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

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
   (see website for links to papers)
Fri 23 Jan: Ch 4
Lab discussion leaders: 21 Jan 1pm - xx 1pm - xx
3pm - xx 3pm - xx

Vertebrate Physiology 437
Syllabus...

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

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.

Integration
Structure/Function relationships
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"

Randall et al. 2002

The role of "physiology"?

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

Randall et al. 2002

- **Conformer**
  - Change in value of variable in internal environment
  - Line of conformity
  - Zone of stability where homeostasis is maintained
  - e.g.: Temp, salinity, glucose, pH, ions, pO₂

- **Regulator**
  - Changes in value of variable in external environment
  - Energy vs. freedom
**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)

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**Negative Feedback**
- opposes deviation from setpoint.

**Positive Feedback**
- reinforces deviation from setpoint.

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**Vertebrate Physiology**

Why are animals considered to be **structurally dynamic**?

What does this term mean?

- "An animal is not a discrete material object" (Hill et al 2004 p. 10)
- Energy continually required for organization (to fight entropy)

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**Physiological Approaches**

1. Mechanism
2. Origin

Adaptive Significance

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

- Sea cucumber
- Human
- Monkey
- Salmon
- Lizard

Evolution by Natural Selection

1. Trait variability in population
2. Heritability of variable traits
3. Differential fitness because of trait variation (natural selection)
4. Multiple generations (time)

Evolutionary Processes

- 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 Gene Variation

Obviously, there are many ways to be "successful."

Vertebrate Physiology

Table 1.2: The five time frames in which physiology changes

<table>
<thead>
<tr>
<th>Type of change</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Acute changes</td>
<td>Short-term changes in the physiology of individual animals; changes that animals exhibit right after their environment has changed; acute changes are reversible.</td>
</tr>
<tr>
<td>2. Chronic changes</td>
<td>Long-term changes in the physiology of individual animals; changes that animals display after they have been in new environments for days, weeks, or months; chronic changes are reversible.</td>
</tr>
<tr>
<td>3. Evolutionary changes</td>
<td>Changes that occur by alteration of gene frequencies over the course of many generations in populations exposed to new environments.</td>
</tr>
<tr>
<td>4. Developmental changes</td>
<td>Changes in the physiology of individual animals that occur in a programmed way as the animals mature from conception to adulthood; not due to environmental changes.</td>
</tr>
<tr>
<td>5. Changes controlled by periodic biological clocks</td>
<td>Changes in the physiology of individual animals that occur in repeating patterns (e.g., each day) under control of the animals’ internal biological clocks.</td>
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</table>
Adaptation

Plasticity
Ontogenetic, environmental

Vertebrate Physiology

Environments
Chemical, physical, and biological components of an organism’s surroundings
1. Temperature
2. Oxygen (air, water)
3. Water (osmoregulation)

-Microhabitats
-Behavior

Environments

Vertebrate Physiology

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.)

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?
### Behavior

![Behavior Diagram](image1)

### Physiology
- **History**
- **Subdisciplines**
- **Rationale**

![Physiology Diagram](image2)

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#### Scientific Literature 1/4

<table>
<thead>
<tr>
<th>Table 1-2</th>
<th>A sampling of scientific journals that publish physiological research papers</th>
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<tbody>
<tr>
<td><strong>General journals</strong></td>
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<tr>
<td>American Journal of Physiology</td>
<td><em>Am J Physiol</em></td>
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<tr>
<td>Journal of General Physiology</td>
<td><em>J Gen Physiol</em></td>
</tr>
<tr>
<td>Comparative Physiology and Biochemistry</td>
<td><em>Comp Physiol</em></td>
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<tr>
<td>Journal of Experimental Biology</td>
<td><em>J Exp Biol</em></td>
</tr>
<tr>
<td>Psychophysiology and Behavioral Biology</td>
<td><em>Psychophysiology</em></td>
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*All journals listed are not abbreviated.

Randall et al. 2002

#### Scientific Literature 2/4

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<td>Brain, Behavior, and Evolution</td>
<td><em>Brain Behav Evol</em></td>
</tr>
<tr>
<td>Circulation Research</td>
<td><em>Circ Res</em></td>
</tr>
<tr>
<td>Endocrinology and Development</td>
<td><em>Endocrinology</em></td>
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<tr>
<td>Immunology</td>
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<td>Journal of Cell Physiology</td>
<td><em>J Cell Physiol</em></td>
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<tr>
<td>Journal of Neuroscience</td>
<td><em>J Neuroscience</em></td>
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<tr>
<td>Behavioral Pharmacology</td>
<td><em>Behav Pharmacol</em></td>
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<tr>
<td>Neurosurgery</td>
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<tr>
<td>Respiratory Physiology</td>
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<td>Annual Review of Neuroscience</td>
<td><em>Annu Rev Neurosci</em></td>
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<tr>
<td>Annual Reviews of Physiology</td>
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<td>Physiological Reviews</td>
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<td>J Neurosci</td>
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