I. **Announcements** Optional notebook check + Lab 6 tomorrow.
   Pulmonary Function Testing. Final exam > your Q on Thurs. Q?

II. **Endocrine Connections** Peripheral endocrine organs
    A. Pancreas (insulin, glucagon, diabetes)
    B. Thyroid
    C. Adrenals
    DC Module 13 pp 109-13, LS pp 513-36

III. **Nervous System & Excitable Cells** DC Module 9, LS ch 5, 4, 7
    A. How is the nervous system organized? fig 5-1 p 108
    B. Neurons? What kind? fig 5-2 p 109
    C. Brain structure & function fig 5-7, 5-8 pp 116 – 7
    D. Protect your head with a helmet!
       Bicycle head injury statistics, NHTSA & BHSI

IV. **Brain + Autonomic Nervous System Overview** DC pp 71-77, LS pp 178 – 85, tab 7-1 p 183 + stories to remember *fight-or-flight!*

V. **Neuromuscular Connections** LS ch 7 pp 186-92, DC pp 69-71
   How does the signal cross the nerve-muscle gap? LS fig 7-5
   A. Normal function? Ca2+ for bones!...but what else? LS p 190
   B. What do black widow spider venom, botulism, curare & nerve gas have in common? Botox? LS p 189-91

VI. **Muscle Structure, Function & Adaptation** LS ch 8, DC Module 12
    A. Muscle types: cardiac, smooth, skeletal LS fig 8-1 p 194-6
    B. How is skeletal muscle organized? LS fig 8-2, DC fig 12-2
Endocrine Pancreas: Insulin (I) & Glucagon (G) See-Saw Hormones in Regulating Blood Glucose

- Bile duct from liver
  - Duodenum
  - Stomach

- 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)

- Blood

The glandular portions of the pancreas are grossly exaggerated.
Times of Plenty!!

NB: Diabetics have problems either here or here.

Cellular uptake and utilization of glucose
**TABLE 4-7**

**Warning Signs of Diabetes**

These signs appear reliably in type 1 diabetes and, often, in the later stages of type 2 diabetes.

- Excessive urination and thirst
- Glucose in the urine
- Weight loss with nausea, easy tiring, weakness, or irritability
- Cravings for food, especially for sweets
- Frequent infections of the skin, gums, vagina, or urinary tract
- Vision disturbances; blurred vision
- Pain in the legs, feet, or fingers
- Slow healing of cuts and bruises
- Itching
- Drowsiness
- Abnormally high glucose in the blood
Diabetics must constantly juggle diet, exercise & medication to control blood glucose!
Like others, diabetics benefit from whole grains, vegetables, fruits, legumes & non-/low-fat milk products!
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 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
Stress Promotes Cortisol Secretion

- Stress activates the hypothalamus, which releases corticotropin-releasing hormone (CRH).
- CRH stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH).
- ACTH triggers the adrenal cortex to produce cortisol.

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
~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!
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!
What is myelin?
Why is it important?

Lipid insulative coat
↑ $\vec{v}$, 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

Cell body
Myelin sheath
Node of Ranvier
Nerve impulse

Axon

L. *saltare* to hop or leap! Fr. *salt*, sautier, sauté, leap, high air, vault

DC 2003
Motor

Sensory

Key

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

M. Supplementary motor area
(on inner surface—not visible; programming of complex movements)

M. Premotor cortex
(coordination of complex movements)

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)

Central sulcus

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)

LS 2006, cf: LS 2012 fig 5-8a
~ 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% ♂
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!

Helmets Cheap, Brains Expensive!!
Use Your Head, Get a Helmet!!

http://www.bhsi.org/stats.htm

Helmets Cheap, Brains Expensive!!
Use Your Head, Get a Helmet!!

http://www.bhsi.org/stats.htm
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**.
Hey, I’m alive because I wore a helmet!!
Stories, Discussion, Questions or Comments!
Homeostasis is a dynamic balance between the autonomic branches.

Rest-and-digest: Parasympathetic activity dominates.

Fight-or-flight: Sympathetic activity dominates.
PARASYMPATHETIC = RESTING, DIGESTIVE, HOUSEKEEPING FUNCTIONS
FIGHT/FLIGHT/ALARM REACTION!!
Autonomic Nervous System

Why overlap or dual innervation?

Fine-tune control & safety!

cf: LS 2012 fig 7-3
Why adrenal activation & response important?
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

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></td>
<td></td>
</tr>
<tr>
<td>Eye</td>
<td>Dilates the pupil</td>
<td>Contracts (emptying)</td>
</tr>
<tr>
<td></td>
<td>Adjusts the eye for far vision</td>
<td>Constricts the pupil</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>
Neuromuscular junction = Nerve-muscle connection
Skeletal Muscles

Homeostasis
Skeletal muscles contribute to homeostasis by playing a major role in the procurement of food, breathing, heat generation for maintenance of body temperature, and movement away from harm.

Body systems maintain homeostasis

Cells make up body systems

Cells

Homeostasis is essential for survival of cells
Skeletal Muscle Histology: Microscopic Anatomy

Muscle fiber or cylindrical cell

“Threads” ≡ Myofibrils

Nuclei

Dark-Light...bands ≡ Overlapping thick & thin filaments

x1000

H Howard 1980.
Organ = Muscle

Cell = Myocyte = Fiber

Subcellular = Cytoskeleton

Molecules = Actin & Myosin

Golf Club Analogy?

(a) Actin binding site
Myosin ATPase site
Heads
Tail

100 nm

Cross bridges
Myosin molecules

LS 2006, cf:
LS 2012 fig 8-4
Broccoli Analogy?

- Myosin Heads
- Myosin Tails
- Bare Zone
- Myosin Heads
Actin molecules

Binding site for attachment with myosin cross bridge

Actin helix

Tropomyosin

Troponin

Thin filament

LS 2006, cf:
LS 2012 fig 8-5
Triad ≡ T tubule abutting cisternae

Mitochondria

Sarcomere

Myofibril
A Band = Dark Band
Anisotropic = Light Can’t Shine Through

/ Band = Light Band
Isotropic = Light Can Shine Through
LS 2012 fig 8-7