BI 121 Lecture 13

I. Announcements
No lab today – Study for Exam II!!
Optional Lab notebook check after last Lab 6, Mac pulmonary function testing (PFT) next Thursday. Q?

II. CNS Connections
Protect your head with a helmet!
Bicycle head injury statistics, NHTSA & BHSI, 2011 data

III. Peripheral Nervous System
LS sections of ch 3, 4, & 7
A. Autonomic NS: Branches, neurotransmitters, receptors, actions, fight-or-flight stories ch 7 pp179-85
B. Why are nerve & muscle unique? ch 4 p 71
C. How do excitable cells signal? ch 3 pp62-7; ch 4 pp74-83
D. How does the signal cross the nerve-muscle gap?
   ch 7 p 185-92 fig 7-5 p 190
   1. Ca2+ bones!…but what else? p 190
   2. What do black widow spider venom, botulism, curare & nerve gas have in common? Botox pp 189-92
Helmets Cheap, Brains Expensive!!
Use Your Head, Get a Helmet!!
http://www.bhsi.org/stats.htm

~540,000 bicyclists/yr visit emergency rooms
67,000 head injuries, 1 in 8 brain injuries
677 cyclists died in 2011 ≡ 2% of all traffic fatalities
9% of deaths children ≤ 14 yr, 69% σ
> 54,000 cyclists have died since 1932

As of 2012, the population of
  Albany, OR  51,322
  Corvallis, OR  54,998
  Springfield, OR  59,869

Bicycle crashes & injuries are under reported,
since majority not serious enough for ER visits.

Helmets may reduce head & brain injury risk by 66-88%!
~$81 million/yr = direct injury costs from not using helmets!
The "typical" bicyclist killed on our roads is a sober male over 16 riding without a helmet. He's hit by a car on a major road between intersections in an urban area on a summer evening. Please wear a helmet – it can make the difference between life and death.
Stories, Discussion, Questions or Comments!
Why overlap or dual innervation?

Fine-tune control & safety!

cf: LS 2012 fig 7-3
PARASYMPATHETIC = RESTING, DIGESTIVE, HOUSEKEEPING FUNCTIONS
FIGHT/FLIGHT/ALARM REACTION!!

BI 121 + other finals!
Homeostasis is a dynamic balance between the autonomic branches.

- **Parasympathetic**
  - Rest-and-digest: Parasympathetic activity dominates.

- **Sympathetic**
  - Fight-or-flight: Sympathetic activity dominates.
Autonomic Neurotransmitters & Receptors

**Cholinergic**
- Nicotinic
- Muscarinic

**Adrenergic**
- $\alpha = \text{Alpha}$
- $\beta = \text{Beta}$

G&H 2011 p 731-3
Autonomic Nerves: Two Chain Pathway with Post-Ganglionic Varicosities

1. Preganglionic fiber
2. Postganglionic fiber

Central nervous system

Autonomic ganglion

Postganglionic neurotransmitter

Varicosity

Effector organ

LS 2012 fig 7-1
**Parasympathetic**

 Ach = Acetylcholine

Parasympathetic Norepinephrine

NE = Norepinephrine

\[ \text{ TEN } = \alpha\text{ Receptor (}\alpha_1, \alpha_2) \]

\[ \downarrow \text{ = } \beta\text{ Receptor (}\beta_1, \beta_2) \]

**Sympathetic**

 Ach = Acetylcholine

Sympathetic Norepinephrine

NE = Norepinephrine

\[ \text{ TEN } = \alpha\text{ Receptor (}\alpha_1, \alpha_2) \]

\[ \downarrow \text{ = } \beta\text{ Receptor (}\beta_1, \beta_2) \]
Nicotine activates both Sympathetic & Parasympathetic post-ganglionic neurons!

Problem?

Like hammering the gas pedal & brake at the same time!!
Autonomic Nervous System Innervation
In Sympathetic Fight-or-Flight why is it important to activate the adrenals?
80% Epinephrine/Adrenaline (E)  
20% Norepinephrine (NE)

Hormonal Adrenaline Surge Reinforces Nervous Outflow & Accesses Tissues Not Directly Innervated!!

Output to blood

Adrenals = Paired organs above kidneys
## Table 7-1 Effects of Autonomic Nervous System on Various Organs

<table>
<thead>
<tr>
<th>Organ</th>
<th>Effect of Sympathetic Stimulation</th>
<th>Effect of Parasympathetic Stimulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>Increases heart rate and increases force of contraction of the whole heart</td>
<td>Decreases heart rate and decreases force of contraction of the atria only</td>
</tr>
<tr>
<td>Blood Vessels</td>
<td>Constricts</td>
<td>Dilates vessels supplying the penis and the clitoris only</td>
</tr>
<tr>
<td>Lungs</td>
<td>Dilates the bronchioles (airways)</td>
<td>Constricts the bronchioles</td>
</tr>
<tr>
<td>Digestive Tract</td>
<td>Decreases motility (movement)</td>
<td>Increases motility</td>
</tr>
<tr>
<td></td>
<td>Contracts sphincters (to prevent forward movement of tract contents)</td>
<td>Relaxes sphincters (to permit forward movement of tract contents)</td>
</tr>
<tr>
<td>Urinary Bladder</td>
<td>Inhibits digestive secretions</td>
<td>Stimulates digestive secretions</td>
</tr>
<tr>
<td>Eye</td>
<td>Relaxes</td>
<td>Contracts (emptying)</td>
</tr>
<tr>
<td></td>
<td>Dilates the pupil</td>
<td>Constricts the pupil</td>
</tr>
<tr>
<td>Liver (glycogen stores)</td>
<td>Adjusts the eye for far vision</td>
<td>Adjusts the eye for near vision</td>
</tr>
<tr>
<td>Adipose Cells (fat stores)</td>
<td>Glycogenolysis (glucose is released)</td>
<td>None</td>
</tr>
<tr>
<td>Exocrine Glands</td>
<td>Lipolysis (fatty acids are released)</td>
<td>None</td>
</tr>
<tr>
<td>Exocrine pancreas</td>
<td>Inhibits pancreatic exocrine secretion</td>
<td>Stimulates pancreatic exocrine secretion (important for digestion)</td>
</tr>
<tr>
<td>Sweat glands</td>
<td>Stimulates secretion by sweat glands important in cooling the body</td>
<td>Stimulates secretion by specialized sweat glands in the armpits and genital area</td>
</tr>
<tr>
<td>Salivary glands</td>
<td>Stimulates a small volume of thick saliva rich in mucus</td>
<td>Stimulates a large volume of watery saliva rich in enzymes</td>
</tr>
<tr>
<td>Endocrine Glands</td>
<td>Stimulates epinephrine and norepinephrine secretion</td>
<td>None</td>
</tr>
<tr>
<td>Adrenal medulla</td>
<td>Inhibits insulin secretion</td>
<td>Stimulates insulin secretion</td>
</tr>
<tr>
<td>Endocrine pancreas</td>
<td>Controls ejaculation (males) and orgasm contractions (both sexes)</td>
<td>Controls erection (penis in males and clitoris in females)</td>
</tr>
<tr>
<td>Genitals</td>
<td>Increases alertness</td>
<td>None</td>
</tr>
<tr>
<td>Brain Activity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fight-or-Flight Stories!

or

or

…choose this!!
Time for a break! 😊
Why are nerve & muscle unique?

They are excitable!!
Action Potentials ≡ Spikes ≡ Impulses

Ultra-short reversal of membrane potential
Only in nerve and muscle cells
Maintains strength over distance
Primary way nerves & muscles communicate!
"Resting"/Membrane Potential?

Cells are slightly negative inside!
Changes Cell Membrane Permeability to Sodium/Na+!

+ Charges/Na+ Rushes In!
Action Potential has occurred!

Brief (1-2 ms) reversal to + inside cell!
Triggering event

Depolarization (decreased membrane potential)

Positive-feedback cycle!

Influx of Na\(^+\) (which further decreases membrane potential)

Opening of some voltage-gated Na\(^+\) channels
= Action potential
= After hyperpolarization

Na⁺ equilibrium

Threshold

Resting potential

K⁺ equilibrium

stimulus

1 msec

Time (msec)

Membrane potential (mV)
Membrane potential (mV)

+60
+50
+40
+30
+20
+10
+0
-10
-20
-30
-40
-50
-60
-70
-80
-90

Time (msec)

Rising phase
Caused by Na⁺ entry

Falling phase
Caused by K⁺ exiting

Threshold

Resting potential

↓$P_{Na^+}$, ↑$P_{K^+}$
Synapse = Generic term = connection between excitable cells!
Neuromuscular junction = Nerve-muscle connection

H Howard 1980
Synapse Animation

[Image with labels: Presynaptic axon terminal, Voltage-gated Ca\(^{2+}\) channel, Neurotransmitter molecule, Synaptic cleft, Chemically-gated ion channel for Na\(^{+}\), K\(^{+}\), or Cl\(^{-}\), Postsynaptic neuron, Receptor for neurotransmitter, Synaptic vesicle, Subsynaptic membrane, Synaptic knob, NT Balance! (Uptake and Release), LS 2012 fig 4-14]

http://outreach.mcb.harvard.edu/animations/synaptic.swf