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."

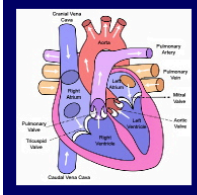
Harvey Mackay

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.

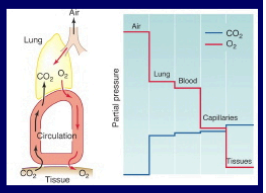
Organization

- Instructors: Rob MacLeod (macleod@cvrti.utah.edu)
- TA: Josh Silvernagel (Joshua.Silvernagel@carma.utah.edu)
- Web page: http://www.sci.utah.edu/~macleod/be6000
- Canvas page: https://utah.instructure.com/courses/220933

Web Site



Bioengineering/Physiology 6000: System Physiology I: Cardiovascular, Respiratory, and Renal Systems Spring of 2013 Edition
Note: this class makes heavy use of Canvas for submission of all assignments.



Spring 2013 Deadlines and Dates

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

- Monday, January 7: first day of class
- Monday, January 21: Martin Luther King Holiday
- Friday, January 25: Lab report #1 (dissection) due
- Monday, February 18: Presidents' Day Holiday

Important Course Information

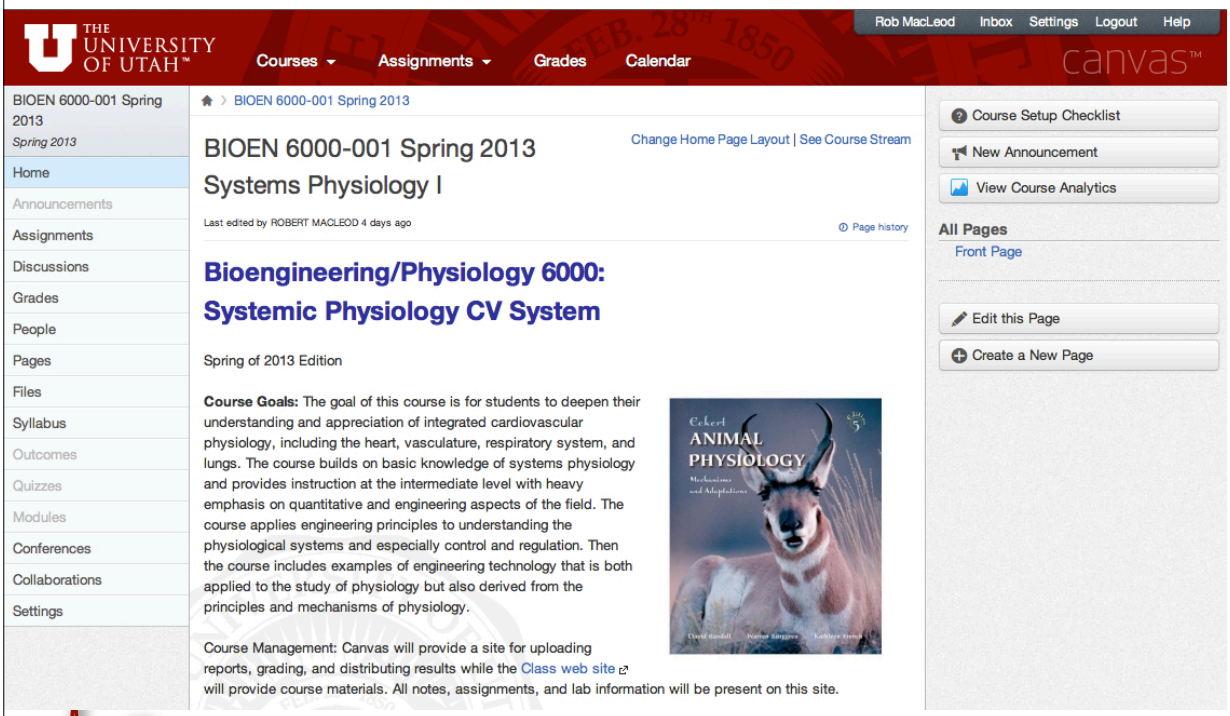
If you have questions about the course please contact Rob MacLeod for any questions.

- Note: this class makes heavy use of Canvas for submission of all assignments.
- Still slightly tentative but always-dynamic Course Syllabus ,(PDF Acrobat format).
- Class schedule (also subject to change) .
- Doodle poll for signing up for lab days. Please check here to see which day you signed up for which lab.
- A LaTeX template for lab reports, included as a zipped archive file that will create a LaTeX subdirectory with all the files necessary.
- College of Engineering Course Guidelines.

Course Lecture Notes

- Lecture block 1 (Rob MacLeod): Introduction
  - Lecture slides in PDF format (3.8 MB)
- Lecture block 2 (Rob MacLeod): Experimental Methods
  - Lecture slides in PDF format (3.5 MB)

Canvas



Lecture Syllabus

- Cardiac electrophysiology/mechanics
  - Membrane and cellular structure/function
  - Action potentials
  - Cardiac tissue and bioelectricity
  - Cardiac mechanics
- 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: Josh Silvernagel (Joshua.Silvernagel@carma.utah.edu)

Schedule

#	Date	Inst.	Topic	Reading	Assignments/Tests
	Bioengineering/Physiology 6000 Schedule, 2013				
1	Mon, Jan 7, 2013	RM	Introduction to course and animal physiology	1:1-14/LB 1	
2	Wed, Jan 9, 2013	RM	Everest video/Extreme Physiology		
3	Fri, Jan 11, 2013	RM	Intro to animal physiology II	1:7-14/LB 1	
LAB 1	Fri, Jan 11, 2013		**Dissection of the bovine heart/lungs**		
4	Mon, Jan 14, 2013	RM	Lab Review \ experimental methods	2:17-39/LB 2	
LAB 1	Mon, Jan 14, 2013		**Dissection of the bovine heart/lungs**		
5	Wed, Jan 16, 2013	RM	Experimental methods	2:17-39/LB 2	
6	Fri, Jan 18, 2013	RM	Ion transport and Resting potentials	4:99-109, 5:118-132/LB 3	
	Mon, Jan 21, 2013		**Martin Luther King Jr. Day Holiday**		
7	Wed, Jan 23, 2013	RM	Action potentials I	5:132-153, 12:479-480/LB 3	
8	Fri, Jan 25, 2013	RM	Action potentials II	5:132-153, 12:479-480/LB 3	
9	Mon, Jan 28, 2013	RM	Action potentials III	5:132-153, 12:477-479/LB 3	
10	Wed, Jan 30, 2013	RM	Pacemakers, Control of heart rate	5:136-137/LB 4	
11	Fri, Feb 1, 2013	RM	Simulation of cell action potential	Notes	
12	Mon, Feb 4, 2013	RM	Review of first lab report	12:479-480/LB 5	
13	Wed, Feb 6, 2013	RM	Tissue Electrophysiology	LB 5	
14	Fri, Feb 8, 2013	RM	Arrhythmias	12:479-480/LB 6	
LAB 2	Fri, Feb 8, 2013		**Regulation of heart rate and contraction (frog)**		
15	Mon, Feb 11, 2013	RM	Electrocardiogram I	12:479-480/LB 6	
LAB 2	Mon, Feb 11, 2013		**Regulation of heart rate and contraction (frog)**		
16	Wed, Feb 13, 2013	RM	Electrocardiogram II		
17	Fri, Feb 15, 2013	RM	EC Coupling	12:478-486/LB 7	
	Mon, Feb 18, 2013		**President's Day Holiday**		
18	Wed, Feb 20, 2013	RM	Heart as a Pump I + Lab Prep	12:478-486/LB 7	
	Fri, Feb 22, 2013		**Midterm #1**		Midterm #1
LAB 3	Fri, Feb 22, 2013		**ECG Lab**		
19	Mon, Feb 25, 2013	RM	Heart as a Pump II	12:478-486/LB 7	
LAB 3	Mon, Feb 25, 2013		**ECG Lab**		
20	Wed, Feb 27, 2013	RM	Overview of CV System	12:473-477/LB 8	
21	Fri, Mar 1, 2013	RM	Hemodynamics	12:495-505/LB 9	
22	Mon, Mar 4, 2013	RM	Arterial System	12:495-505/LB 10	
23	Wed, Mar 6, 2013	RM	Arterial System	12:495-505/LB 10	
24	Fri, Mar 8, 2013	RM	Capillaries and microcirculation	12:506-511/LB 11	
LAB 4	Fri, Mar 8, 2013				
	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 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

Death Zone Video

Motivation and background for semester project

Lab Review

What did you see?

Tips for second group?

Excellent Photo Example

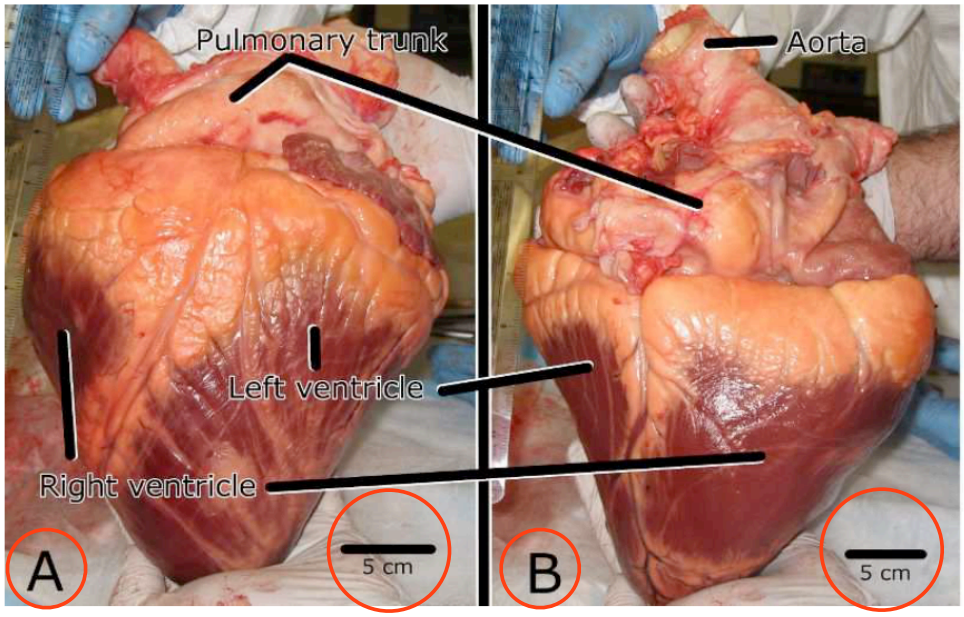


Figure 4: External anatomy of the bovine heart. Frame A on the left shows the anterior face of the heart, frame B the posterior.

And Another

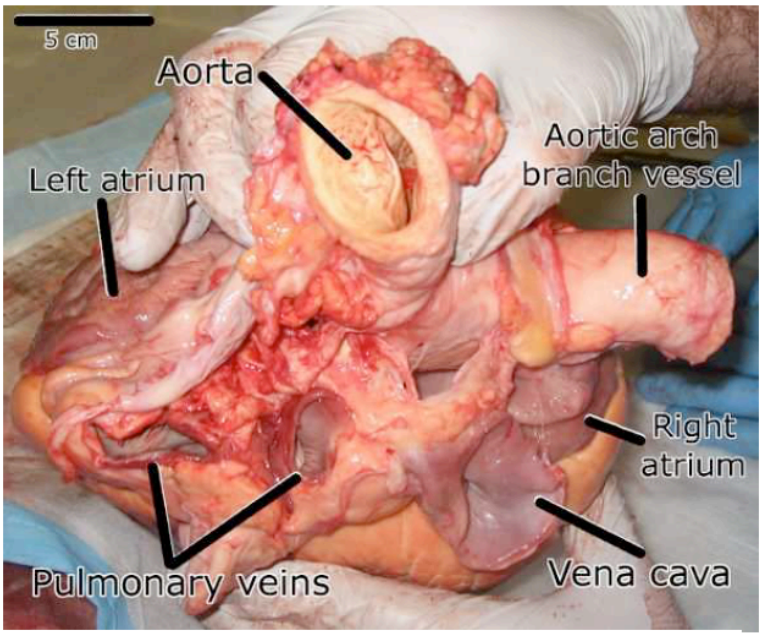


Figure 5: Major vessels of the bovine heart. Pericardial tissue obscures the pulmonary artery in this photo. It is located almost directly above the right most pulmonary vein.

Lessons for Next Time?

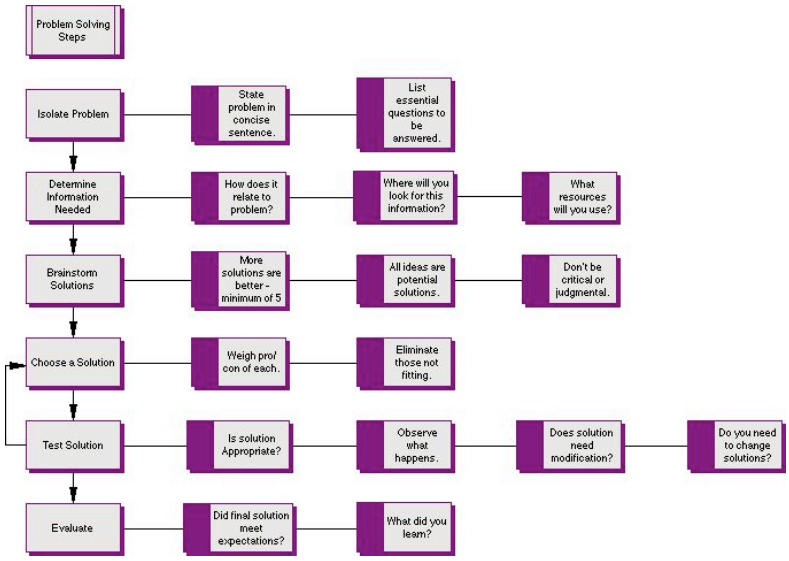
- Cuts are irreversible; make them carefully
- Take more/better photos
  - backup for measurements
  - provide flexibility in subsequent description
  - allow selection of best from a larger set
- Include scale and context, e.g., ruler in photos
- Bring camera for all experiments
  - makes photos for report
  - record connections, settings, etc from the lab
- Be curious! Feel free to do more than what is in the description
  - e.g., dissecting a valve leaflet or measuring tensile strength of chordae tendinae

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%
  - 3-4 homework assignments
  - Simulations, calculations

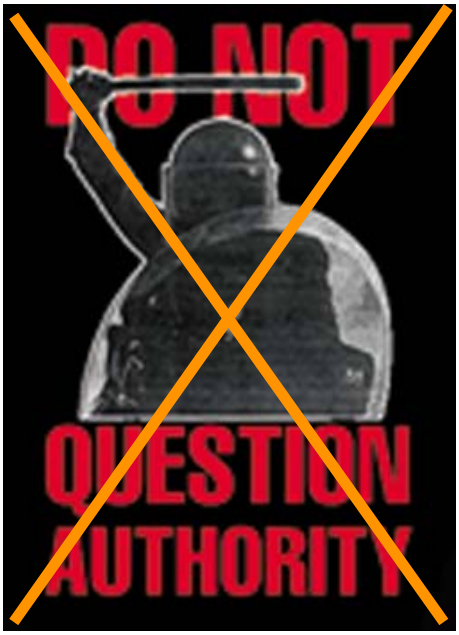
Learning Approach: Problem Identifying

Learning Approach: Problem Solving

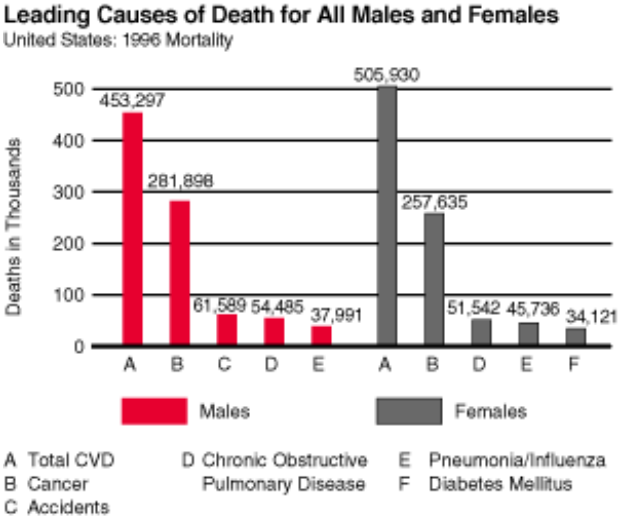


Learning Approach: Motivation

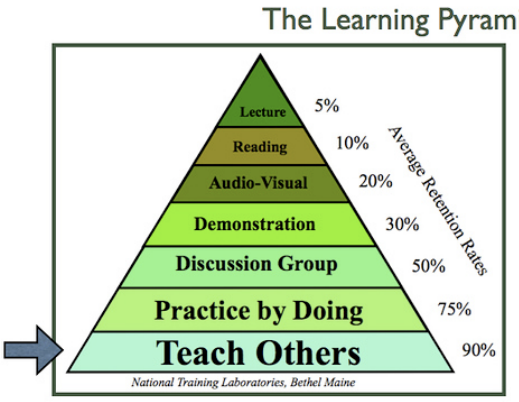
By Force?



Learning Approach: Finding Good Questions



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

Don't memorize

Ask Good Questions!

So what are some good questions?

Lab Logistics

- Lab time: Friday at 12:00 and Monday at 1:00 PM
- First lab: Friday, Jan 11 (this week!!)
- Lab materials
  - Camera (one per team)
  - Tolerant, comfortable clothes

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

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Introduction

Bioengineering 6000 CV Physiology

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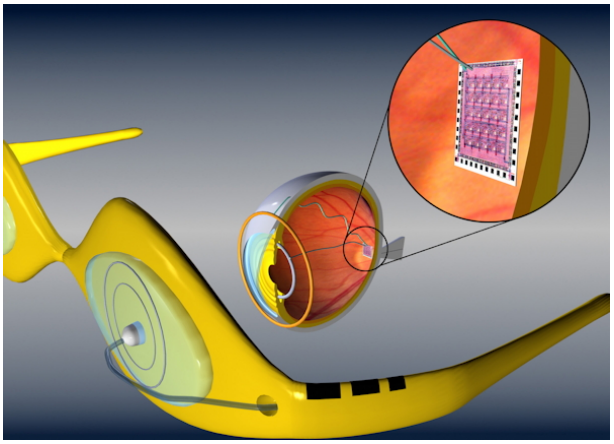

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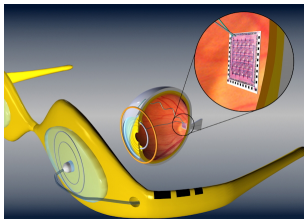
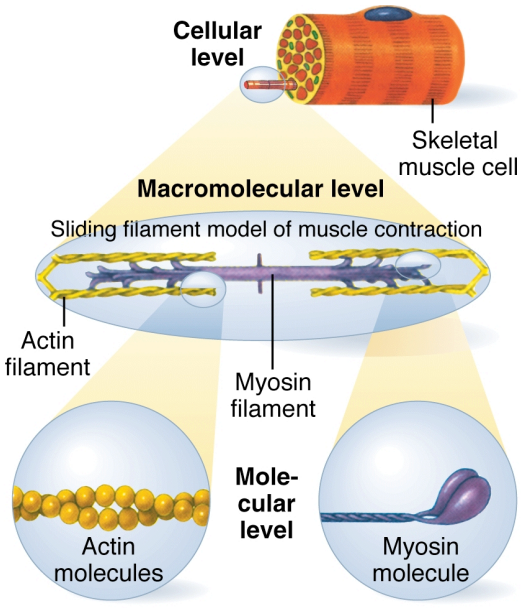


Physiological Has Central Themes

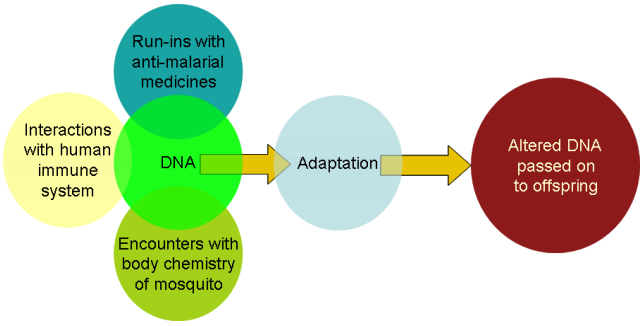
1. Structure/function relationships
2. Methods of change: Adaptation, acclimatization, and acclimation
3. Homeostasis
4. Conformity and regulation
5. Feedback control systems

1. Structure/Function Relationships

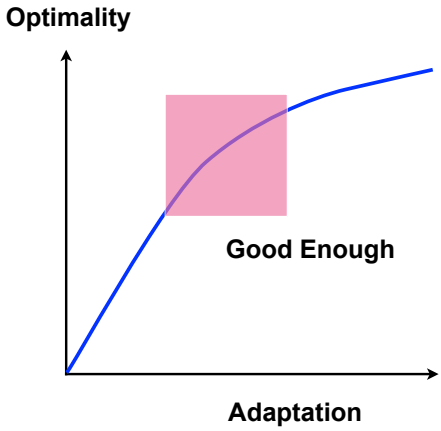
- Function follows from structure, e.g., different muscle forms have different function
  - skeletal
  - smooth
  - cardiac
- Present across scales



2. Mechanisms of Change

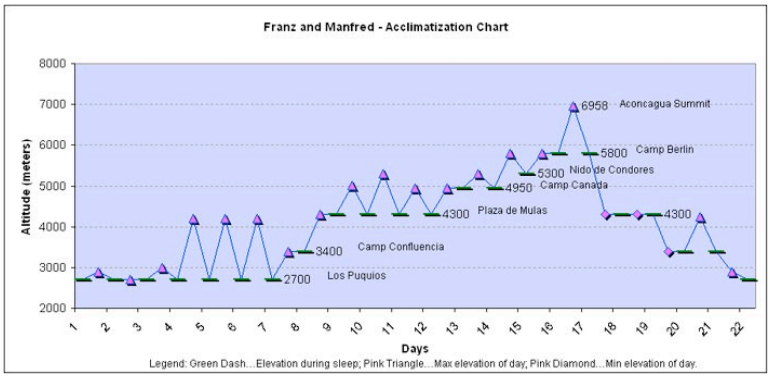


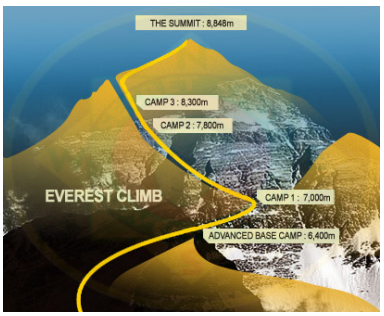
Dyann Wirth



- 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

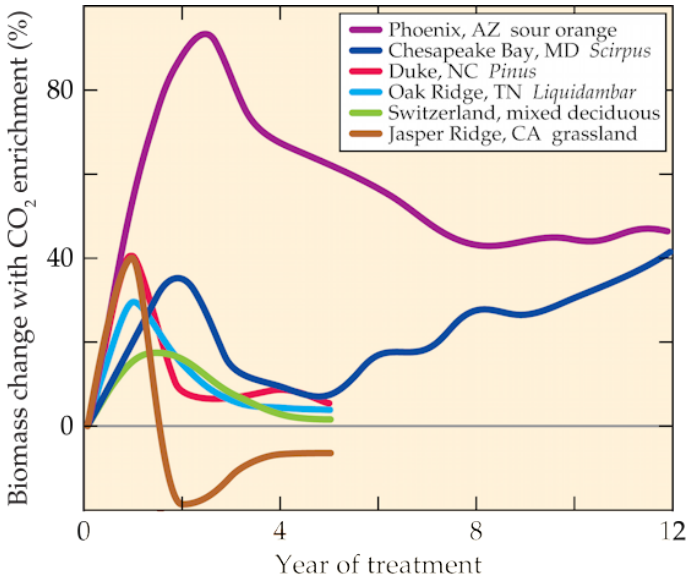




www.aconcaguaexpeditions.com

- Acclimatization
  - change in response to exposure to environment
  - relatively rapid and reversible
  - e.g., response to change in altitude

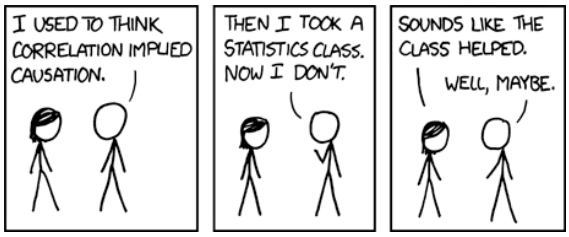
2. Mechanisms of Change



Bloom (2010) Global Climate Change: Convergence of Disciplines. Sinauer Associates.

- Acclimation
  - same as acclimatization but induced by investigator

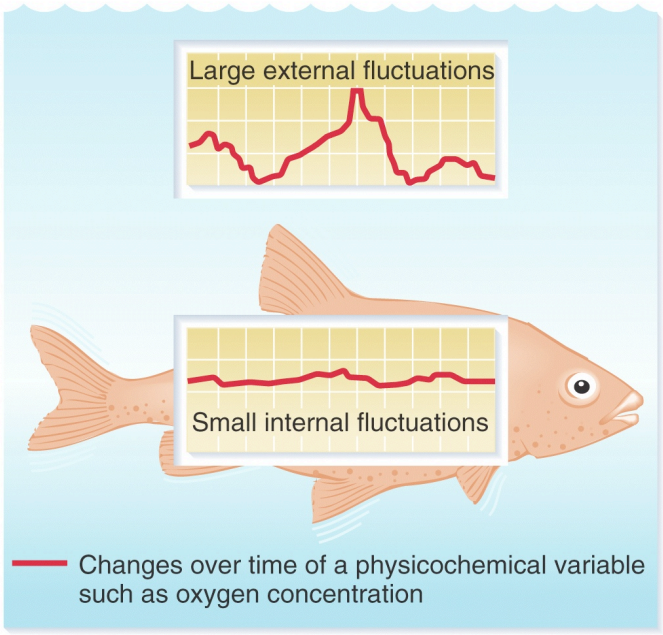
Causality and Teleology



- 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."
- 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."

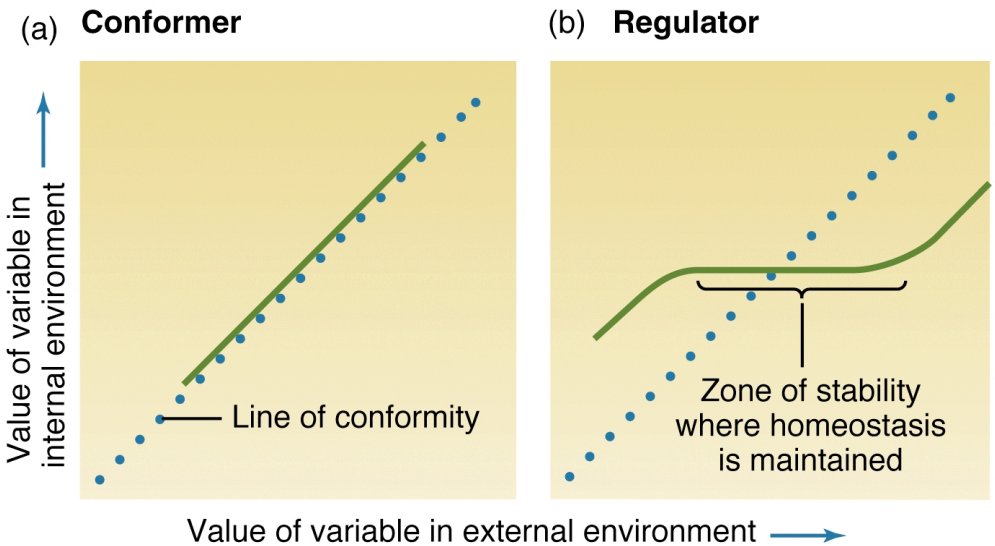
http://www.answers.com/topic/teleology

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

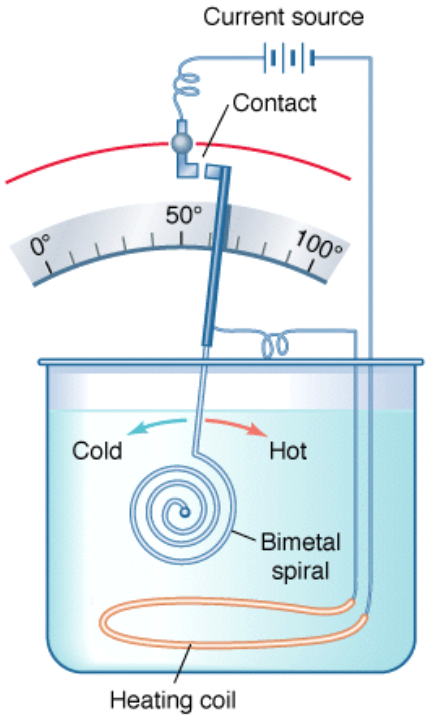


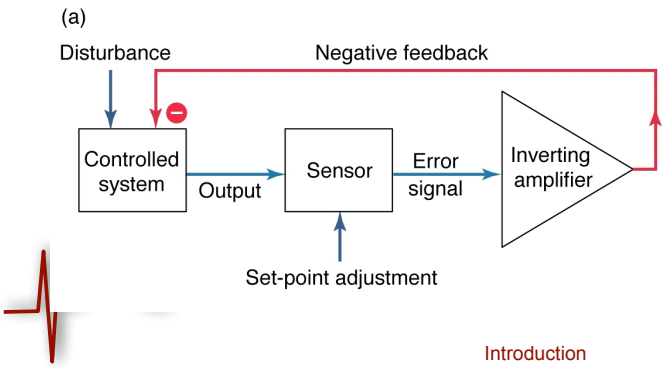
- Internal = external
- E.g., starfish (salinity) annelid worms (oxygen)

- 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





Features of Cardiovascular Physiology

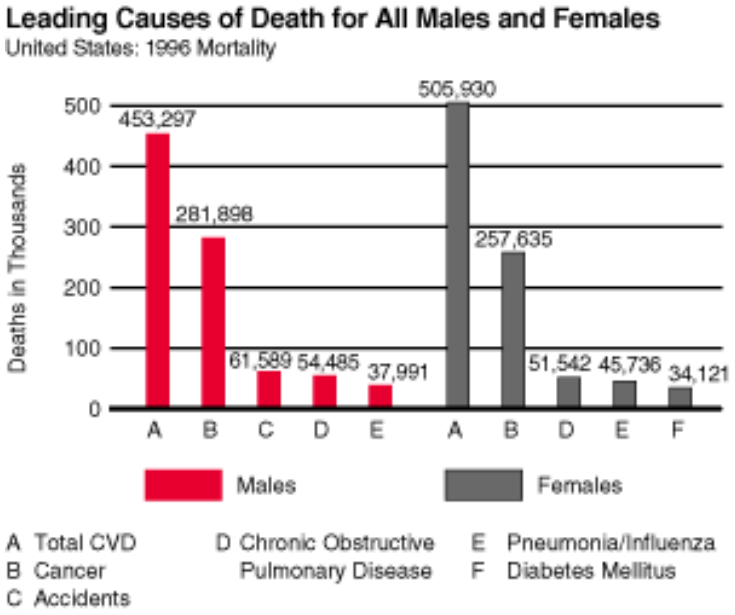
(Why engineers might hate physiology)

– 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)

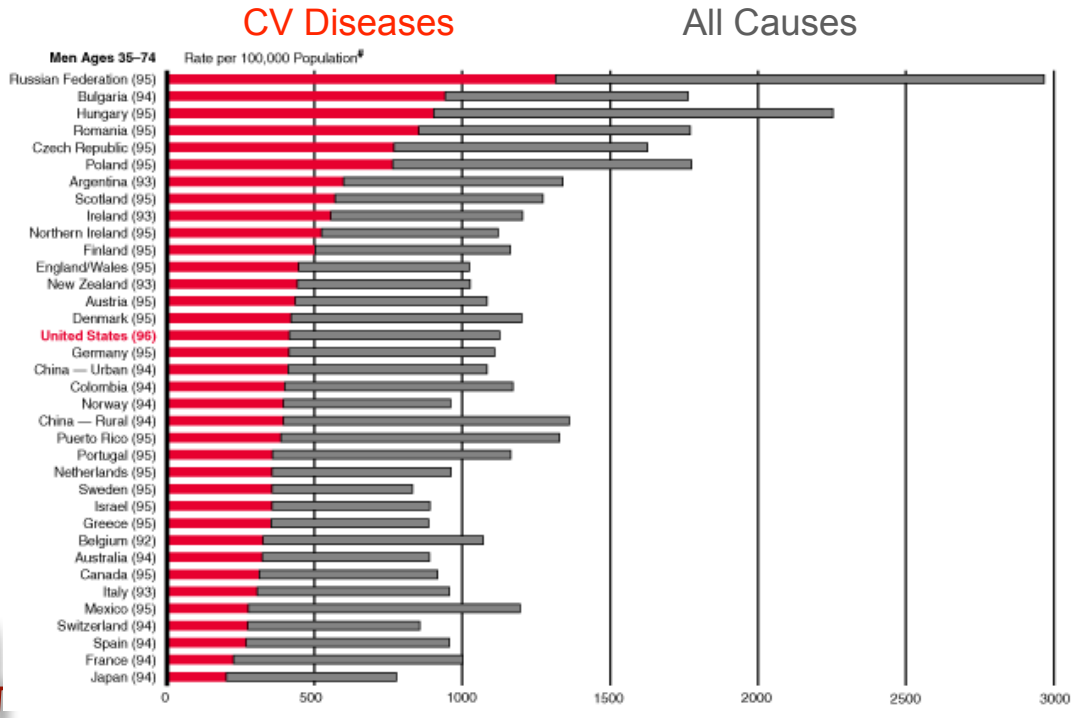
– Physiology is physics (just complicated physics)
– Homeostasis = control

Overall Causes of Death



Source: CDC/NCHS and the American Heart Association.

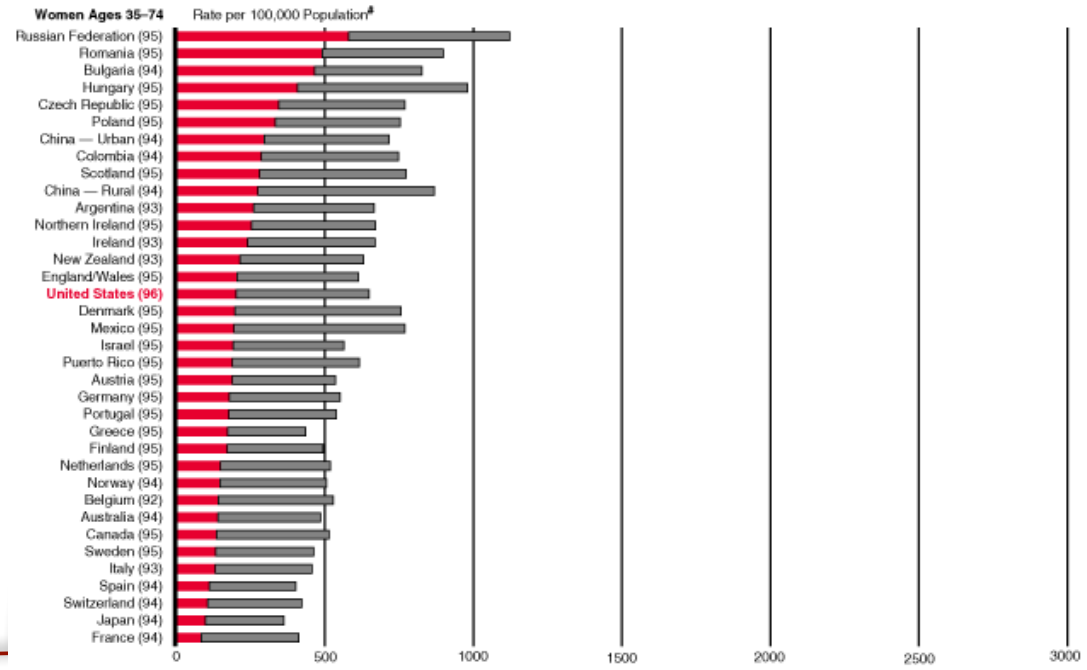
World CV Death rates (men)



World CV Death rates (women)

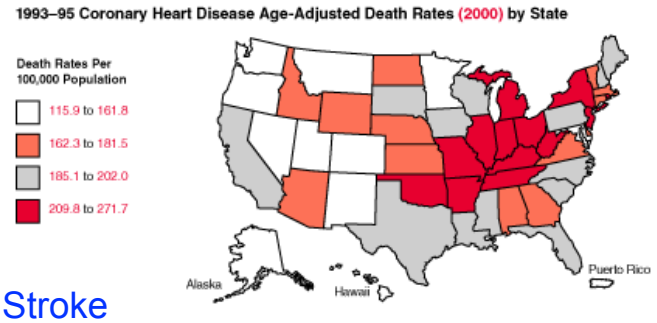
CV Diseases

All Causes



CV Disease Rates: US

CHD



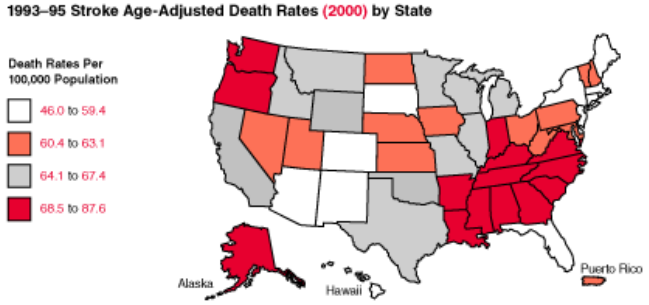
Rank: Low to High

#1: New Mexico

#52: New York

Utah: #3

Stroke

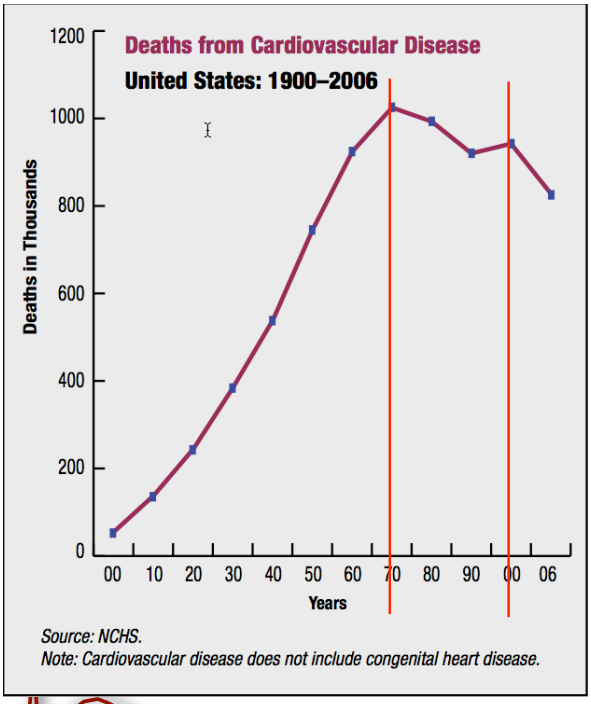


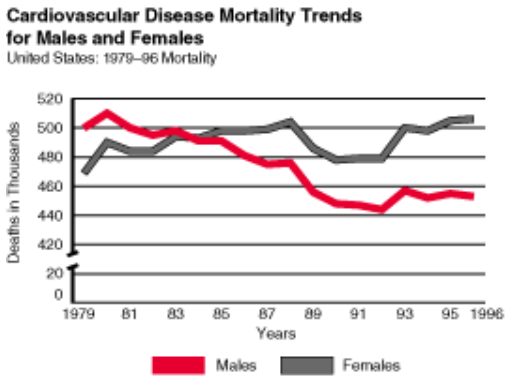
#1: New York

#52: S. Carolina

Utah: #11

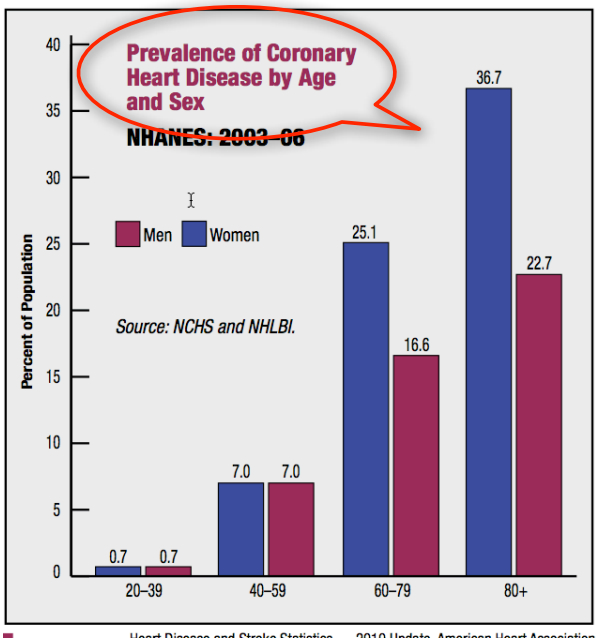
The Updated Trends

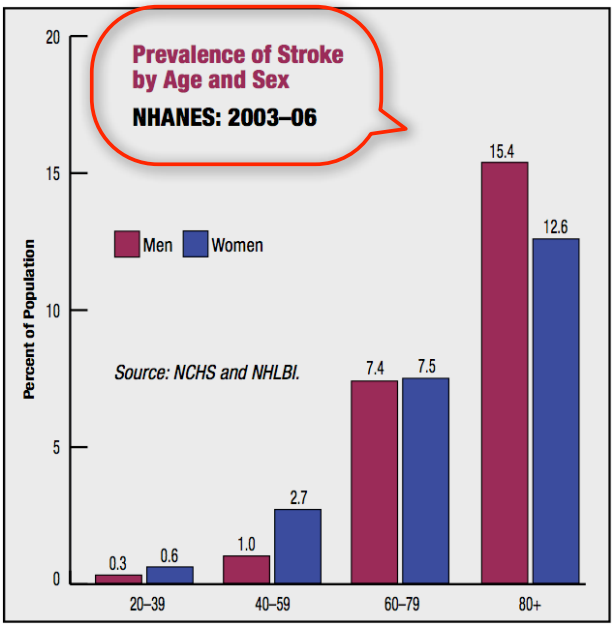




Source: CDC/NCHS and the American Heart Association.

Update and Breakdown

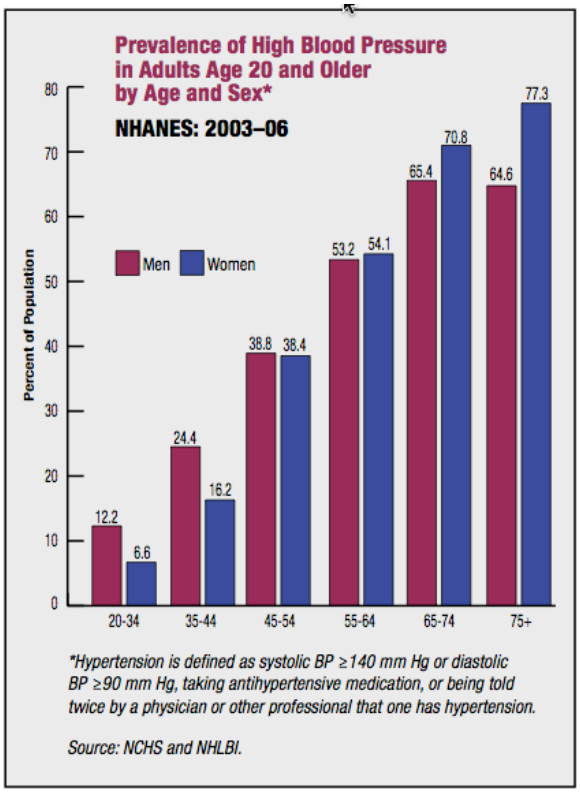




Heart Disease and Stroke Statistics — 2010 Update, American Heart Association

Hypertension

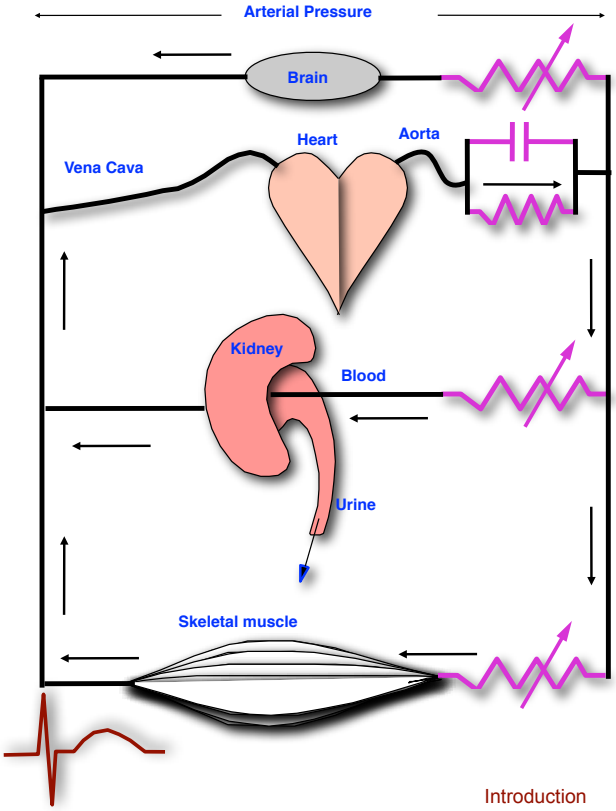
- HBP is associated with shorter overall life expectancy as well as shorter life expectancy free of cardiovascular disease (CVD) and more years lived with CVD.
- At age 50, total life expectancy is 5.1 years longer for men with normal blood pressure, and 4.9 years longer for women with normal blood pressure, than in those with hypertension.



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?