Systems Physiology I: Cardiovascular, Respiratory, and Renal Systems

Quote of the Day (Week, or Semester)

"A mediocre person tells. A good person explains. A superior person demonstrates. A great person inspires others to see for themselves."

Harvey Mackay

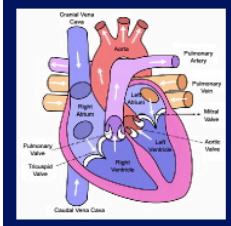
Harvey Mackay (born 1932 in Saint Paul, Minnesota) is a businessman and columnist. Mackay is perhaps best known as the author of five business bestsellers, including Swim With the Sharks (Without Being Eaten Alive), Beware the Naked Man Who Offers You His Shirt and Dig Your Well Before You're Thirsty. He is a nationally syndicated columnist, and one of America's most popular business speakers. He is also founder, Chairman and CEO of Mackay Envelope Corporation, whose story he tells in anecdotes sprinkled throughout his books.

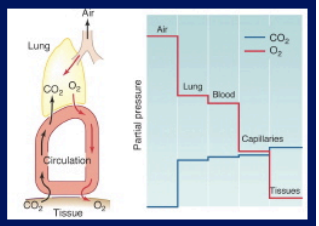
Organization

- Instructors: Rob MacLeod (macleod@cvrti.utah.edu)
- TA: Andrew Miller (acmiller015@gmail.com)
- Web page: http://www.sci.utah.edu/~macleod/be6000
- Canvas page: https://utah.instructure.com/courses/269693

Web Site

Bioengineering/Physiology 6000:
System Physiology I: Cardiovascular, Respiratory, and Renal Systems
Spring of 2014 Edition
Note: this class makes heavy use of Canvas for submission of all assignments.





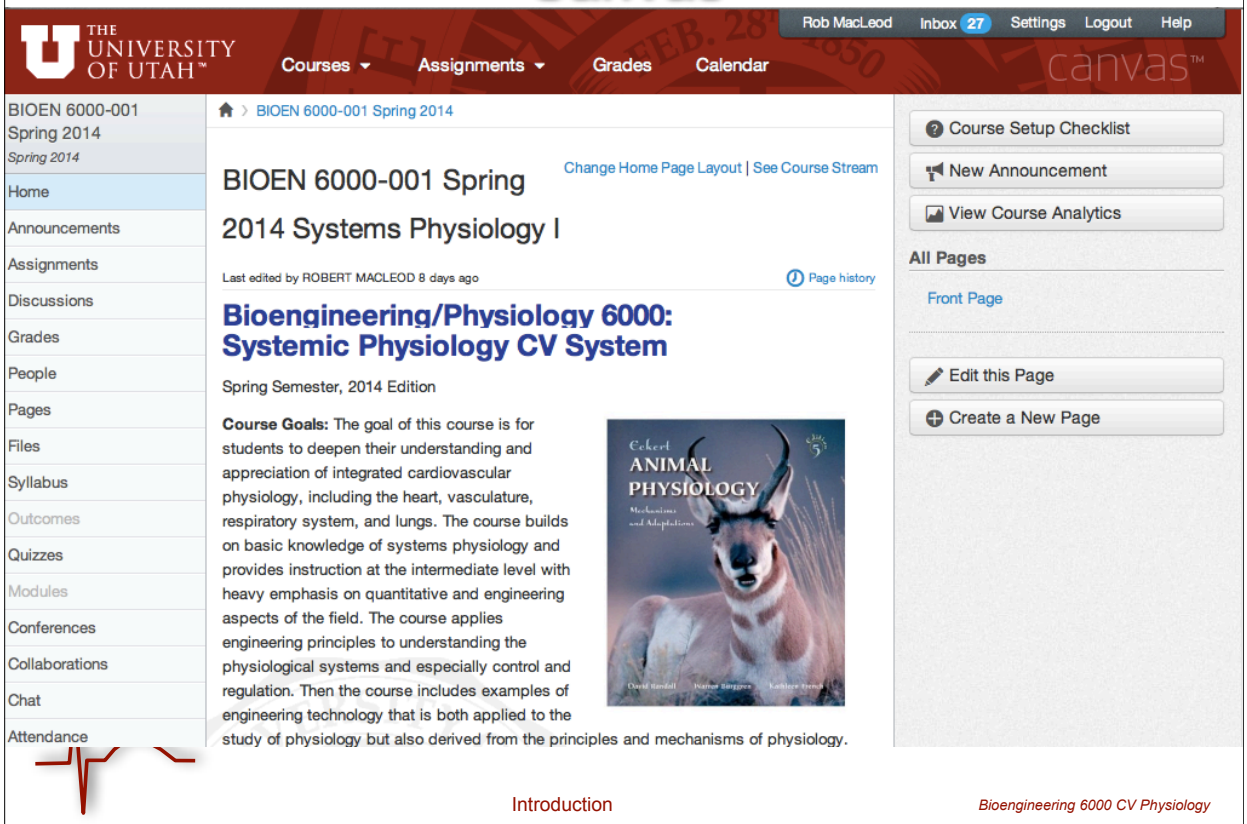
Spring 2014 Deadlines and Dates

Here are the current (and past) deadlines for the class.

- Monday, January 6: first day of class
- Friday, January 10 and Monday, January 13: first lab days
- Monday, January 20: Martin Luther King Holiday
- Friday, January 24 5:00 PM: Lab report #1 (dissection) due
- Monday, February 17: Presidents' Day Holiday
- Thursday, April 24, 8:00-10:00 **Final Exam** (in regular classroom)

Important Course Information

Canvas



Lecture Syllabus

- Cardiac electrophysiology/mechanics
  - Membrane and cellular structure/function
  - Action potentials
  - Cardiac tissue and bioelectricity
  - Cardiac mechanics, regulation
- Cardiovascular structure/function
  - Vascular system
  - Hemodynamics, transport, regulation
- Respiration
  - Gases and gas transport
  - Ventilation
  - Regulation
- Renal function
  - Osmotic regulation
  - Renal transport
  - Regulation

Lab Syllabus

- Sessions:
  - Dissection of CV system (bovine heart)
  - Regulation of cardiac function (frog)
  - Exercise and blood pressure
  - ECG
  - Pulmonary function
  - Simulation
- TA: Andrew Miller (acmiller015@gmail.com)

Schedule

#	Date	Inst.	Topic	Reading	Assignments/Tests
	Bioengineering/Physiology 6000 Schedule, 2014				
1	Mon, Jan 6, 2014	RM	Introduction to course	Notes	
2	Wed, Jan 8, 2014	RM	Everest video/Extreme Physiology		
3	Fri, Jan 10, 2014	RM	Animal physiology + Preparation for Lab	1:1-14/LB 1	
LAB 1	Fri, Jan 10, 2014		**Dissection of the bovine heart/lungs**		
4	Mon, Jan 13, 2014	RM	Intro to animal physiology II	1:7-14/LB 1	
LAB 1	Mon, Jan 13, 2014		**Dissection of the bovine heart/lungs**		
5	Wed, Jan 15, 2014	RM	Lab Review/Reports	Notes	
6	Fri, Jan 17, 2014	RM	Lab Reports	Notes	
	Mon, Jan 20, 2014		**Martin Luther King Jr. Day Holiday**		
7	Wed, Jan 22, 2014	RM	Ion transport and Resting potentials	5:132-153, 12:479-480/LB 3	
8	Fri, Jan 24, 2014	RM	Action potentials I	5:132-153, 12:477-479/LB 3	Lab Report #1
9	Mon, Jan 27, 2014	RM	Action potentials II	5:136-137/LB 4	
10	Wed, Jan 29, 2014	RM	Simulation of cell action potential	Notes	
11	Fri, Jan 31, 2014	RM	Pacemakers, Control of heart rate	12:479-480/LB 5	
12	Mon, Feb 3, 2014	RM	Pacemakers, Control of heart rate	12:479-480/LB 4	
13	Wed, Feb 5, 2014	RM	Review of first lab report	12:479-480/LB 6	
14	Fri, Feb 7, 2014	RM	Tissue Electrophysiology I	LB 5	Lab Report #1 2nd submit
LAB 2	Fri, Feb 7, 2014		**Regulation of heart rate and contraction (frog)**		
15	Mon, Feb 10, 2014	RM	Tissue Electrophysiology II	LB 5	
LAB 2	Mon, Feb 10, 2014		**Regulation of heart rate and contraction (frog)**		
16	Wed, Feb 12, 2014	RM	Arrhythmias	Notes	
17	Fri, Feb 14, 2014	RM	Electrocardiogram I	12:478-486/LB 7	Cell Sim Homework
	Mon, Feb 17, 2014		**President's Day Holiday**		
18	Wed, Feb 19, 2014	RM	Electrocardiogram II	12:478-486/LB 7	
19	Fri, Feb 21, 2014		Lab Preparation	Notes	
LAB 3	Fri, Feb 21, 2014		**ECG Lab**		Lab Report #2
20	Mon, Feb 24, 2014	RM	Homework #1 Discussion	Notes online	
LAB 3	Mon, Feb 24, 2014		**ECG Lab**		
21	Wed, Feb 26, 2014	RM	EC Coupling I	12:478-486/LB 7	
22	Fri, Feb 28, 2014	RM	Guest Lecture/WAF Conference		
23	Mon, Mar 3, 2014	RM	EC Coupling II	12:478-486/LB 7	
24	Wed, Mar 5, 2014	RM	Heart as a Pump	12:478-486/LB 7	
	Fri, Mar 7, 2014	AM	**Midterm #1**		Midterm #1
LAB 4	Fri, Mar 7, 2014		**ECG Simulation lab**		
	March 12-17		Spring Break		March 12, Lab 3 Report

Resource Material

- Class web page :
  - www.sci.utah.edu/~macleod/be6000
- Text: Eckert Animal Physiology, Randall, Burggren, & French
- Notes: available before most lectures on the web site in pdf format.
- Study topic list: prepared before each major test
- Additional references (see web site):
  - Human Physiology: An Integrated Approach by Silverthorn
  - Physiology by Berne and Levy;
  - Mathematical Physiology by Keener and Sneyd
  - Cardiovascular Physiology by Mohrman and Heller.

Labs

- Goals:
  - Put theory into practice
  - Get exposure to real biological data
  - Encourage sound analysis and interpretation
  - Develop/improve writing and organizational skills
  - Explore Design of Experiments
- Guidelines:
  - Generally two lab days per lab (Friday/Monday, Friday/Tuesday, Wed/Friday)
  - Sign up for the lab Doodle Poll: see web site
  - Review lab instructions and associated web sites for Friday
  - Start of lab time: 12:00 on Friday, 1:00 pm Monday

Lab Logistics

- Lab time: Friday at 12:00 and Monday at 1:00 PM
- First lab: Friday, Jan 10 (this week!!)
- Lab materials
  - Camera (one per team)
  - Tolerant, comfortable clothes

Lab Reports

- Writing/presentation is important!
- Format varies with the lab
- Emphasis on results and discussion
- Requirement of clear, logical, concise scientific writing
- Plentiful feedback (our job)
- Resubmissions allowed (on first two labs)

My Expectations

Students should:

- Already possess a basic understanding of human physiology, e.g., Human Physiology: in Integrated Approach, by Silverthorn
- Already have a working knowledge of MATLAB
- Immediately check Canvas: see web site for instructions
- Already have previous experience with writing lab reports
- Plan to read the text (during the semester)
- Plan to read some literature
- Ask questions and participate

Our Deliverables

We will offer:

- Intermediate level coverage of cardiovascular physiology
- Generalized approach to physiological systems
- Lab experiences that integrate class material
- Design of experiments
- Feedback and a chance to act on that feedback
- Flexible syllabus based on class interest
- Answers to the Why Should We Care? question at any time
- Experiment with peer learning
- Accessibility: after class and by email are best

Grading

- Exams: 3 * 15% = 45% of total grade
  - Types of questions
    - True/false with explanation
    - Describe a mechanism
    - Explain an observation
    - Interpret data
- Labs: 30%
  - 6 labs with written reports,
- Semester project: 20%
  - Written exploration of extreme physiology
- Homework: 5%
  - 2-3 homework assignments
  - Simulations, calculations

Death Zone Video

Motivation and background for semester project

Comments from Video

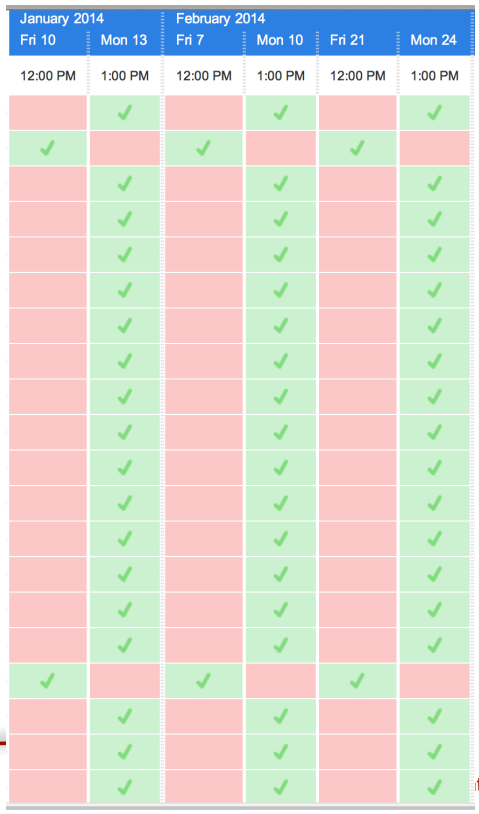
Structure

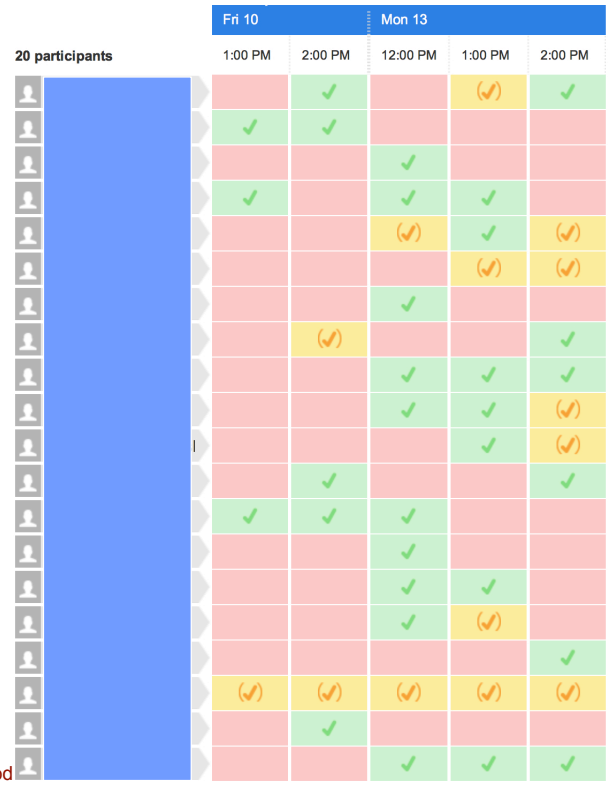
Content

Approach

Message

Lab Scheduling

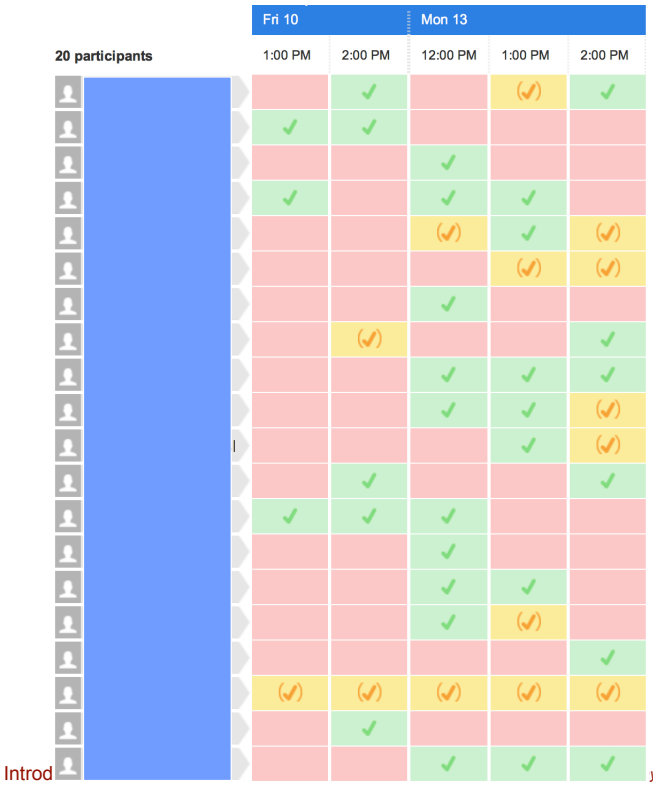




Lab Scheduling

Decision

Friday Lab: 2:00
Monday Lab: 1:00



Lab Scheduling

Heather's reply re BIOEN 4202 Friday sessions:

> "I haven't had any students in the past approach me with anything I couldn't work around, so I don't anticipate it being an issue the students can't manage."

Lab Planning and Practice

Goals

Logistics

Careful Execution

Cleanup

Data Acquisition

Data Processing

Before

During

After

Excellent Photo Example

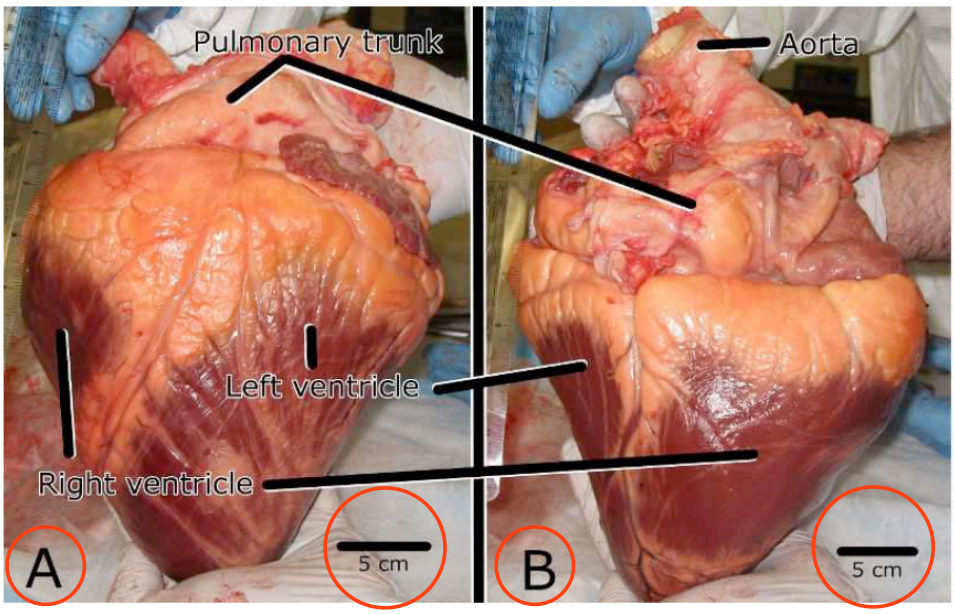


Figure 4: External anatomy of the bovine heart. Frame A on the left shows the anterior face of the heart, frame B the posterior.

And Another

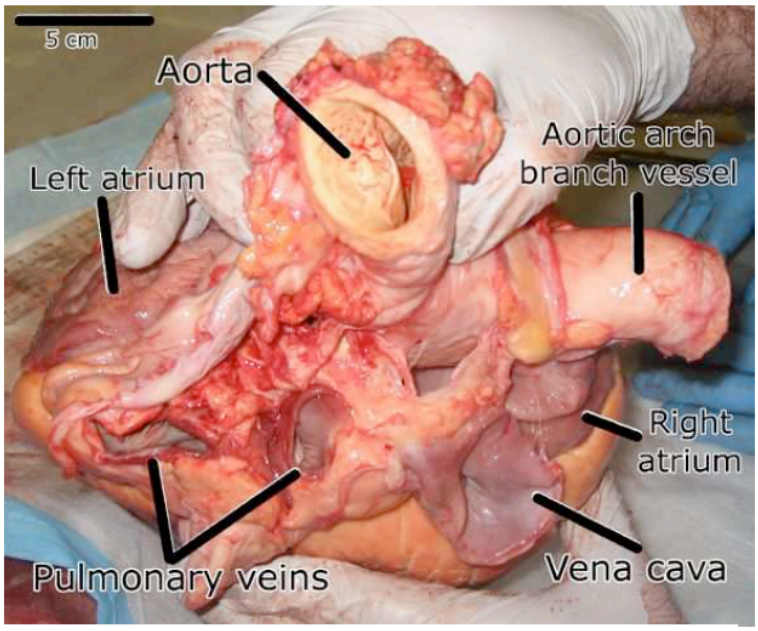
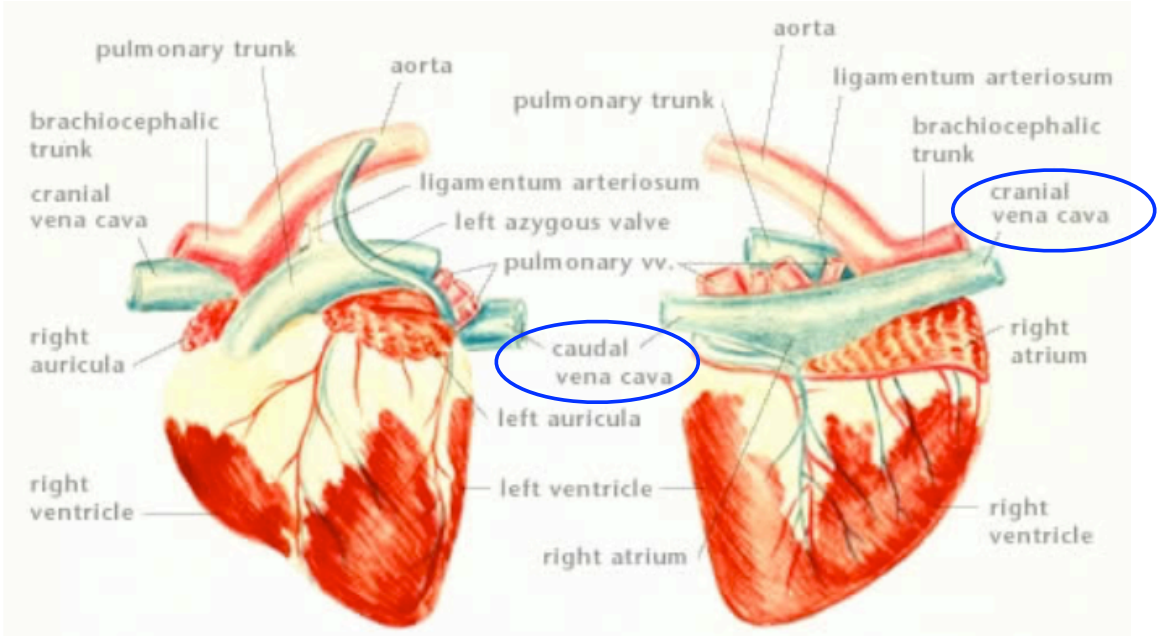


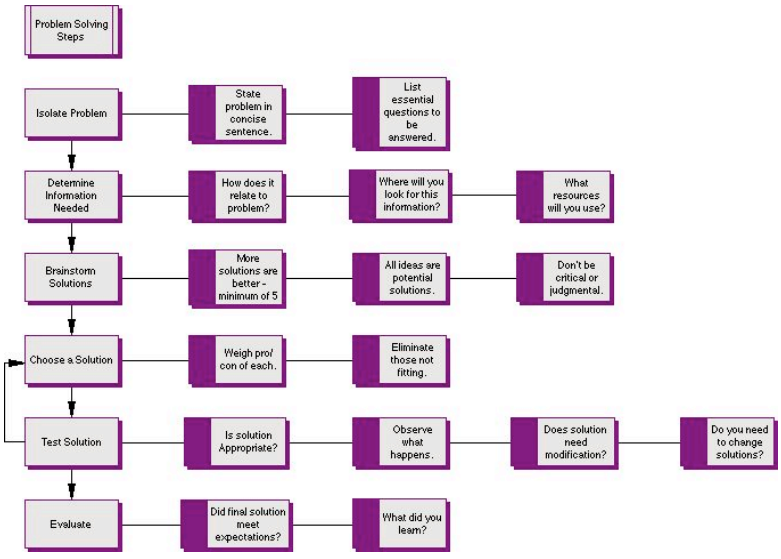
Figure 5: Major vessels of the bovine heart. Pericardial tissue obscures the pulmonary artery in this photo. It is located almost directly above the right most pulmonary vein.

Cow Specific Information



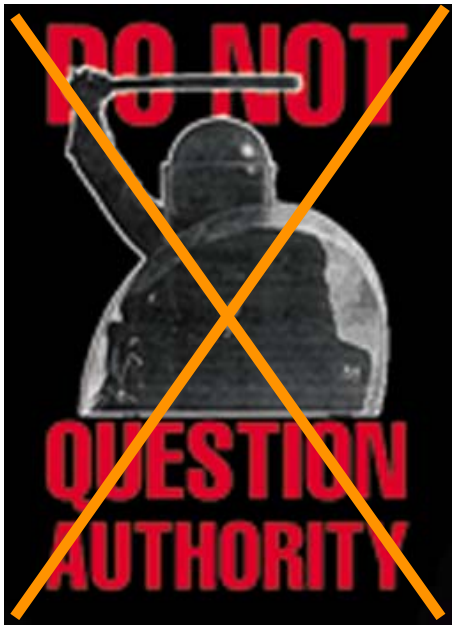
Meanwhile, Back in the Classroom...

Learning Approach: Problem Solving



Learning Approach: Motivation

By Force?



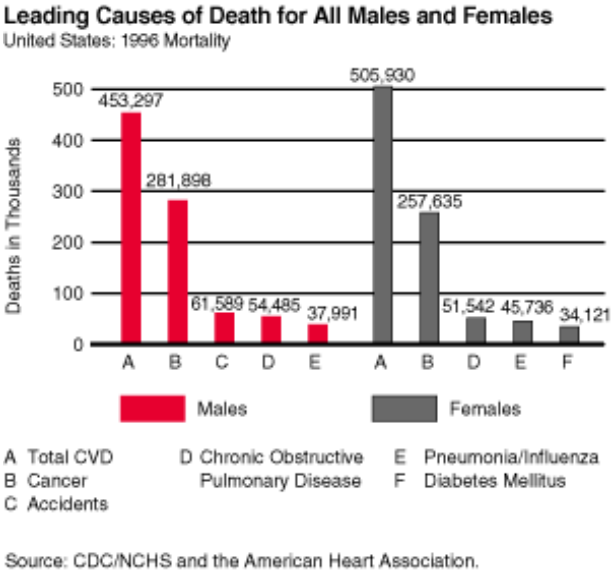
Don't memorize

Ask Good Questions!

So what are some good questions?

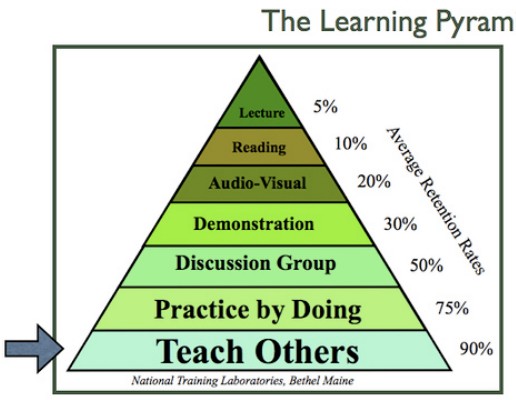
Learning Approach: Finding Good Questions

Scott Sandford, NASA



Ann Improb.Res., annual swimsuit issue, 4(2) March/April 1998

Peer Learning



"Peer learning is based in real work: sharing what one is doing with others, asking for support, questions and answers and feedback."

wiki.sos.wa.gov/PeerLearning

Plagiarism

What is it?

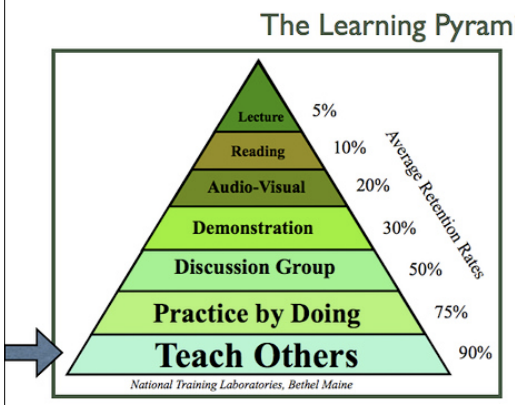
1. To use and pass off as one's own (the ideas or writings of another).
2. To appropriate for use as one's own passages or ideas from (another).
3. To put forth as original to oneself the ideas or words of another.

Why is it bad?

- Reputation and fraud
- The law
- Fairness
- Self-delusion

www.rbs2.com/plag.pdf

How Do We Reconcile?

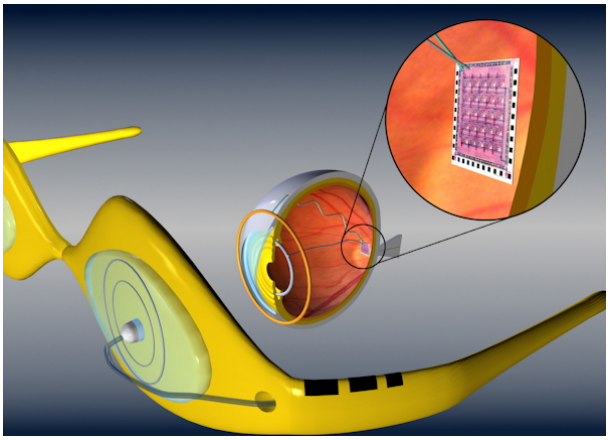


versus

Why Animal Physiology?

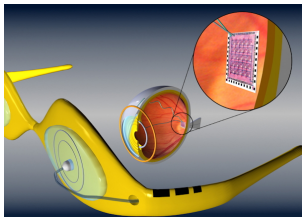
Why Animal Physiology?

Why Animal Physiology?



Why Animal Physiology?

- Scientific curiosity
  - animals can do things humans cannot!
- Insights into human physiology
  - source of experimental models
  - similarities and differences important to know
- Bioengineering strategies
  - "Bio-based" approach
- Commercial/agricultural applications
  - veterinary medicine
  - genetically modified/cloned animals

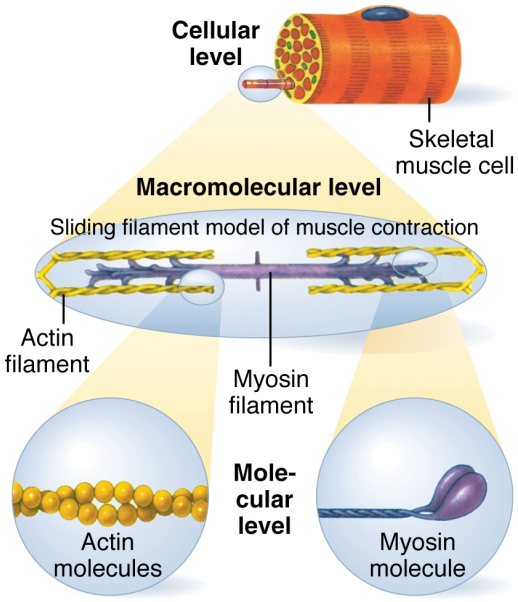


Physiological Has Central Themes

1. Structure/function relationships
2. Methods of change: Adaptation, acclimatization, and acclimation
3. Homeostasis
4. Conformity and regulation
5. Feedback control systems

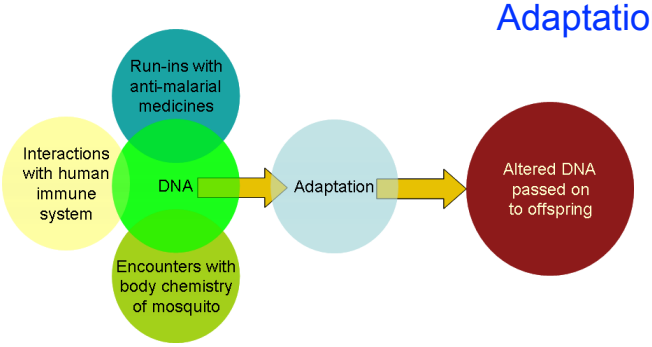
1. Structure/Function Relationships

- Function follows from structure, e.g., different muscle forms have different function
  - skeletal
  - smooth
  - cardiac
- Present across scales

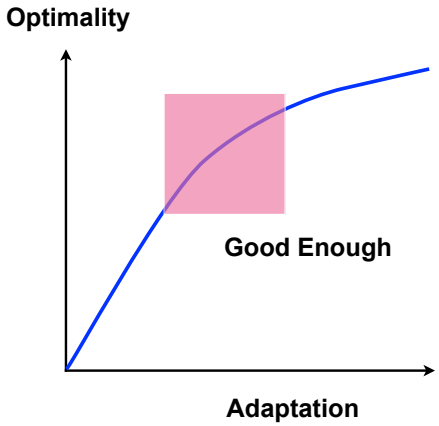


2. Mechanisms of Change

Adaptation



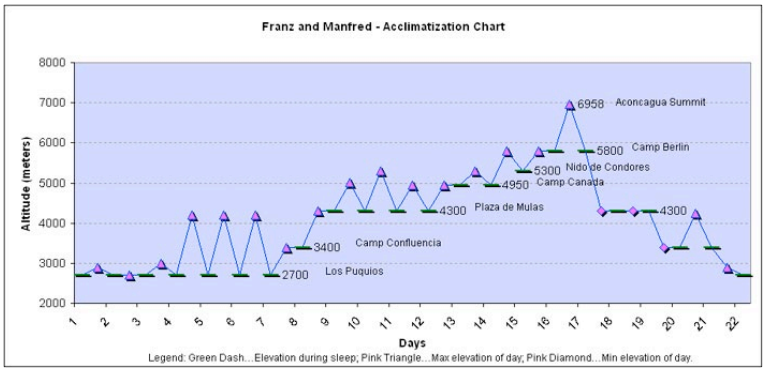
Dyann Wirth

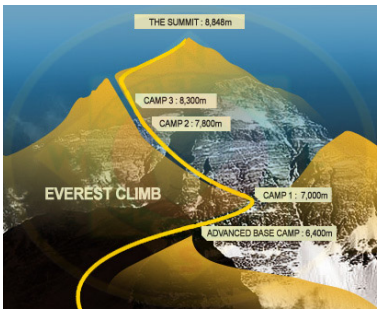


- Adaptation
  - passed by genetic material, slow, not reversible
  - occur by mutation, selected by environment
  - can be difficult to determine, must bring survival advantages, e.g., same response to same stress across different species

2. Mechanisms of Change

Acclimatization and Acclimation

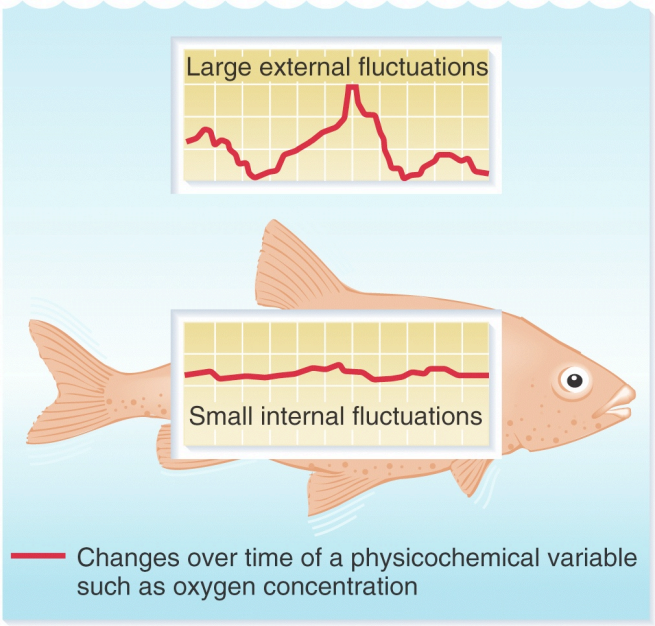




www.aconcaguaexpeditions.com

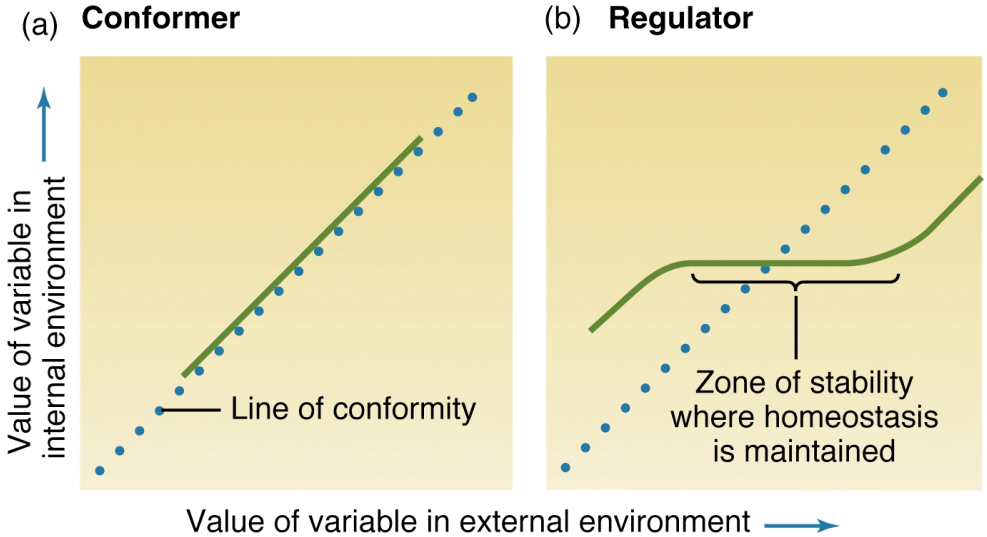
- Acclimatization
  - change in response to exposure to environment
  - relatively rapid and reversible
  - e.g., response to change in altitude
- Acclimation
  - same as acclimatization but induced by investigator

3. Homeostasis



- System to remove or attenuate response to external changes
- Produces constant internal environment
- E.g., body temperature
- Effective across scales
- Different animals respond differently to same stress

4. Conformity and Regulation

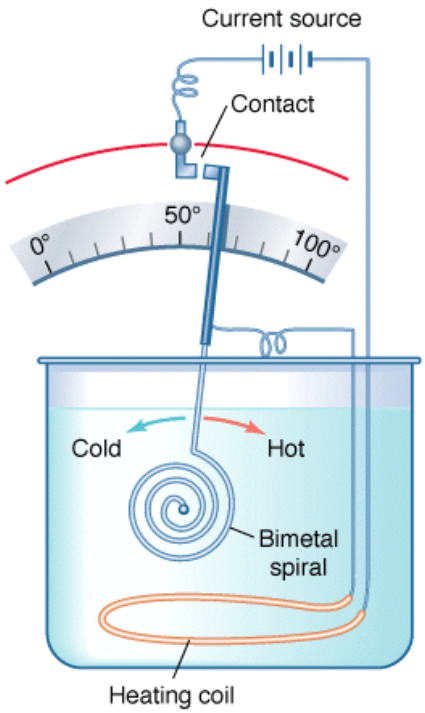


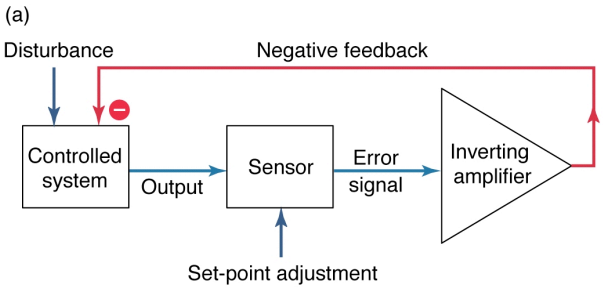
- Internal = external
- E.g., starfish (salinity) annelid worms (oxygen)

- Internal != external
- E.g., crustations (oxygen) mammals (temperature, etc.)

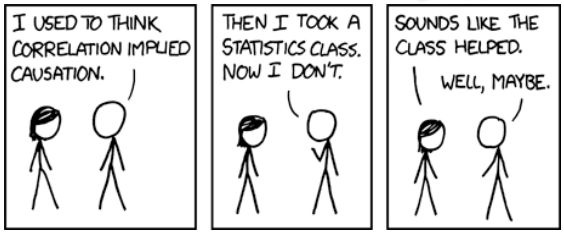
5. Feedback control

- Central to all physiology
- Mechanism for homeostasis
- Positive versus negative feedback
- Set point
- Gain





Causality and Teleology



- Teleology:
  - "A thing, process or action is teleological when it is for the sake of an end, i.e., a telos or final cause."
  - "The use of ultimate purpose or design as a means of explaining phenomena."
  - Avoid this type of thinking in science as we cannot tell purpose.
- Example (from lab report):
  - "One initial observation is that the right lung is much larger than the left lung. This makes sense physiologically since the heart is generally located on the left side of the body; therefore to optimize lung capacity, the right lung has more room inside of the body to grow."

http://www.answers.com/topic/teleology

Features of Cardiovascular Physiology

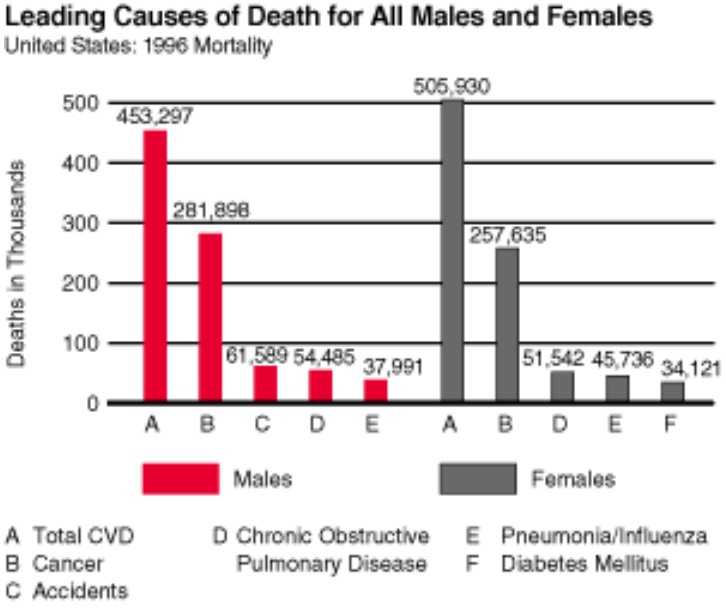
(Why engineers might hate physiology)

– Blood is thicker than water (it is a suspension of particles)
– Blood vessels are not pipes (walls are elastic, contractile)
– The heart is a "permissive" pump (follows rather than leads)
– Most heart failure is electrical not mechanical in origin

(Why engineers should love physiology)

– Physiology is physics (just complicated physics)
– Homeostasis = control

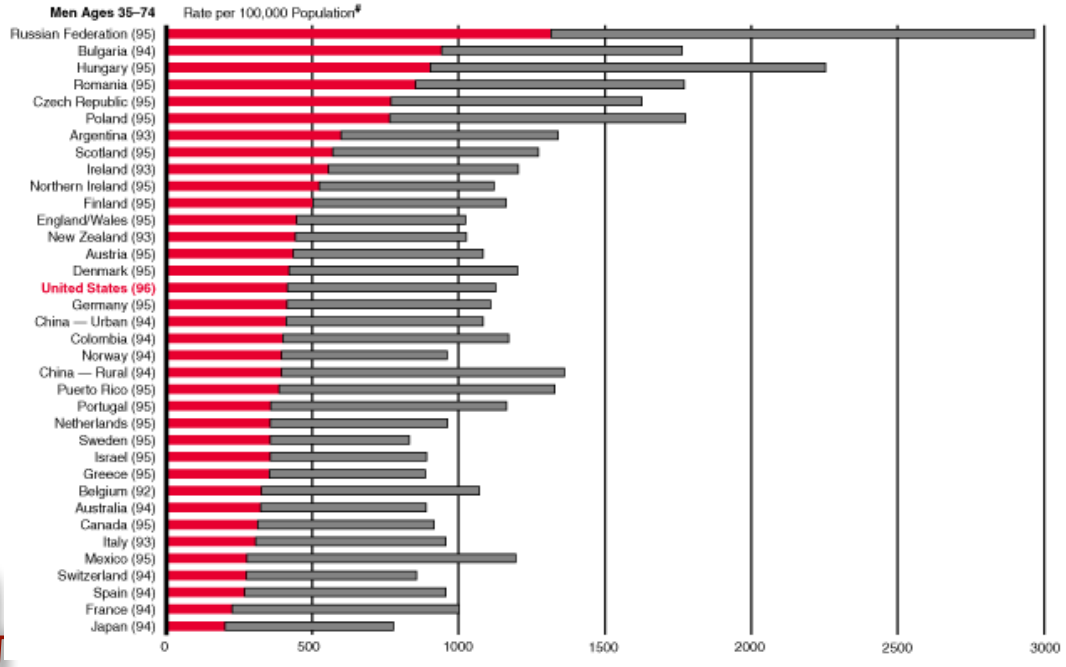
Overall Causes of Death



Source: CDC/NCHS and the American Heart Association.

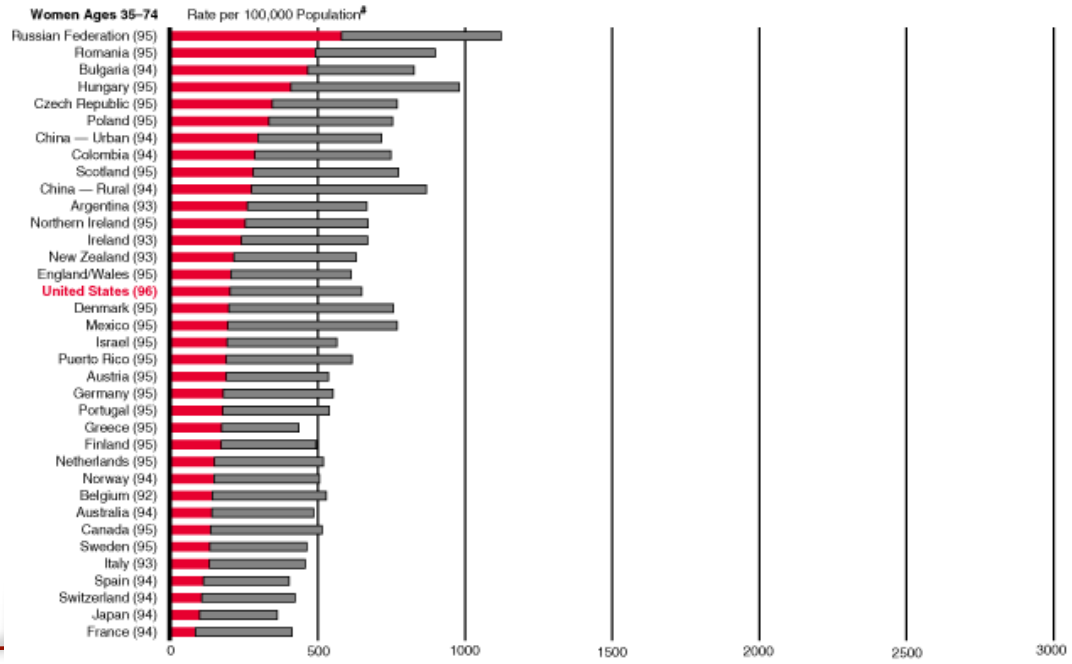
World CV Death rates (men)

CV Diseases All Causes



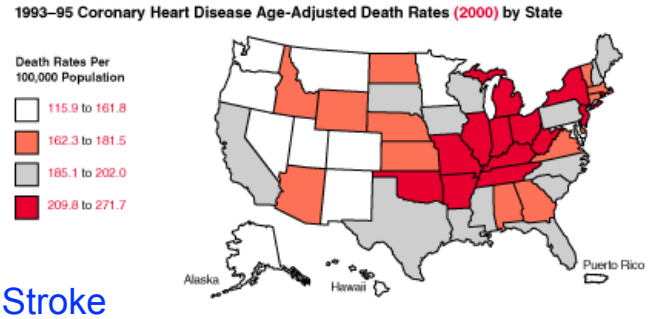
World CV Death rates (women)

CV Diseases All Causes



CV Disease Rates: US

CHD



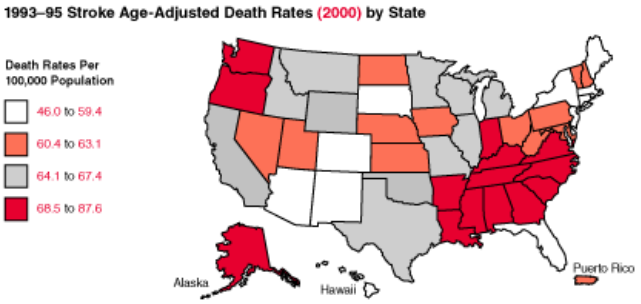
Rank: Low to High

#1: New Mexico

#52: New York

Utah: #3

Stroke

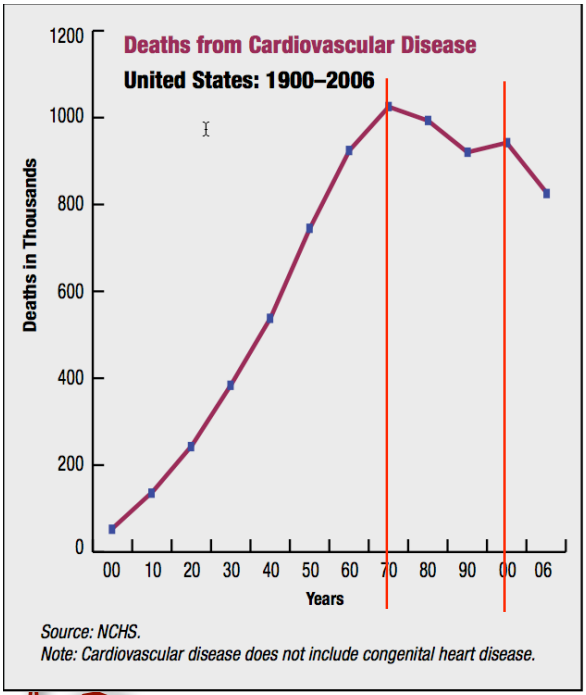


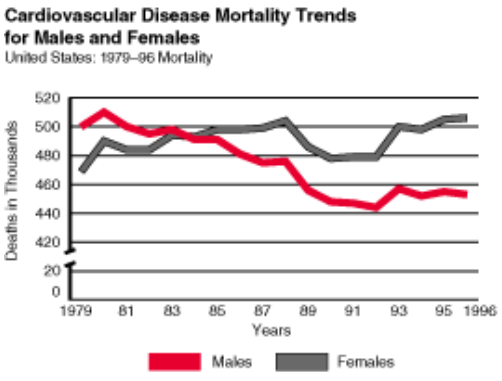
#1: New York

#52: S. Carolina

Utah: #11

The Updated Trends

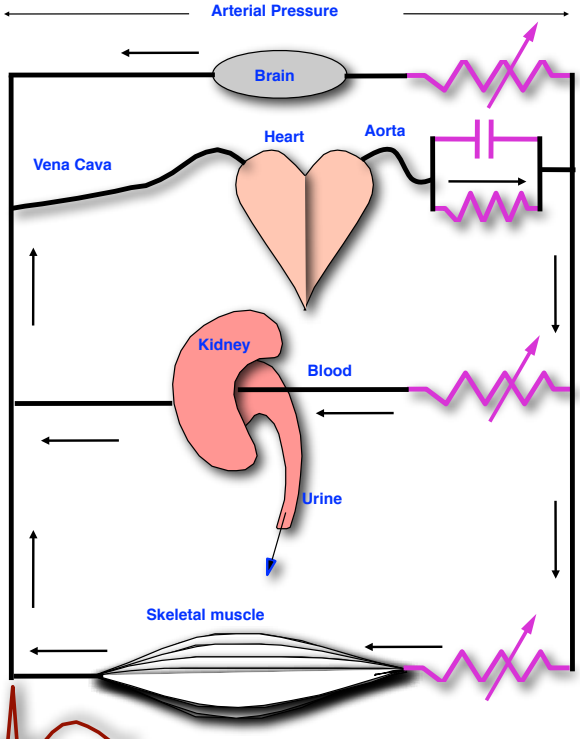




Cardiovascular System Overview

- The plumbing: circulation systems in the body
- The wiring: cardiac electrophysiology
- The pump: the heart as a pump
- The flow: blood and hemodynamics
- The control: brain/hormonal/local, feedback

Cardiovascular System Regulation



- Goal: adequate flow
- Process: pump and flow
- Regulation: parallel circuit with valves
- Sensors?
- Feedback?