1. Neurons & Synapses (Ch11&12)
   (finish slides posted for 30 Jan 2008)

http://eebweb.arizona.edu/eeb_course_websites.htm
In conjunction with 2 or 3 students around you, explain how a change in the postsynaptic membrane potential from -70 to -65 could actually be inhibitory.

(Assume that -70 is resting and that -50 is threshold for an AP.)

-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
A given nerve bundle can have multiple axons, each with different conduction velocities.

**SYNAPSES**
- communication between neurons
  or between neuron and effector organ

1. electrical (rapid)
2. chemical ('fast' or slow)

In postsynaptic neuron:
1. De- or hyper-polarize
2. Change # ion channels in membrane
3. Alter rate of ion channel activity
4. Modify sensitivity to activation signals

**Electrical Synapse (rapid)**
- direct ionic coupling via gap junctions
  - examples in retina, CNS, smooth muscle, cardiac muscle, etc.

**Chemical (neurotransmitter)**
20-30nm apart

1. amplify
2. excitatory or inhibitory
3. one-way
4. modifiable
TABLE 13.1 Kinds of synapses

<table>
<thead>
<tr>
<th>Mechanism and time course function effect</th>
<th>Characteristic</th>
<th>Chemical synapse</th>
<th>Electrical synapse</th>
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</thead>
<tbody>
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<td>Mechanism and time course function effect</td>
<td>Chemical synapse</td>
<td>Electrical synapse</td>
<td></td>
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<tr>
<td>Fast, ionotropic</td>
<td>Slow, metabotropic</td>
<td>Instantaneous current flow</td>
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<tr>
<td>Excitation (EPSP), inhibition (IPSP)</td>
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<td>Neurotransmitter modulation</td>
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NT role depends primarily on receptor characteristics on postsynaptic neuron

1. Fast and direct
   1. Nicotinic (muscles, autonomic/sympathetic NS)

2. Slow and indirect
   2. Muscarinic (parasympathetic, indirect)

Bitten 11 Sept 2001, died 12 Sept 2001

Joe Slowinski
Myanmar/Burma
Bungarus multicinctus
Multibanded Krait
alpha bungarotoxin
nicotinic ACh receptor antagonist
Postsynaptic Neurotransmitter Effects
1. Fast and direct  e.g., fast nicotinic ACh receptors

Acetylcholinesterase
Hill et al. 2004, Fig 12.10, 12.7

How do we study these receptors?
Patch-clamp technique

Neuromuscular Junction
Ionotropic
Quantal packets (~5,000 ACh/vesicle)

Ionotropic
Acetylcholinesterase
Hill et al. 2004, Fig 12.10, 12.7

Nicotinic ACh receptor

Postsynaptic Neurotransmitter Effects
1. Fast and direct  e.g., fast nicotinic ACh receptors

ACh binds alpha subunits

Randall et al. 2002

ACh binds alpha subunits

Randall et al. 2002

Hill et al. 2004, Fig 12.16

Hill et al. 2004, Fig 12.16

Hill et al. 2004, Fig 12.7

Hill et al. 2004, Fig 12.10, 12.7
Agonist (mimics)
(e.g., heroin mimics natural opiates)

vs.

Antagonist (blocks)
(e.g., curare blocks ACh reception)
Hill et al. 2004, Fig. 11.17

Voltage-gated channel superfamily

4 different domains

4 identical subunits

Hill et al. 2004, Fig. 11.18

Voltage-gated Channels

Proposed Evolution

Neurotransmitters:

1. small-molecule neurotransmitters
   (often made in axon terminals; common)

2. neuroactive peptides
   (often made in soma and shipped down axon)

Nematodes use a lot of the same neurotransmitters.

Synaptic Plasticity

• Change synaptic efficacy
• Alter rate of NT production and release

• Learning and Memory

• Facilitation vs. antifacilitation/depression

• Retrograde messengers (i.e., NO)

• Calcium-dependent
  - Research on-going

TABLE 13.3 Some neurotransmitters and receptors of vertebrate central nervous systems

These lists are not exhaustive: there are many more transmitters, and many receptors for each transmitter.
Long-term Potentiation

- Often in Hippocampus
  - Site of Learning and Memory

- “Neurons that fire together wire together”

- NMDA glutamate receptors...

NMDA = N-methyl-D-aspartic acid

Genetic engineers upregulated production of juvenile subunit of NMDA receptor in adult mice (Doogie mice).

Ethical?

Should we do this in humans or other animals?

Under what conditions?