I. **Announcements**
   Tomorrow HR & BP Lab 4 + **Required Notebook Check.** Turn in today? Thurs Blood Chemistry Lab 5. Please read Lab 5 twice prior to Thursday. 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
      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. Heart 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 heart & CV system
      Billy has a hole in his heart SI Fox 2009 fig 13.16, 13.17

III. **Comments on Midterm & Tests Returned**
NB: Figure-8 loop

Pulmonary Systemic
Dual Pump Action & Parallel Circulation
Lymphatic System Blockage in Elephantiasis from Mosquito-borne Parasitic Filaria Worm
Lymphatics collect run-off & are parallel to venules/small veins!
Human $\big{\heartsuit} = 4$-chambered box?
2 separate pumps?

Upper = Atria

Lower = Ventricles

RA

LV

RV

LA

Pulmonary

Systemic

Primer Pumps

Power Pumps
Heart Valves Ensure Unidirectional Blood Flow!

Mom's valve!

Valves must be normal & healthy to work well!

- Right AV valve
- Left AV valve
- Aortic or pulmonary valve

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

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

(c) Prevention of eversion of AV valves

FIGURE 9-4 Heart valves.
Veins → Atria → Ventricles → Arteries
BI 121 Lecture 9

I. Announcements  Lab notebook due today! Lab 4 HR & BP. Thursday, Lab 5 Blood Chemistry. Read pp 5-1 thru 5-6 x2. Q?

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

III. Cardiovascular Connections  LS 2012 ch 9
   A. Cardiac cycle? Contract-relax!
   B. ♠‘s electrical highway + Pacemaker activity
      LS fig 9-7 p 235, tab 9-1 p 236, fig 9-8 p 237
   C. NHLBI & AHA websites

IV. CV Physiology in the News  NHLBI & AHA websites
   Exercise & Nic? Exercise guidelines: ACSM, AHA, CDC

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
Heart's Electrical Highway!

- Interatrial pathway
- Sinoatrial (SA) node
- Right atrium
- Internodal pathway
- Atrioventricular (AV) node
- Left atrium
- Left branch of bundle of His
- Right ventricle
- Left ventricle
- Right branch of bundle of His
- Purkinje fibers

LS 2012 fig 9-7a p 235
(a) Normal pacemaker activity: Whole train will go 70 mph (heart rate set by SA node, the fastest autorhythmic tissue).

(b) Takeover of pacemaker activity by AV node when the SA node is nonfunctional: Train will go 50 mph (the next fastest autorhythmic tissue, the AV node, will set the heart rate).

(c) Takeover of ventricular rate by the slower ventricular autorhythmic tissue in complete heart block: First part of train will go 70 mph; last part will go 30 mph (atria will be driven by SA node; ventricles will assume own, much slower rhythm).
American Heart Association (AHA) & National Heart, Lung & Blood Institute

http://www.my.americanheart.org

http://www.nhlbi.nih.gov/

Department of Health and Human Services · National Institutes of Health

National Heart Lung and Blood Institute

People Science Health
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
**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
HEALTH-RELATED FITNESS

Cardiorespiratory Endurance

Muscular Strength/Endurance

Flexibility

Neuromuscular Relaxation
Pick an abundance of whole grains, legumes, nuts, vegetables & fruits!
Healthy Oils to Minimize Atherosclerosis

HAPOC?
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?

CVD & Oil Connections Anti-inflammatory vs. inflammatory? S&W ch 5

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: O₂-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

Blood Glucose & Diabetes Mellitus LS ch 17, DC Module 13
Essential Fatty Acids: Ω-6 Linoleic & Ω-3 Linolenic Acids

Linoleic → Arachadonic Acid → Inflammatory Cascade

Linolenic → EPA, DHA → Anti-inflammatory
Deep cold water fish are fabulous sources of Ω-3 fatty acids!
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)

Packed cell volume, or hematocrit

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
**Glucose:**
Sugar in Blood

**Normal:** 70-99
**Pre-Diabetes:** 100-125
**Diabetes:** ≥ 126 mg/dL
**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
Times of Plenty!!

NB: Diabetics have problems either here or here.

Fox 1987
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!
I. Lab 5 Review: Safety & Techniques

II. 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
   H. Peripheral endocrine organs DC pp 109-13, LS pp 513-36
      1. Pancreas (insulin, glucagon, diabetes) 2. Thyroid 3. Adrenals

III. Nervous System & Excitable Cell Connections 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
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
Hormone/Endocrine Classifications

Exogenous

Endogenous
Hypothalamus-Anterior Pituitary Vascular Connection!

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

- [ ] = Hypophysiotropic hormones
- [ ] = Anterior pituitary hormone

LS 2007
Pituitary Nourishing or Growth Hormones

Hypothalamus

Neurosecretory neuron

Systemic arterial inflow

Hypothalamic-hypophyseal portal system

RH + or RIH -

Releasing or Release-Inhibiting Hormones

Pituitary Nourishing or Growth Hormones

Systemic venous outflow

= Hypophysiotropic hormones

= Anterior pituitary hormone

Hypophysis = Pituitary

LS 2007
Paraventricular nucleus
Supraoptic nucleus
Median eminence
Portal system
Anterior pituitary

Hypothalamus
Infundibulum

Posterior pituitary

Mammary gland

Prolactin

Thyroid

Adrenal cortex

Bone
Muscle
Adipose tissue

Growth hormone

ACTH

Gonadotropins

FSH
LH

Ovary
Testis

SI Fox 2008
cf: LS 2012 fig 17-5
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!!

![Graph showing the relationship between growth hormone (GH) levels and time of day, with peaks during strenuous exercise and during sleep. The y-axis represents growth hormone concentration in ng/ml plasma, and the x-axis represents time of day. The graph indicates that growing hormone levels are highest during sleep and after strenuous exercise.]

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

CNS

PNS

input

output

C
Approximately 99% of all neurons in humans! CNS ~100 billion interneurons!!
Motor

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

M. Premotor cortex
   (coordination of complex movements)

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)

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

S. Primary sensory cortex
   (sensation)

M. Primary motor cortex
   (voluntary movement)

Central sulcus

Sensory

Key

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

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

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)

LS 2006, cf: LS 2012 fig 5-8a
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
716 cyclists died in 2008 ≡ 2% of all traffic fatalities
½ of deaths children < 15 yr
53,000 cyclists have died since 1932
that's more than the population of
Springfield, OR  52,864
Bend, OR      52,029
Corvallis, OR  49,322

Bicycle crashes & injuries are under reported, since majority not serious enough for ER visits.
Helmets may prevent 45-88% of brain injuries!
~$81 million/yr = direct injury costs from not using helmets!
I. **Announcements** Optional notebook check + Lab 6 tomorrow. Pulmonary Function Testing. Final exam > your Q on Wed. Q?

II. **Autonomic Nervous System Overview** LS pp 178 – 85
   LS Table 7-1 p 183 + stories to remember **fight-or-flight!**

III. **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

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 8-2, 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...
Homeostasis is a **dynamic balance** between the autonomic branches.

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

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

Fine-tune control & safety!

cf: LS 2012 fig 7-3

LS 1995
Hormonal Adrenaline Surge Reinforces Nervous Outflow & Accesses Tissues Not Directly Innervated!!

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

Adrenals = Paired organs above kidneys

Output to blood
<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></td>
<td></td>
<td>Stimulates secretion by specialized sweat glands in the armpits and genital area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stimulates a large volume of watery saliva rich in enzymes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></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>
Axon of motor neuron
Myelin sheath
Action potential propagation in motor neuron
Axon terminal
Calcium channel
Vesicle of acetylcholine
Plasma membrane of muscle fiber
Acetylcholine receptor site
Cation channel
Acetylcholinesterase
Motor end plate
Contractile elements within muscle fiber
Terminal button
Muscle fiber
Local current flow between depolarized end plate and adjacent membrane
Action potential propagation in muscle fiber

3
4
7
Skeletal Muscle Histology: Microscopic Anatomy

Muscle fiber or cylindrical cell

Nuclei

“Threads” ≡ Myofibrils

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)

(b)

LS 2006, cf:
LS 2012 fig 8-4
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
Cross-Bridge Cycle

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

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

3. Bending (power stroke)
   - Fresh ATP available

4. Detachment
   - No ATP (after death)
   - Rigor complex
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.
Adaptations to Exercise?
Mode, Intensity, Duration, Frequency, Distribution of Training Sessions? Conditions of Environment? Individual?
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 Ila)</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>
I. *Announcements* Optional notebook check today. Discussion-Review followed by final exam tomorrow. Q?

II. *Introduction to PFT Lab 6* Pulmonary Function Testing

III. *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 p347, DC, SI Fox +...
   C. Histology LS fig 12-4 pp 347-9, DC
   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

IV. *Physiology of Cigarette Smoking*
   A. ANS, autonomic nerves & nicotine? Route of chemicals,...
   B. Emphysema? 2nd-hand smoke?... p 356, 365
   C. UO Smoke-Free since Fall 2012! Help is available!
NB: Should be able to blow out ≥ 75 - 85% of VC/FVC in 1 second! That's FEV$_{1.0}$/FVC ≥ 0.75 – 0.85. If less, may indicate asthma or other lung disease.

Respirometer → measures complete Pulmonary Function Test or PFT!
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)
Lombo’s simplified steps!

1. Breathe in & out!

2. Cross membranes!

3. Move with blood!
   Go with the flow!

4. Cross membranes!

Steps of external respiration:

1. Ventilation or gas exchange between the atmosphere and air sacs (alveoli) in the lungs.

2. Exchange of O₂ and CO₂ between air in the alveoli and the blood in the pulmonary capillaries.

3. Transport of O₂ and CO₂ by the blood between the lungs and the tissues.

4. Exchange of O₂ and CO₂ between the blood in the systemic capillaries and the tissue cells.

LS 2012 fig 12-1 modified
**NB: In vivo, Cupola or peak of each lung goes into neck > clavicle line!**

- Nasal passages
- Mouth
- Pharynx
- Larynx
- Trachea
- Cartilaginous ring
- Right bronchus
- Bronchiole
- Terminal bronchiole
- Branch of pulmonary artery
- Smoooth muscle
- Branch of pulmonary vein
- Pulmonary capillaries
- Alveolar sac
- Left bronchus
- Enlargement of alveoli (air sacs) at terminal ends of airways

**LS 2012 fig 12-2**
No Gas Exchange

1st alveolar outpouching!

Gas Exchange

SI Fox
**Inhale** (active)

Contract & flatten diaphragm

**Exhale** (passive @ rest)

Relax & pouch up diaphragm!
Brain stem $\equiv$ Control Center for automatic breathing!
Respiratory membrane separates air from blood, is 6 layers, yet 1/50th thickness of tracing paper!
Across pulmonary capillaries:
- $\text{O}_2$ partial pressure gradient from alveoli to blood = 60 mm Hg (100 → 40)
- $\text{CO}_2$ partial pressure gradient from blood to alveoli = 6 mm Hg (46 → 40)

Across systemic capillaries:
- $\text{O}_2$ partial pressure gradient from blood to tissue cell = 60 mm Hg (100 → 40)
- $\text{CO}_2$ partial pressure gradient from tissue cell to blood = 6 mm Hg (46 → 40)

Numbers are mm Hg pressure.

cf: LS 2012 fig 12-19
<table>
<thead>
<tr>
<th>GAS</th>
<th>METHOD OF TRANSPORT IN BLOOD</th>
<th>PERCENTAGE CARRIED IN THIS FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_2$</td>
<td>Physically dissolved</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Bound to hemoglobin</td>
<td>98.5</td>
</tr>
<tr>
<td>$CO_2$</td>
<td>Physically dissolved</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Bound to hemoglobin</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>As bicarbonate ($HCO_3^-$)</td>
<td>60</td>
</tr>
</tbody>
</table>
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
Parasympathetic

Ach = Acetylcholine

= Nicotinic Receptor

= Muscarinic Receptor

Sympathetic

NE = Norepinephrine

= α Receptor ($\alpha_1$, $\alpha_2$)

= β Receptor ($\beta_1$, $\beta_2$)
Cigarettes $\equiv$ 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

Blood → Pulmonary Veins → Left Atrium → Left Ventricle → Aorta → Heart → Brain

Systemic Circulation
Keep it Basic?

Cigarette smoking is the most important preventable cause of premature death in the U.S. accounting for 443,000 annual deaths.

http://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/tobacco_related_mortality/#cigs
Cigarette smoking causes 87% of lung cancer deaths and is responsible for most cancers of the larynx, oral cavity & pharynx, esophagus, & bladder.
Emphysema ≡ Corrosion of Alveolar Walls with ↓ SA & Labored Breathing

Internet Journal of Pathology
Mayo Clinic Health
On the Pill & Smoke?

Increased Risk of:

1. Blood Clots
2. Heart Attack
3. Strokes!

Why you have to tell your gynecologist you smoke. Even if it’s only at parties.

Increased Risk of:
1. Blood Clots
2. Heart Attack
3. Strokes!

You figure an occasional cigarette can't hurt, and you really don't want to listen to the 'stop smoking' lecture from your doctor. But if you want any type of hormonal birth control, smoking is a vitally important issue.

Hormonal birth control is a prescription drug and while the risks are rare, they can be serious. And smoking, even a little, increases the risks, especially if you're over 35.

Risks include blood clots, stroke, and heart attack. If you have a history of these conditions or certain cancers, you shouldn't use hormonal birth control.

Of course, you should tell your healthcare professional if you could be pregnant, and because hormonal birth control doesn't protect against HIV or sexually transmitted diseases, learn how to stay safe and healthy.

Hormonal birth control has been used safely by millions of women for 45 years, and is 99% effective when used correctly. It could be a good choice for you. To find out, talk to your healthcare professional. And to help you get started, there's a list of questions to ask at www.orthowomenshealth.com

Be smart about your body.
Be smart about your birth control.
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 ≡ ASTHMA?

Petri-dish Effect

Ugh!! Cough! Cough!!
Ammonia converts nicotine, the addictive 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. The Oregon Graduate Institute study confirms the contention that...
Nicotine Addiction & Help Quitting Smoking

http://www.cancer.org/healthy/stayawayfromtobacco/guide
toquittingsmoking/guide-to-quitting-smoking-help-phys-nrt

2nd-Hand Smoke or ETS & 3rd-Hand Smoke?

http://www.cancer.org/cancer/cancercauses/tobaccocancer/
secondhand-smoke

2nd-Hand Smoke Addictive?

%20smoke%20addictive