Exam II Review Slides

Exam II!
Whee!
I. **Announcements**

HR & BP Lab 4 tomorrow + **Required Notebook Check**. Include Nutrition Analyses. Q? Exam I? Please read Blood Chemistry Lab 5 twice < Thurs. Thanks!

II. **Cardiovascular System**

LS 2012 ch 9, Torstar Books 1984, DC 2013 Module 4, Guyton & Hall (G&H) 2011 +...

A. Circulatory vs Cardiovascular (CV)? cf + parts

CV vs Lymphatic LS pp 229; DC pp 23, 31

B. CV Pulmonary & Systemic circuits

DC fig 4-1 p 24, LS fig 9-2b p 231

C. Arteries, capillaries, veins G&H + Torstar

D. Varicose veins? Phlebitis? DC

E. ♥ layers, box, chambers, valves, inlets, outlets

LS fig 9-4 p 233, fig 9-2a p 231; DC pp 23-6

F. Normal vs abnormal blood flow thru ♥ & CV system

Billy has a hole in his ♥ SI Fox 2009 fig 13.16, 13.17

G. Cardiac cyle & heart murmurs?

III. **Aerobic Exercise: Heart & Blood Vessels. Strength?** ACSM

IV. **Cardiovascular Diseases Intro** LS ch 9 pp 252-7; DC pp 29-30
Cardiovascular (CV) = Heart + Vessels + Blood!
**NB:** Figure-8 loop

Pulmonary

8

Systemic

---

Capillary beds of lungs where gas exchange occurs

Pulmonary arteries

Pulmonary veins

Vena cavae

Aorta and branches

Right ventricle

Left ventricle

Systemic circuit

Systemic circulation

Arterioles

Capillary beds of all body tissues where gas exchange occurs

Oxygen-poor, CO₂-rich blood

Oxygen-rich, CO₂-poor blood

D Chiras 2013 fig 4-1b
Dual Pump Action & Parallel Circulation
Lymphatic System

1. Lymph Nodes
2. Vessels
3. Lymph

No pump!

DC 2003
Lymphatic System Blockage in Elephantiasis from Mosquito-borne Parasitic Filaria Worm
Lymphatics collect run-off & are parallel to venules/small veins!
Microcirculation Exchange: 10 Billion Capillaries!

No cell > 25-50 μ away from a capillary! Like having bus stops @ every other block!

Guyton & Hall 2011 fig 1-2
Human ♥ = 4-chambered box? 2 separate pumps?

Upper = Atria
Lower = Ventricles

RA ➔ RV ➔ Pulmonary
LA ➔ LV ➔ Systemic
Human ❤ = 4 unique valves?  
2 valve sets?

**Semilunar** = Half-moon shaped

1. Pulmonic/Pulmonary
2. Aortic

**AV** = Atrioventricular

3. ① AV = Tricuspid
4. ① AV = Mitral/Bicuspid
Cardiac Cycle

**Systole**
Contract & Empty

**Diastole**
Relax & Fill

Diagram showing the cycle between systole and diastole.
Veins ➔ Atria ➔ Ventricles ➔ Arteries

https://www.nhlbi.nih.gov/health-topics/how-heart-works
https://www.youtube.com/watch?v=zJXAlh9VDDU
Heart Murmurs? An unusual or extra heart sound lub-dup, lub-dup vs lub-gurgle-dup, lub-swish-dup…

S1 = lub  S2 = dup

https://www.thinklabs.com/heart-sounds
BI 121 Lecture 9

I. **Announcements** Lab notebook due today! Lab 4 HR & BP. Thursday, Lab 5 Blood Chemistry. Read 2x pp 5-1 thru 5-6. Q?

II. **Overview of Labs** HR & BP. 💖Cycle. Blood chem lab review.

III. **Cardiovascular Connections** LS 2012 ch 9, DC Mod 4 CVDs & exercise. Coronary arteries. 💖attack?

IV. **CV Physiology in the News** NHLBI & AHA websites Nicole Kidman & exercise? ACSM, AHA, CDC guidelines

V. **CV Pathophysiology & Risk Reduction** LS ch 9, 10 +…DC Mod 4
   A. Atherosclerosis? LS fig 9-27, 9-25, 9-26 pp 266-8
   B. How to minimize risk of CVDs? Treatment triad: Exercise, Diet, Drugs + Surgery
   C. PTCA, Stent, CABG? Bypass #?
   D. Plant-based diet to minimize CVD! What’s HAPOC?
Blood Chemistry on Thursday!
No food, drink or gum in lab!

Thanks sincerely!
Glucose: Sugar in Blood

Normal: 70-99
Pre-Diabetes: 100-125
Diabetes: ≥ 126 mg/dL

NB: Read & Record!
How much aerobic?

Continuous exercise

≥ 50% muscle mass

≥ Conversational pace

20-60 min/session

3-5 days/wk


Guidelines: Healthy Adults < 65 yr

Do moderately intense aerobic exercise
30 min/d, 5 d/wk

OR

Do vigorously intense aerobic exercise
20 min/d, 3 d/wk

AND

Do 8-10 strength-training exercises
8-12 repetitions/each exercise, 2 d/wk
AMI
CVDs
CVA
TIA
HTN
PVD
**Figure 9-35**

Extent of myocardial damage as a function of the size of the occluded vessel.
Treatment Triad

NB: Last blasted resort!!

Drugs/Surgery

Exercise

Dietary Modification
CABG = Coronary Artery Bypass Graft

Double?
Triple?
Quadruple?
Quintuple?

SI Fox 2013 fig 14.19
**Apple** type of obesity predisposed to CVD!

*Pear* type of fat pattern...

implies lower disease risk!

Eat more apples...

to help prevent the apple type of obesity!
Fish Oil Intakes & Cardiovascular Death Rates

Cardiovascular Deaths per 100,000 Population

- Ireland: 0.09%
- USA: 0.13%
- France: 0.14%
- Japan: 0.37%
Healthy Oils to Minimize Atherosclerosis

HAPOC?
I. **Announcements** Remember to read Lab 5 before Thursday. Thanks for helping us be well-prepared. Q from last time? Calculating grade from estimated final. Keys to success? Q?

II. **CVDs Prevention & Treatment Follow-up or Q?**
Exercise, dietary modifications, anti-inflammatory foods?

III. **Blood Form & Function**

A. Formed vs. nonformed/cells vs. plasma
   fig+tab 11-1

B. **Red blood cells/erythrocytes:** O$_2$-carrying sickle cells, ABO blood typing, Rh factor
   pp 299-304

C. **White blood cells/leukocytes:** Defense/immunity differential + general functions
   pp 309-12

D. **Platelets/thrombocytes:** Initial clotting
   p 304

IV. **Blood Glucose & Diabetes Mellitus**

LS ch 17, DC Module 13
What's in Blood? Plasma & Blood Cells

Plasma
(55% of whole blood)

Buffy coat:
platelets and
leukocytes
(<1% of whole blood)

Packed cell
volume, or
hematocrit

Erythrocytes
(45% of whole blood)

Platelets

Leukocytes
(white blood cells)

Erythrocytes
(red blood cells)
A & B Antigens
(Agglutinogens)
Erythroblastosis Fetalis?

eg, Rh- mom Rh+ baby

What a difference one amino acid can make!

Amino acid sequence of normal hemoglobin:
Val → His → Leu → Thr → Pro → Glu → Glu

Amino acid sequence of sickle-cell hemoglobin:
Val → His → Leu → Thr → Pro → Val → Glu
I. **Blood Cell Connections** Q?

II. **Lab 5 Review: Safety & Techniques** Q?

III. **Blood Glucose & Insulin** LS pp 530-2, DC pp 110-2

IV. **Introduction to Endocrinology** LS ch 17, DC Module 13, SI Fox+
   A. Endocrine vignette: Cushing's syndrome LS fig 17-20 p 521-2
   B. Endocrine system DC p 103 fig 13-1, LS fig 17-1, tab 17-1
   C. What's an endocrine? + classes ~ LS pp 495 – 6
   D. Hypothalamus (Master) – Pituitary (subcontroller)
      DC pp 104-6 + LS pp 499-506
   E. Posterior pituitary + hormones DC p 108, LS fig 17-4 p 502
   F. Anterior pituitary + hormones DC pp 105-7, LS pp 502-6
   H. Peripheral endocrine organs DC pp 109-13, LS pp 513-36
      1. Pancreas 2. Thyroid 3. Adrenals

Fun lab today! Lifetime data! Thanks for being prepared!
10 Q: Clumping in Any Wells?

Source: S Wong, BI 121 Lab, 2016
Times of Plenty!!

NB: Diabetics have problems either here or here.

Fox 1987

https://www.youtube.com/watch?v=8dgoeYPoE-0
## 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!
Cushing’s Syndrome = Hypersecretion of Cortisol: Hypothalamic (CRH), Pituitary (ACTH), or Adrenal (Cortisol)
ANP = Atrial Natriuretic Polypeptide

https://www.youtube.com/watch?v=IRJE8c3ghRE
https://www.hopkinsallchildrens.org/Patients-Families/Health-Library/HealthDocNew/Movie-Endocrine-System
Hormone/Endocrine Classifications?

Exogenous

Endogenous

Amino Acid/PP/Protein

Thyroid

Steroid
Hypothalamus & Pituitary: Intimate Relationship
Nervous Connection!!
Hypothalamus-Anterior Pituitary Vascular Connection!
Pituitary Nourishing or Growth Hormones

RH + or RIH -

Releasing or Release-Inhibiting Hormones

Hypophysis = Pituitary

Systemic arterial inflow

Hypothalamic-hypophyseal portal system

Systemic venous outflow

• = Hypophysiotropic hormones

• = Anterior pituitary hormone

LS 2007
Paraventricular nucleus
Supraoptic nucleus
Median eminence
Portal system
Anterior pituitary
Hypothalamus
Infundibulum
Posterior pituitary

Mammary gland

Prolactin
TSH
ACTH
Gonadotropins
FSH
LH

Bone
Muscle
Adipose tissue

Thyroid
Adrenal cortex
Ovary
Testis
I. **Announcements** Thanks! Q from last t?

II. **Endocrine Connections** DC pp 109-13, LS pp 513-36
   A. GH glucose mismatch. B. Peripheral endocrine organs
      1. Thyroid  2. Adrenals  C. Stress response?

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

Mismatch!!
Thyroid → metabolism highly vascularized

**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.
Stress Also Promotes Cortisol Secretion!

Cushing's Syndrome Excess Nutrients!

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)
~99% of all neurons in humans! CNS ~100 billion interneurons!!
Astrocytes

\( \sim 90\% \) of Cells w/in CNS are not neurons but glial cells = neuroglia or nerve glue!
What is myelin? Why is it important?

Lipid insulative coat

↑ $\vec{V}$, conserves ions & ATP
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)

M. Primary motor cortex (voluntary movement)

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)

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

M. Broca’s area (speech formation)

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

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

Key

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

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
Homeostasis is a dynamic balance between the autonomic branches.

Rest-and-digest: Parasympathetic activity dominates.

Fight-or-flight: Sympathetic activity dominates.
Why overlap or dual innervation?

Fine-tune control & safety!

cf: LS 2012 fig 7-3

LS 1995
Parasympathetic

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!!
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
<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><em>Exocrine pancreas</em></td>
<td>Inhibits pancreatic exocrine secretion</td>
<td>Stimulates pancreatic exocrine secretion (important for digestion)</td>
</tr>
<tr>
<td><em>Sweat glands</em></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><em>Salivary glands</em></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><em>Adrenal medulla</em></td>
<td>Stimulates epinephrine and norepinephrine secretion</td>
<td>None</td>
</tr>
<tr>
<td><em>Endocrine pancreas</em></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>
Pulmonary Function Testing today! Hooray!

BI 121 Lecture 13

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

II. Pulmonary Function Lab Overview

III. Neuromuscular Junction Overview
LS pp 186-92, DC pp 69-70

IV. 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

C. What do thick filaments look like?
LS fig 8-4, DC fig 12-4

D. How about thin filaments?
LS fig 8-5

E. Banding pattern?
LS fig 8-3, fig 8-7

F. How do muscles contract?
LS fig 8-6, 8-10

G. What's a cross-bridge cycle?
LS fig 8-11 +…

H. Summary of skeletal muscle contraction

I. Exercise adaptation variables:
mode, intensity, duration,
frequency, distribution, individual & environmental char...?

J. Endurance vs. strength training continuum? fiber types...
Spirogram graphing complete PFT from computer simulation.

- **TV** = Tidal volume (500 ml)
- **IRV** = Inspiratory reserve volume (3,000 ml)
- **IC** = Inspiratory capacity (3,500 ml)
- **ERV** = Expiratory reserve volume (1,000 ml)
- **RV** = Residual volume (1,200 ml)
- **FRC** = Functional residual capacity (2,200 ml)
- **VC** = Vital capacity (4,500 ml)
- **TLC** = Total lung capacity (5,700 ml)
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

DC 2013 fig 12-3
Golf Club Analogy?
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 $\equiv$ T tubule abutting cisternae

Mitochondria

Sarcomere

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

I Band = Light Band
Isotropic = Light Can Shine Through
Cross-Bridge Cycle

1. Energized
   - ATP (Mg++)
   - Energy
   - ADP
   - Pi
   - No Ca++

2a. Binding
   - Energy
   - ADP
   - Pi

2b. Resting
   - Energy
   - ADP
   - Pi
   - Ca++ present (excitation)

3. Bending (power stroke)
   - Energy
   - ADP
   - Pi

4a. Detachment
   - Fresh ATP available

4b. Rigor complex
   - No ATP (after death)
Acetylcholine released by axon of motor neuron crosses cleft and binds to receptors/channels on motor end plate.

Action potential generated in response to binding of acetylcholine and subsequent end plate potential is propagated across surface membrane and down T tubules of muscle cell.

Action potential in T tubule triggers Ca\(^{2+}\) release from sarcoplasmic reticulum.

With Ca\(^{2+}\) no longer bound to troponin, tropomyosin slips back to its blocking position over binding sites on actin; contraction ends; actin passively slides back to original resting position.

Ca\(^{2+}\) actively taken up by sarcoplasmic reticulum when there is no longer local action potential.

Myosin cross bridges attach to actin and bend, pulling actin filaments toward center of sarcomere; powered by energy provided by ATP.

Calcium ions released from lateral sacs bind to troponin on actin filaments; leads to tropomyosin being physically moved aside to uncover cross-bridge binding sites on actin.
A. Malcolm Campbell
Davidson College, Davidson, NC
www.bio.davidson.edu/courses/movies.html

David Bolinsky, XVIVO
Rocky Hill, CT
http://www.xvivo.net/

Muscle Contraction Resources

https://ed.ted.com/lessons/how-your-muscular-system-works-emma-bryce

https://ed.ted.com/on/s3Zzdm8u


https://www.ncbi.nlm.nih.gov/books/NBK9961/
Adaptations to Exercise?
Mode, Intensity, Duration, Frequency, Distribution of Training Sessions?
Conditions of Environment? Individual?
Skeletal Muscle

Atrophy

Hypertrophy

Hyperplasia

Atrophy
Hypertrophy: *Increased Number of Myofibrils*
*Thick & Thin Filaments*
*Myosin & Actin Molecules*
## Characteristics of Skeletal Muscle Fibers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Slow Oxidative (Type I)</th>
<th>Fast Oxidative (Type IIa)</th>
<th>Fast Glycolytic (Type IIb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myosin-ATPase Activity</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Speed of Contraction</td>
<td>Slow</td>
<td>Fast</td>
<td>Fast</td>
</tr>
<tr>
<td>Resistance to Fatigue</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Aerobic Capacity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Anaerobic Capacity</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>Mitochondria</td>
<td>Many</td>
<td>Many</td>
<td>Few</td>
</tr>
<tr>
<td>Capillaries</td>
<td>Many</td>
<td>Many</td>
<td>Few</td>
</tr>
<tr>
<td>Myoglobin Content</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Color of Fibers</td>
<td>Red</td>
<td>Red</td>
<td>White</td>
</tr>
<tr>
<td>Glycogen Content</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
</tbody>
</table>
Extremes of the energy continuum!
Changes in Muscle Due to Endurance Training

↑ Mitochondria, # & size
↑ Mitochondrial (aerobic) enzymes including those specific for fat burning
↑ Vascularization of muscles (better blood flow)
↑ Stores of fat in muscles accompanied by
↓ Triglycerides/fats in bloodstream
↑ Enzymes: activation, transport, breakdown (β-oxidation) of fatty acids
↑ Myoglobin (enhances O₂ transport)
↑ Resting energy levels which inhibit sugar breakdown
↑ Aerobic capacity of all three fiber types.
I. **Announcements**  Notebooks returned. Discussion-Review followed by Exam II tomorrow. Q? Thanks for a super term! 😊

II. **Respiratory System**  LS ch 12, DC Module 7, SI Fox +...
   A. Steps of respiration? External vs. cellular/internal?  LS fig 12-1 pp 345-7
   B. Respiratory system anatomy  LS fig 12-2 p 347, DC, SI Fox+
   C. Histology  LS fig 12-4 pp 347-9, DC fig 7-4 p 54
   D. How do we breathe?  LS fig12-12, fig12-25 pp 349-56, 373-8
   E. Gas exchange  LS fig 12-19 pp 362-5
   F. Gas transport  LS tab 12-3 pp 365-70

III. **Physiology of Cigarette Smoking**
   A. ANS, autonomic nerves & nicotine? Route of chemicals,...
   B. Emphysema? 2nd-hand smoke?... LS pp 356, 365
   C. UO Smoke-Free since Fall 2012! Help is available!
Lombo’s simplified steps!

1. **Breathe in & out!**

2. **Cross membranes!**

3. **Move with blood!**
   - Go with the flow!

4. **Cross membranes!**
NB: *In vivo*, Cupola or peak of each lung goes into neck > clavicle line!
No Gas Exchange

Gas Exchange

1st alveolar outpouching!
**Inhale** (active)

- Contract & flatten diaphragm

**Exhale** (passive @ rest)

- Relax & pouch up diaphragm!
**Brain stem ≡ Control Center for automatic breathing!**
Respiratory membrane separates air from blood, is 6 layers, yet 1/50th thickness of tracing paper!
**Gas Exchange**

Across pulmonary capillaries:
- O₂ partial pressure gradient from alveoli to blood = 60 mm Hg (100 → 40)
- CO₂ partial pressure gradient from blood to alveoli = 6 mm Hg (46 → 40)

Across systemic capillaries:
- O₂ partial pressure gradient from blood to tissue cell = 60 mm Hg (100 → 40)
- CO₂ partial pressure gradient from tissue cell to blood = 6 mm Hg (46 → 40)

Numbers are mm Hg pressure.

cf: LS 2012 fig 12-19
**O₂ is carried mainly by red blood cell hemoglobin!**

Each hemoglobin molecule carries 4 O₂ on 4 iron-containing disks!

Carbon monoxide, CO, binds ≥ 200x more powerfully to these same sites, thus poisoning the hemoglobin!

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LS 2012 fig 11-2
Cigarette Smoking: #1 Preventable Cause of Premature Death in the US

Cardiovascular Mortality (average annual incidence per 1,000)

- None: 7
- Less than 20: 8.4
- More than 20: 12.4
- Quit One Year: 7

Cigarettes Smoked Per Day
Not only the Lungs, but the Heart, Brain & 100s of Other Tissues & Organs Adversely Affected!

Tobacco smoke = Deadly mix of > 7000 chemicals!

http://www.cdc.gov/tobacco/data_statistics/sgr/50th-anniversary/index.htm#fact-sheets
Cigarette + Smoke: > 7000 Chemicals; ~600 Tobacco Company Additives
Atherogenic, Carcinogenic (C), Tumor Initiating, Tumor Promoting (TP),
Toxic (T), Cornucoppia of Unknowns, Synergistic, Reactive...?

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Type</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-aminobiphenyl</td>
<td>C</td>
<td>140 ng per cigarette...</td>
</tr>
<tr>
<td>benz(a)anthracene</td>
<td>C</td>
<td>40-200 ng</td>
</tr>
<tr>
<td>benzene</td>
<td>C</td>
<td>400 μg</td>
</tr>
<tr>
<td>benz(o)pyrene</td>
<td>C</td>
<td>40-70 ng</td>
</tr>
<tr>
<td>carbon monoxide</td>
<td>T</td>
<td>26.8-61 mg</td>
</tr>
<tr>
<td>formaldehyde</td>
<td>C</td>
<td>1500 μg</td>
</tr>
<tr>
<td>hydrazine</td>
<td>C</td>
<td>90 ng</td>
</tr>
<tr>
<td>hydrogen cyanide</td>
<td>T</td>
<td>14-110 μg</td>
</tr>
<tr>
<td>2-naphthylamine</td>
<td>C</td>
<td>70 ng</td>
</tr>
<tr>
<td>nitrogen oxides</td>
<td>T</td>
<td>500-2000 μg</td>
</tr>
<tr>
<td>N-nitrosodimethylamine</td>
<td>C</td>
<td>200-1040 ng</td>
</tr>
<tr>
<td>N-nitrosodiethanolamine</td>
<td>C</td>
<td>43 ng</td>
</tr>
<tr>
<td>N-nitrospyrrolide</td>
<td>C</td>
<td>30-390 ng</td>
</tr>
<tr>
<td>phenol</td>
<td>TP</td>
<td>70-250 μg</td>
</tr>
<tr>
<td>polonium 210</td>
<td>C</td>
<td>0.5-1.6 pCi</td>
</tr>
<tr>
<td>quinoline</td>
<td>C</td>
<td>15-20 μg</td>
</tr>
<tr>
<td>O-toluidine</td>
<td>C</td>
<td>3 μg</td>
</tr>
</tbody>
</table>

**SOURCES:** US Surgeon General's Office, American Cancer Society, American Heart Association.
Ammonia converts nicotine, the additive agent in tobacco, into a more volatile form, Pankow said. “Ammonia is the thing that helps tobacco companies hook the smoker by providing a means of delivering the nicotine.”

Last October, a former tobacco industry employee revealed that secret industry documents indicated that ammonia was added to tobacco to double the impact of nicotine. Research now indicates that ammonia can boost nicotine availability up to 100x! The Oregon Graduate Institute (now a part of OHSU) was the 1st to research!

http://pubs.acs.org/doi/abs/10.1021/es970402f
http://www.nasw.org/users/sperkins/nicotine.html
**Parasympathetic**

\[ \text{Ach} \] = Acetylcholine

- **Nicotinic Receptor**
- **Muscarinic Receptor**

**Sympathetic**

\[ \text{NE} \] = Norepinephrine

- **α Receptor** (α₁, α₂)
- **β Receptor** (β₁, β₂)
Cigarettes ≡ Patient-Assisted Drug-Delivery System
Inhaling Bypasses the Systemic Circulation
& Is Powerfully Reinforcing!
Tracing the Route of Cigarette Smoke
Puff to Brain Time 5 to 8 seconds!!

Mouth
↓
Pharynx
↓
Larynx
↓
Trachea
↓
Bronchi
↓
Bronchioles
↓
Alveoli

Blood

Pulmonary Veins
↓
Left Atrium
↓
Left Ventricle
↓
Aorta
↓
Heart
↓
Brain

Respiratory Membrane

Systemic Circulation
Emphysema \equiv Corrosion of Alveolar Walls with ↓ SA & Labored Breathing
2nd-hand smoke is the 3rd leading preventable cause of death in the US!

"Mind if I smoke?"

"Care if I die?"

Each year ~45,000 Americans die due to 2nd-hand smoke exposure!
Health risks of e-cigarettes emerge

Vaping pollutes lungs with toxic chemicals and may even make antibiotic-resistant bacteria harder to kill

By JANET RALOFF 4:31PM, JUNE 3, 2014

https://www.sciencenews.org/article/health-risks-e-cigarettes-emerge
SMOKING \equiv ASTHMA?

Petri-dish Effect

Ugh!! Cough! Cough!!