I. **Announcements**  Thanks for your help with blood lab! Great job! No lab this week. Study for Exam II, Dec 7, Wed, 8 am!

II. **Endocrine Connections**  GH + Peripheral Endocrine Organs

DC Module 13 p 104-113, LS pp 506-25 fig 17-18, 17-19 +…

III. **Introduction to the Nervous System**  LS ch 5, DC Module 9

A. How is the nervous system organized?  LS fig 5-1 DC p 67
C. What’s myelin? How does it help? DC fig 9-3, LS pp 83-5
D. Brain structure & function DC fig 9-6 thru 9-10 pp 71-5 +…
E. Protect your head with a helmet!  Bicycle head injury statistics, *NHTSA & BHSI* from 2013 & 2014

IV. **Autonomic Nervous System**  LS ch 7 pp 178-85+…

A. Sympathetic vs Parasympathetic branches LS fig 7-3
B. Neurotransmitters & receptors LS fig 7-1 & 7-2, tab 7-2
C. Actions LS tab 7-1
D. Fight-or-flight stories!
Growth Hormone = Somatotrophin Hormone
Body Builder’s Dream?
GH/STH Effects: Insulin Resistance/Type II Diabetes?

↑ Amino Acid uptake & Protein synthesis

↑ Lipolysis & Fatty Acid mobilization

↓ Glucose uptake
   (skeletal muscle & adipocytes)

↑ Glucose production
   (liver glycogenolysis)

↑ Insulin secretion
Increase GH naturally with exercise & sleep!!

Growth hormone (ng/ml plasma)

Sleep

Strenuous exercise

Time of day

ng/ml = nanograms per milliliter
Endocrine Pancreas: Insulin (I) & Glucagon (G)
See-Saw Hormones in Regulating Blood Glucose

Duct cells secrete aqueous NaHCO₃ solution
Acinar cells secrete digestive enzymes
Exocrine portion of pancreas (Acinar and duct cells)

Endocrine portion of pancreas (Islets of Langerhans)

Hormones (insulin, glucagon)

Bile duct from liver
Duodenum

Stomach

Blood

The glandular portions of the pancreas are grossly exaggerated.
FIGURE 13-12
Adrenal Gland  The adrenal glands sit atop the kidney and consist of an outer zone of cells, the adrenal cortex, which produces a variety of steroid hormones, and an inner zone, the adrenal medulla. The adrenal medulla produces adrenalin and noradrenalin.
Adrenals/Suprarenals

Adrenal gland

Adrenal medulla

Adrenal cortex

Mineralocorticoids (aldosterone)

Glucocorticoids (cortisol) and sex hormones (dehydroepiandrosterone)

Catecholamines (epinephrine and norepinephrine)

Connective tissue capsule

Zona glomerulosa

Zona fasciculata

Zona reticularis

Medulla

Cortex
Stress Promotes Cortisol Secretion

Metabolic fuels and building blocks available to help resist stress

- Blood glucose (by stimulating gluconeogenesis and inhibiting glucose uptake)
- Blood amino acids (by stimulating protein degradation)
- Blood fatty acids (by stimulating lipolysis)
Epinephrine 80%
Norepinephrine 20%
Nervous System

CNS

PNS

input

output
Diagram of the central nervous system (CNS) and peripheral nervous system (PNS).

**Central nervous system (CNS)**
- Brain and spinal cord
- Input to CNS from periphery
- Output from CNS to periphery

**Peripheral nervous system (PNS)**
- Afferent division
  - Sensory stimuli
  - Visceral stimuli
- Efferent division
  - Somatic nervous system
  - Autonomic nervous system
- Effector organs (made up of muscle and gland tissue)
  - Skeletal muscles
  - Smooth muscle
  - Cardiac muscle
  - Exocrine glands
  - Some endocrine glands
  - Enteric nervous system
  - Digestive organs only

**Key**
- Red: Central nervous system
- Yellow: Peripheral nervous system
- Purple: Afferent division of PNS
- Blue: Efferent division of PNS
- Green: Somatic nervous system
- Dark blue: Autonomic nervous system
- Green: Enteric nervous system

*LS 2012 fig 5-1*
~99% of all neurons in humans!
CNS ~100 billion interneurons!!
~ 90% of Cells w/in CNS are not neurons but glial cells = neuroglia or nerve glue!
Neuron 1

Input
Dendrites ≡ Antennae

Controller
Soma ≡ NCB

Output
Axon

Neuron 2

Neuron 3

H. Howard 1980
A single nerve cell may have as many as 200,000 inputs!
Nerve cell with multiple axons grown by adding a mitogen/neurogen ≡ nerve growth factor!
Sensory nerves especially, come in all shapes & sizes!
Nerve Extremes: Far ends of the Continuum

A = Large to medium myelinated, up to 120 m/sec

C = Small unmyelinated, 0.25 m/sec

α, β, γ, δ

IV
What is myelin?
Why is it important?

Lipid insulative coat
\[ \uparrow \text{\(v\), conserves ions & ATP} \]
A large myelinated "survival" nerve can conduct impulses the length of football field in < 1 second!
Saltatory/Leaping Conduction!
Crucial Sensory & Motor Nerves

L. saltare to hop or leap! Fr. salt, sautier, sauté, leap, high air, vault
M. Supplementary motor area (on inner surface—not visible; programming of complex movements)

M. Premotor cortex (coordination of complex movements)

A. Prefrontal association cortex (planning for voluntary activity; decision making; personality traits)

M. Broca's area (speech formation)

S. Primary auditory cortex surrounded by higher-order auditory cortex (hearing)

A. Limbic association cortex (mostly on inner and bottom surface of temporal lobe; motivation and emotion; memory)

M. Primary motor cortex (voluntary movement)

S. Primary sensory cortex (sensation)

A. Posterior parietal cortex (integration of somatosensory and visual input; important for complex movements)

A. Wernicke's area (speech understanding)

A. Parietal-temporal-occipital association cortex (integration of all sensory input; important in language)

S. Primary visual cortex surrounded by higher-order visual cortex (sight)

Key
M. Motor cortex
A. Association cortex
S. Sensory cortex

LS 2006, cf: LS 2012 fig 5-8a
300 million axons enable R & L hemisphere cross-talk!!
MRI 061307
Lumbar spine
Lateral view

Disc herniation
Discs bulging

L5
S1
L1
L2
L3
L4
L5

Oregon Imaging
Helmets Cheap, Brains Expensive!!
Use Your Head, Get a Helmet!!
http://www.bhsi.org/stats.htm

~ 500,000 bicyclists/yr visit emergency rooms

As of 2014, the population estimate of
State of Wyoming  584,153
   Albany OR  51,980
   Corvallis OR  54,953
   Springfield OR  60,263

~ 26,000 traumatic brain injuries

743 of ~900 cyclist deaths, 2013  ≡  ~ 2% of all traffic fatalities
13% of deaths children ≤ 14 yr, 87% σ
11% involved wrong-way riding!

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

Helmets may reduce head & brain injury risk by 85%!

~$2.3 billion/yr = indirect injury costs from not using helmets!

~ 26,000 traumatic brain injuries

~ 26,000 traumatic brain injuries
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 exams!
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**
- $\alpha = \text{Alpha}$
- $\beta = \text{Beta}$

Acetylcholine

Norepinephrine

G&H 2011 p 731-3
Parasympathetic

Ach = Acetylcholine

Ach = Acetylcholine

= Nicotinic Receptor

= Muscarinic Receptor

Sympathetic

NE = Norepinephrine

= α Receptor (α₁, α₂)

= β Receptor (β₁, β₂)
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?
Hormonal Adrenaline Surge Reinforces Nervous Outflow & Accesses Tissues Not Directly Innervated!!

80% Epinephrine/Adrenaline (E)
20% Norepinephrine (NE)

Output to blood

Adrenals = Paired organs above kidneys
Fight-or-Flight Stories!

or

...choose this!!
<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></td>
<td>Inhibits digestive secretions</td>
<td>Stimulates digestive secretions</td>
</tr>
<tr>
<td>Urinary Bladder</td>
<td>Relaxes</td>
<td>Contracts (emptying)</td>
</tr>
<tr>
<td>Eye</td>
<td>Dilates the pupil</td>
<td>Constricts the pupil</td>
</tr>
<tr>
<td></td>
<td>Adjusts the eye for far vision</td>
<td>Adjusts the eye for near vision</td>
</tr>
<tr>
<td>Liver (glycogen stores)</td>
<td>Glycogenolysis (glucose is released)</td>
<td>None</td>
</tr>
<tr>
<td>Adipose Cells (fat stores)</td>
<td>Lipolysis (fatty acids are released)</td>
<td>None</td>
</tr>
<tr>
<td>Exocrine Glands</td>
<td></td>
<td></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></td>
<td></td>
</tr>
<tr>
<td>Adrenal medulla</td>
<td>Stimulates epinephrine and norepinephrine secretion</td>
<td>None</td>
</tr>
<tr>
<td>Endocrine pancreas</td>
<td>Inhibits insulin secretion</td>
<td>Stimulates insulin secretion</td>
</tr>
<tr>
<td>Genitals</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>Brain Activity</td>
<td>Increases alertness</td>
<td>None</td>
</tr>
</tbody>
</table>