Exam II Review Slides

Exam II!
Whee!
Announcements

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

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
LS pp 229, CV vs Lymphatic, 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

Comments on Exam I & Exams Returned
Cardiovascular (CV) = Heart + Vessels + Blood!
*NB:* Figure-8 loop

Pulmonary

8

Systemic

Pulmonary circuit

Capillary beds of lungs where gas exchange occurs

Pulmonary arteries

Pulmonary veins

Aorta and branches

Right ventricle

Left ventricle

Systemic circuit

Capillary beds of all body tissues where gas exchange occurs

Arterioles

Venules

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!
Lymphatic System Blockage in Elephantiasis from Mosquito-borne Parasitic Filaria Worm
Human 🖤 = 4-chambered box?  
2 separate pumps?

Upper = Atria

Lower = Ventricles

Pulmonary

Systemic

RA

LV

RV

LA

R

L

Primer Pumps

Power Pumps
Heart Valves Ensure Unidirectional Blood Flow!

(b) Heart valves in closed position, viewed from above

Right atrium
Right AV valve
Direction of backflow of blood
Right ventricle
Papillary muscle
Chordae tendineae
Septum

(c) Prevention of eversion of AV valves

**FIGURE 9-4** Heart valves.
Veins ➔ Atria ➔ Ventricles ➔ Arteries

https://www.nhlbi.nih.gov/health-topics/how-heart-works
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
Normal vs abnormal blood flow! Q?

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 +…

A. AMI, CVA, CVD, PVD, TIA, HTN? + surgical treatments
B. Atherosclerosis? LS fig 9-27, 9-25, 9-26 pp 266-8
C. How to minimize risk of CVDs? Treatment triad:
   Exercise, Diet, Drugs + Surgery
D. Food choices make a difference?
What’s HAPOC?
Cardiac Cycle

**Systole**
- Contract
- & Empty

**Diastole**
- Relax
- & Fill
How much aerobic?

Continuous exercise
≥ 50% muscle mass
≥ Conversational pace
20-60 min/session
3-5 days/wk

How much strength?

- 2-3 days/wk
- 8-10 exercises for major muscle groups
- ≥ 1 set/exercise
- 8-12 (most) or 10-15 (frail/≥ 50-60 yr) repetitions/set
Area of cardiac muscle deprived of blood supply if coronary vessel is blocked at point A:

Right coronary artery

Right ventricle

Area of cardiac muscle deprived of blood supply if coronary vessel is blocked at point B:

Left coronary artery

Left ventricle

**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 By-pass Graft
**Apple type** of obesity predisposed to CVD!

*Pear type of fat pattern...*

implies lower disease risk!

**CAUTION: HAZARDOUS WAIST**

Eat more apples...

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

<table>
<thead>
<tr>
<th>Country</th>
<th>Cardiovascular Deaths per 100,000 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>0.09%</td>
</tr>
<tr>
<td>USA</td>
<td>0.13%</td>
</tr>
<tr>
<td>France</td>
<td>0.14%</td>
</tr>
<tr>
<td>Japan</td>
<td>0.37%</td>
</tr>
</tbody>
</table>
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 oils?

III. **Blood Form & Function** LS ch 11 pp 296-304, 309-12
DC Module 5 + SI Fox + National Geographic Lennart Nilsson
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)

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
Megakaryocyte

Clusters of platelets about to shed off

Developing leukocyte

Cluster of developing erythrocytes
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 fig17-20 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
     - 1. Pancreas 2. Thyroid 3. Adrenals

Fun lab today! Lifetime data! Thanks for being prepared!
Glucose: Sugar in Blood

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

NB: Read & Record!
10 Q? Clumping in Any Wells?

Here?

Type AB+

Here?

Here?

Source: S Wong, BI 121 Lab, 2016
Diabetic & Normal Response to Glucose Load

Ingest Glucola or eat meal

Guyton & Hall 2000
Endocrine Pancreas: Insulin (I) & Glucagon (G)
See-Saw Hormones in Regulating Blood Glucose
**Times of Plenty!!**

Diabetics have problems either here or here.

*NB:* Diabetics have problems either here or here.

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Fox 1987


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

T = 0, near normal

T = 4 months later
ANP = Atrial Natriuretic Polypeptide

https://www.youtube.com/watch?v=lRJE8c3ghRE
https://www.hopkinsallchildrens.org/Patients-Families/Health-
Hormone/Endocrine Classifications

Exogenous

Endogenous
Nervous Connection!!
Hypothalamus-Anterior Pituitary Vascular Connection!

- Neurosecretory neuron
- Systemic arterial inflow
- Hypothalamic-hypophyseal portal system
- Anterior pituitary
- Systemic venous outflow

- = Hypophysiotropic hormones
- = Anterior pituitary hormone

LS 2007
Pituitary Nourishing or Growth Hormones

Hypophysis = Pituitary

Neurosecretory neuron

Systemic arterial inflow

Hypothalamic-hypophyseal portal system

Systemic venous outflow

RH + or RIH -

Releasing or Release-Inhibiting Hormones

● = Hypophysiotropic hormones
● = Anterior pituitary hormone

LS 2007
I. **Announcements** Optional notebook check + Lab 6 tomorrow. Pulmonary Function Testing. Exam II > your Q on Thurs. Q?

II. **Endocrine Connections** Feedback loops, growth hormone, thyroid & 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
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!!

Strenuous exercise

Sleep

Growth hormone (ng/ml plasma)

Time of day

ng/ml = nanograms per milliliter
Insulin Stores Sugar, Glucagon Mobilizes Sugar!

- High blood sugar promotes insulin release, which stimulates glycogen formation from glycogen breakdown.
- Glucose is stored as glycogen in the liver and muscles.
- Insulin lowers blood sugar when glucose is taken up by tissue cells.
- Low blood sugar promotes glucagon release, which stimulates glucose uptake from the blood and mobilizes sugar.

~ 4-6 hr of Stored Glucose

Peripheral Endocrine & Digestive Organ

Benjamin Cummings 2001

https://www.youtube.com/watch?v=y9Bdi4dnSlg
https://www.fuseschool.org
Thyroid metabolism
highly vascularized
**Adrenals/Suprarenals**

**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.

**Cortisol**

**Stress hormones!**
Epinephrine 80%
Norepinephrine 20%

FIGURE 77-1
Secretion of adrenocortical hormones by the different zones of the adrenal cortex.
Stress Promotes Cortisol Secretion

- Stress promotes the secretion of Corticotropin-releasing hormone (CRH) from the Hypothalamus.
- CRH stimulates the Anterior pituitary to secrete Adrenocorticotropic hormone (ACTH).
- ACTH stimulates the Adrenal cortex to produce Cortisol.
- Cortisol levels increase due to both stress and the diurnal rhythm.

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)
Nervous System

CNS

PNS

input

output
What is myelin?
Why is it important?

Lipid insuluvative coat
↑ 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

DC 2003
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)

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

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

M. Broca’s area (speech formation)
~ 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!

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
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>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>
I. **Announcements** Optional notebook ✓ + Lab 6 today. Pulmonary Function Testing. Final exam > your Q on Wed. 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)
Links That May Be Helpful!

https://www.youtube.com/watch?v=6RbPIOq0O3w
https://www.youtube.com/watch?v=mltV4rC57kM
https://www.youtube.com/watch?v=WhowH0kb7n0
http://sites.sinauer.com/psychopharm2e/animation03.01.html
https://www.youtube.com/watch?v=VitFvNvRIIY
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?**

- Actin binding site
- Myosin ATPase site
- Heads
- Tail
- 100 nm

(a)

- Cross bridges
- Myosin molecules

(b)

LS 2006, cf: LS 2012 fig 8-4
Actin molecules

Actin helix

Binding site for attachment with myosin cross bridge

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
1. Acetylcholine released by axon of motor neuron crosses cleft and binds to receptors/channels on motor end plate.

2. 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.

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

4. 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.

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

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

7. 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.

LS 2006 cf: LS 2012 fig 8-10
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/

A. Malcolm Campbell
Davidson College, Davidson, NC
www.bio.davidson.edu/courses/movies.html

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

Atrophy

Hyperplasia

Hypertrophy
Hypertrophy: *Increased Number of Myofibrils, Thick & Thin Filaments, Myosin & Actin Molecules*
% AEROBIC (Oxidative Energy System)  
% ANAEROBIC (Immediate & Non-Oxidative Energy Systems)  

Primary Fuel  
Fat, Carbohydrate & Protein (Small Amounts)  
Carbohydrate (Glucose & Glycogen)  
ATP, ADP & Creatine Phosphate (CP)  

Activity  
Marathon  
Cross-Country Skiing  
10-K Run  
3-Mile Run  
2-Mile Run  
800-Meter Swim  
Boxing  
200-Meter Swim  
Circuit Weight Training  
Soccer  
Lacrosse  
Tennis  
Basketball  
Volleyball  
200-Meter Dash  
Football  
Conventional Weight Training  

Time (Min:Sec)  
135:00  
29:00  
14:00  
9:00  
3:45  
1:30  
0:50  
0:20  
0:10  

AEROBIC w/O₂  
ANAEROBIC  
MITOCHONDRIA  
CYTOSOL  
Glycolysis  
Immediate/ATP-PC
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** Optional notebook check today. Discussion-Review followed by final exam tomorrow. Q?

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

1st alveolar outpouching!

Gas Exchange
**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
$O_2$ is carried mainly by red blood cell hemoglobin!

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

Each hemoglobin molecule carries 4 $O_2$ on 4 iron-containing disks!
Cigarette Smoking: #1 Preventable Cause of Premature Death in the US
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>Category</th>
<th>Concentration</th>
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</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-napthylamine</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](https://www.surgeongeneral.gov), [American Cancer Society](https://www.cancer.org), [American Heart Association](https://www.ahajournals.org).
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

Ach = Acetylcholine

= Nicotinic Receptor

= Muscarinic Receptor

Sympathetic

NE  = Norepinephrine

= α Receptor ($\alpha_1$, $\alpha_2$)

= β Receptor ($\beta_1$, $\beta_2$)
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

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

"Mind if I smoke?"

"Care if I die?"

Each year ~45,000 Americans die due to 2\textsuperscript{nd}-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 4:31 PM, JUNE 3, 2014
SMOKING ≡ ASTHMA?

Petri-dish Effect

Ugh!! Cough! Cough!!