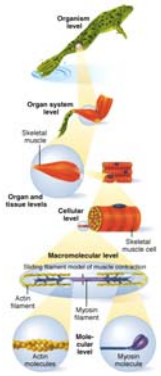
Lecture 1, 14 Jan 2009

Vertebrate Physiology
ECOL 437 (MCB/VetSci 437)
Univ. of Arizona, spring 2009

Kevin Bonine & Kevin Oh

1. Syllabus
2. Vertebrate Physiology
   - Integration
   - Structure/Function
   - Homeostasis
   - Feedback
   - Adaptation
   - Literature
3. Introductions

Chapter 1



Randall et al. 2002

Housekeeping, 14 January 2009

LAB BEGINS TODAY

Upcoming Readings

today: Textbook, chapter 1
Fri 16 Jan: Textbook chapter 2
Wed 21 Jan: Textbook chapter 4
LAB Wed 21 Jan: Lienhard et al. 1992, Nesse & Williams 1998 (see website for links to papers)
Fri 23 Jan: Ch 4

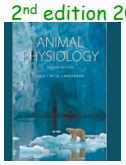
Lab discussion leaders: 21 Jan
1pm – xx
3pm – xx

Lab discussion leaders: 28 Jan
1pm – xx
3pm – xx

Vertebrate Physiology 437

Syllabus…

2nd edition 2008



Text – you may skip the non vertebrate material (but it is usually really cool information)

Two older texts on reserve in science library

Additional readings available on 437 course website or electronic reserve in science library
http://eebweb.arizona.edu/eeb_course_websites.htm

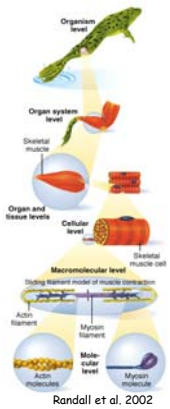
Physiology

In this course:
How non-human vertebrate animals function, how they work…

Integrate many systems, levels, areas of biology, physics, chemistry, biochemistry, genetics, etc.

Lots of cool examples and questions.

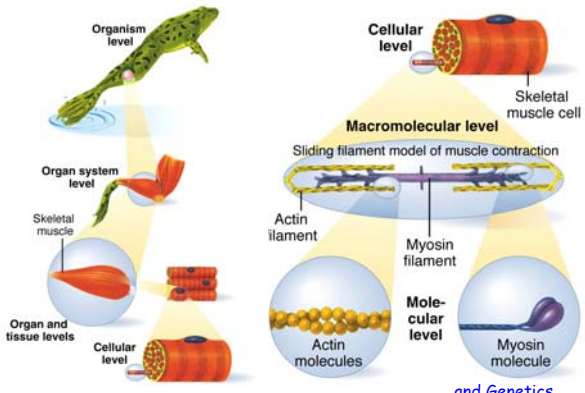
Hummingbirds
High-altitude geese
Endotherms in cold water
Freeze tolerance
Nitrogen excretion
Camels
Etc.



Randall et al. 2002

Integration

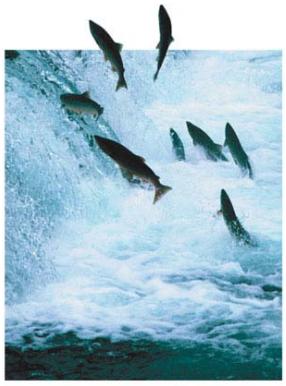
Structure/Function relationships



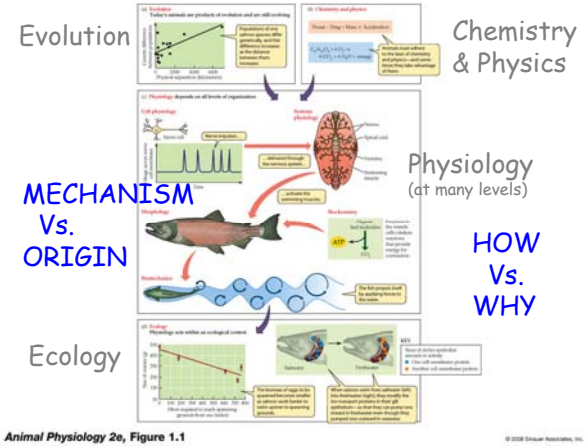
Randall et al. 2002

and Genetics…

Salmon…



Hill et al. 2004



What proportion of the cells in multicellular animals are in contact with the external environment?

How does this pertain to the evolution of multicellularity?

Homeostasis

"The coordinated physiological processes which maintain most of the [constant] states in the organism"

(Hill et al. 2004, p. 12)

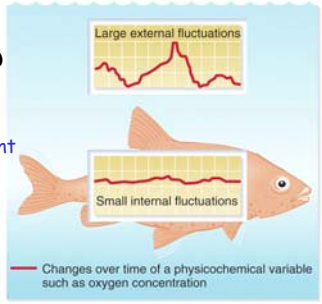
Homeostasis

"The coordinated physiological processes which maintain most of the [constant] states in the organism" (Hill et al. 2004, p. 12)

The role of "physiology"?

milieu interior
internal environment

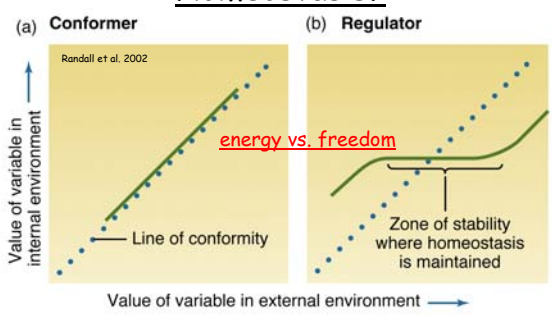
scale?



Randall et al. 2002

"Constancy of the internal environment is the condition of free life"

Homeostasis?



e.g.: Temp. salinity [glucose] pH [ion] pO_2

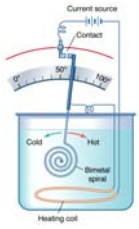
Feedback Loops
to maintain Homeostasis

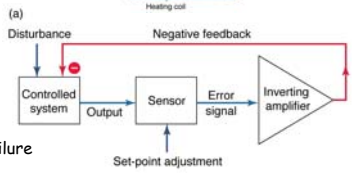
negative

set point (can be reset)

homeostasis

[blood glucose]





positive

less common
-voiding
-pregnancy
-congestive heart failure
-nerve transduction
(action potentials)

Randall et al. 2002

Negative Feedback
-opposes deviation from setpoint.

Positive Feedback
-reinforces deviation from setpoint.

Why are animals considered to be *structurally dynamic*?

What does this term mean?

Animal
-"An animal is not a discrete material object" (Hill et al 2004 p. 10)

-Energy continually required for organization (to fight entropy)

-Body size:

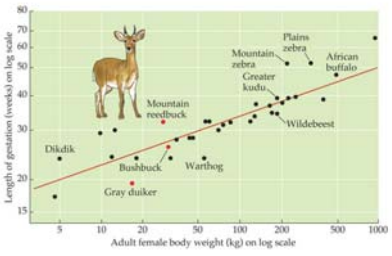


Figure 1.8
Hill et al. 2004

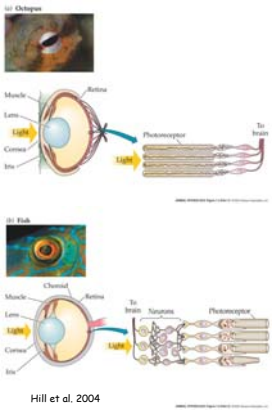
Body Size Influences Physiology, Life History, Natural Selection, etc.

Physiological Approaches

1. Mechanism

2. Origin
Adaptive Significance

TINKERING



Hill et al. 2004

Put this list of animals in order from *least* evolved to *most* evolved

- Sea cucumber
- Human
- Monkey
- Salmon
- Lizard

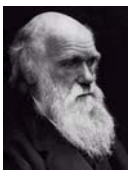
Which evolves, individual or population? Why?

Evolutionary Processes

Evolution: Change of allele frequencies over time

1. Adaptation: a subset of evolution, driven by natural selection

2. Genetic Drift
3. Founder Effect
4. Pleiotropy (one gene, several traits)
5. No longer adaptive



Role of Genetic Variation

Evolution by Natural Selection

1. Trait variability in population
2. Heritability of variable traits

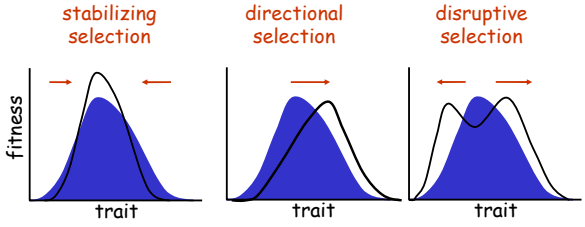
Why was Lamarck wrong?

3. Differential fitness because of trait variation (=natural selection)

What are common definitions or measures of fitness?

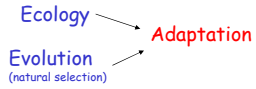
4. Multiple generations (time)

Three types of natural selection



NS generally leads to ADAPTATIONS…

Adaptation



Adaptation (ENVIRONMENT SPECIFIC)
Evolution by natural selection

Acclimatization

Modification in response to environment within a lifetime (reversibility?)

Acclimation (laboratory)

Similar to acclimatization but more artificial

TIME

TABLE 1.2 The five time frames in which physiology changes Hill et al. 2004

Type of change	Description
Changes in physiology that are responses to changes in the external environment	
1. Acute changes	Short-term changes in the physiology of individual animals: changes that individuals exhibit right after their environments have changed; acute changes are reversible
2. Chronic changes (acclimation and acclimatization)	Long-term changes in the physiology of individual animals: changes that individuals display after they have been in new environments for days, weeks, or months; chronic changes are reversible
3. Evolutionary changes	Changes that occur by alteration of gene frequencies over the course of many generations in populations exposed to new environments
Changes in physiology that are internally programmed to occur whether or not the external environment changes	
4. Developmental changes	Changes in the physiology of individual animals that occur in a programmed way as the animals mature from conception to adulthood and then to senescence
5. Changes controlled by periodic biological clocks	Changes in the physiology of individual animals that occur in repeating patterns (e.g., each day) under control of the animals' internal biological clocks

Genotype vs. Phenotype

Adaptation

Plasticity

Ontogenetic, environmental

Plastic Man

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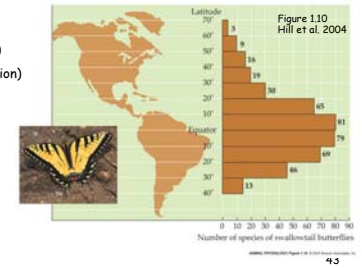
Vertebrate Physiology

Environments

Chemical, physical, and biological components of an organism's surroundings

1. Temperature
2. Oxygen (air, water)
3. Water (osmoregulation)

-Microhabitats
-Behavior



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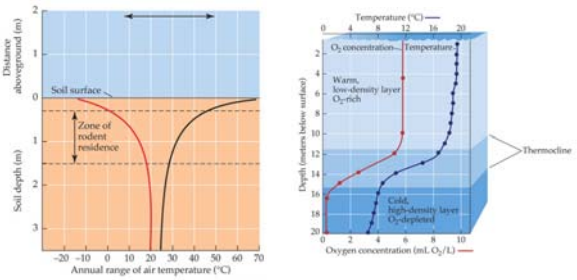
Environments

-Microhabitats
-Behavior

Vertebrate Physiology



Figures 1.13, 1.15
Hill et al. 2004

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Krogh principle

For many physiological questions, there is an *animal model* ideally suited to answer it.

Xenopus eggs

Squid giant axons

Sea raven (fish) heart

Kangaroo rat kidney

Horned lizard diet

Genetic engineering
(diabetic mice, knockouts, obesity, etc.)

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Discussion Question

In small groups of about 3 students:

How would you design an experiment to test the hypothesis that saltwater crocodiles are osmoconformers?

OR

How would you ascertain whether or not the extra-long loops of Henle in Kangaroo Rat kidneys were an adaptation to their desert habitat and lifestyle?

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Organism-level Approaches

- Physiological State

- Sleeping
- Resting
- Alert
- Exercising
- Stress-level
- Fasting or Fed

- Age
- Sex
- Season
- Reproductive Condition

- BMR
- RMR

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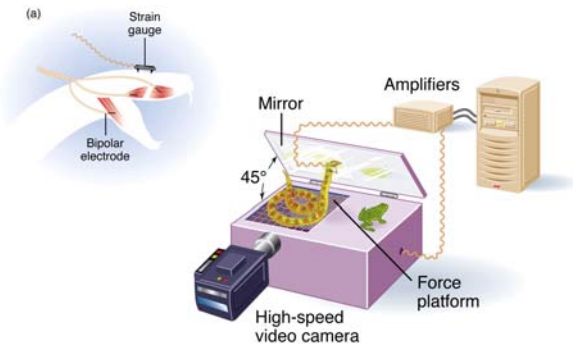
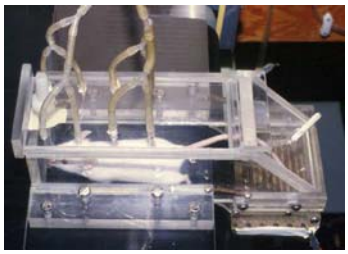
Behavior



Physiology

- History
- Subdisciplines
- Rationale



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Scientific Literature 1/4

Table 1–2 A sampling of scientific journals that publish physiological research papers

Name	Abbreviation*	Topics covered
General journals		
American Journal of Physiology	*Am. J. Physiol.*	Broad areas of physiology from the cell to organ systems
Pflügers Archiv für Physiologie (now European Journal of Physiology)	*Pflugers Arch. Physiol. (Eur. J. Physiol.)*	
Journal of Physiology	*J. Physiol.*	
Journal of General Physiology	*J. Gen. Physiol.*	Physiological and biophysical studies at the cellular and subcellular level
Comparative Physiology and Biochemistry	*Comp. Physiol. Biochem.*	Many different areas, with emphasis on lower vertebrates and invertebrates
Journal of Comparative Physiology	*J. Comp. Physiol.*	
Journal of Experimental Biology	*J. Exp. Biol.*	
Physiological and Biochemical Zoology	*Physiol. Biochem. Zool.*	

*Single-word journal names are not abbreviated.

Randall et al. 2002

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Scientific Literature 2/4

Table 1–2 A sampling of scientific journals that publish physiological research papers

Name	Abbreviation*	Topics covered
Specialty journals		
Brain, Behavior, and Evolution	*Brain Behav. Evol.*	Research related to specific areas or processes indicated by journal's name
Cell		
Circulation Research	*Circ. Res.*	
Evolution and Development	*Evol. Dev.*	
Endocrinology		
Gastroenterology		
Journal of Cell Physiology	*J. Cell Physiol.*	
Journal of Membrane Biology	*J. Membr. Biol.*	
Journal of Neurophysiology	*J. Neurophysiol.*	
Journal of Neuroscience	*J. Neurosci.*	
Molecular Endocrinology	*Mol. Endocrinol.*	
Nephron		
Respiration Physiology	*Respir. Physiol.*	

*Single-word journal names are not abbreviated.

Randall et al. 2002

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Scientific Literature 3/4

Table 1–2 A sampling of scientific journals that publish physiological research papers

Name	Abbreviation*	Topics covered
Annual reviews		
Annual Review of Neuroscience	*Annu. Rev. Neurosci.*	Summaries and evaluations of original papers on particular topics published in other journals
Annual Review of Physiology	*Annu. Rev. Physiol.*	
Federation Proceedings	*Fed. Proc.*	
Physiological Reviews	*Physiol. Rev.*	

*Single-word journal names are not abbreviated.

Randall et al. 2002

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Scientific Literature 4/4

Table 1–2 A sampling of scientific journals that publish physiological research papers

Name	Abbreviation*	Topics covered
Taxonomy-oriented journals		
Auk		Physiology and other topics related to birds
Condor		
Emu		
Crustaceana		Physiology and other topics related to crustaceans
Copeia		Amphibian and reptilian physiology
Herpetologica		
Journal of Herpetology	*J. Herpetol.*	
Journal of Mammalogy	*J. Mammal.*	Physiology and other topics dealing with mammals
Weekly journals		
Nature		Preliminary reports about topics of general interest to the scientific community
Science		

*Single-word journal names are not abbreviated.

Randall et al. 2002

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