrane Potential

Terms:
- Hyperpolarization 1 and 2
- Depolarization 3 and 4
- Threshold Potential 3 and 4

Hyperpolarization

Depolarization

Threshold Potential

Terms:
- Hyperpolarization 1 and 2
- Depolarization 3 and 4
- Threshold Potential 3 and 4

Examples of ion channels depicted above:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Characteristics</th>
<th>Selectivity/Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺ channel</td>
<td>Channel open, Na⁺ flows into cell</td>
<td>Facilitates the conducting of AP</td>
</tr>
<tr>
<td>Voltage-gated Na⁺ channel</td>
<td>Rapidly opened by depolarization</td>
<td>Responsible for the rising phase of AP</td>
</tr>
<tr>
<td>Voltage-gated Ca²⁺ channel</td>
<td>Actively inhibited by depolarization</td>
<td>Produces the depolarization phase of AP</td>
</tr>
<tr>
<td>Voltage-gated K⁺ channel</td>
<td>Actively inhibited by hyperpolarization</td>
<td>Produces the repolarization phase of AP</td>
</tr>
<tr>
<td>GABA-dependent K⁺ channel</td>
<td>Actively inhibited by hyperpolarization</td>
<td>Produces the repolarization phase of AP</td>
</tr>
</tbody>
</table>

Hill et al. 2004, Fig. 11.11

Hill et al. 2004, Fig. 11.12

Action Potential

Hill et al. 2004, Fig. 11.12
Voltage-gated Na+ channels

local current flow causes Vm change

AP is regenerative

Voltage-gated Na+ channels

Hodgkin Cycle (~Feed Forward)

Initial depolarization

Further membrane depolarization

Opening of voltage-gated Na+ channels increases P_{Na}

(c) Increased Na+ flow

Refractory Periods

- Absolute
- Relative

~ Toilet Analogy...

How would you make the membrane in the axon hillock/spike initiation zone more, or less, likely to send an AP?
- Role of local current flow

- But can see local graded potential diminishing

- Receptor potential is graded and decremental

- Magnitude of graded receptor potential determines frequency of APs (~all of the same size)

- Neurotransmitter Release

- Alternate between graded psp's and all-or-none APs

\[ \text{psp} = \text{postsynaptic potential} \]
EPSP and IPSP

Excitatory or Inhibitory Postsynaptic Potentials

Graded current causing graded potential:

Na⁺, Ca²⁺, K⁺, Cl⁻

EPSP

IPSP

psp

Integration

Reversal Potential

Opening channel for a given ion species X means V_{m} will move toward E_{X}

E_{rev} is the reversal potential

Can’t change membrane potential beyond E_{rev} for a given ion(s) and its channels

Use Nernst to calculate for one ion species

Goldman equation for multiple ions

ACh opens for K⁺ and Na⁺, so E_{rev} between E_{K} and E_{Na}

Synaptic Efficacy

Presynaptic inhibition

e.g., Cl⁻, K⁺ or alter Ca²⁺

NT release via exocytosis: the role of Ca²⁺
-How increase conduction velocity?

1 - Diameter

2 - Insulation

-Long axons require insulation (support cells)
-glial cells for myelination (fatty tissue) aka:

-Schwann cells in peripheral nerves
-Oligodendrocytes in CNS

Multiple sclerosis caused by demyelination