1. Thermal Physiology (Ch 8)

http://eebweb.arizona.edu/eeb_course_websites.htm

Housekeeping, 30 April 2008

Upcoming Readings
Wed 30 Apr: Ch 8, Thermal Physiology
LAB 30 Apr, 07 May: Funding Panel Prep
Fri 02 May: Ch 8
Mon 05 May: Ch 8
Wed 07 May: Review for FINAL EXAM
LAB 07 May: Funding Panel Presentations/Decisions
Thermal Physiology

Microhabitat

![Graph showing temperature changes in different microhabitats](image)
Thermoregulation

Cardiovascular control of heating and cooling

- Cardiac Shunts
- Peripheral Vasodilation

Pough et al., 2001

Endothermy

<table>
<thead>
<tr>
<th>No</th>
<th>Poikilotherms or ectotherms</th>
<th>Endotherms</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Nonthermoregulating poikilotherms or ectotherms</td>
<td>Nonthermoregulating endotherms</td>
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<tr>
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<td>Thermoregulating poikilotherms or ectotherms</td>
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<tr>
<td></td>
<td>Behavioral thermoregulators</td>
<td>Homeotherms</td>
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Pough et al., 2001
Heat Windows

Rabbit Ears

Blood flow to ears increases

Guanaco

Hot Body, Cool Brain

Keep brain cool during prolonged increased organismal activity:

- Countercurrent
- Carotid Rete
Neuronal Control of Thermoregulation

Temperature Set Point
(season, reproductive state, infection)

Hypothalamus functions as thermostat

Physiology and Behavior
Endotherms in the **COLD...**

**Countercurrent Heat Exchange**

![Diagram of countercurrent heat exchange](image)

*Figure 8.9 Countercurrent heat exchange. (A) A diagram representing the countercurrent heat exchange in a bird showing how the hot blood flows in the legs and the cold blood flows in the wings. (B) Diagram showing how the blood flows in the legs and the cold blood flows in the wings. The arrows indicate the direction of blood flow. In (A), the warm blood flows in the legs and the cold blood flows in the wings. In (B), the warm blood flows in the legs and the cold blood flows in the wings.*


**Blood Vessels in a Bird Leg** Cross section (left) and surface view of the blood vessels in the leg of a European rook (Corvus frugilegus), a crow-like bird. The thick-walled artery runs in the center and is surrounded by several thin-walled veins that branch and anastomose so that they virtually cover the bone. The structure is 2 mm. [Oswar University of Copenhagen]

*Knut Schmidt-Nielsen 1997*

*Figure 217 Model of a countercurrent heat exchanger. In this design heat is conducted from the incoming water to the outgoing water so that the temperature difference between the two streams is maintained at a constant level.*
Thermogenesis

**Shivering** (or locomotion)
- antagonistic muscle contractions
- heat byproduct

**Non-shivering**
- fats metabolized, but produce heat instead of ATP
- **brown fat** specialized

**sympathetic** stimulation:
1. ATP hydrolysis used to **pump ions needlessly**
2. Proton leakage in mitochondria, rather than production of ATP in presence of **thermogenin**

Endotherms in the COLD...

Thermogenesis

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Ectotherms in the COLD

**Freeze Tolerance vs. Supercooling/Antifreeze**

(a) Extracellular compartment

- Formation of ice crystals is stimulated by nucleating agent.
- Solute excluded from forming ice; solute concentration increases.

(b) Intracellular compartment

- Osmotic loss of water increases solute concentration, preventing ice crystals from forming.

- Extracellular Nucleation

- [Solute]

- Rate

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Thermoregulation

Freezing - ice crystal formation
- alter osmolality
- physical destruction

Freeze Resistance
supercool
prevent ice crystals
*(Sceloporus jarrovii)*
*(Chrysemys picta)*
Thermal Neutral Zone

**Within TNZ:**
- Vasomotor
- Posture
- Insulation: fluff fur/feathers

**Below TNZ:**
- Increase metabolism above basal

**Above TNZ:**
- Cool via evaporation

![Diagram of Thermal Neutral Zone](image1)

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**Critical Temperature**

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<th>Lower</th>
<th>Upper</th>
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![Critical Temperature Diagram](image2)

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**Figure 7.11** Body temperature of a willow tit (Parus montanus) during the night hours at three different ambient temperatures. The records are from midafternoon one day to the following morning. (Reinersen and Haltom 1986)

Knut Schmidt-Nielsen 1997
COST/BENEFIT ANALYSIS

Would you rather be an ectotherm or an endotherm?

Ectothermy vs. Endothermy

1. Ectotherms
   - lower metabolic rate
   - require less water
   - require less food (foraging time)
   - greater proportion energy into growth and repro
   - small body size works (different shapes)
   - reliant on environmental heat sources
   - seasonal and daily limits on activity
   - low aerobic capacities

2. Endotherms with ‘opposite’ costs and benefits