Lecture 42
30 April 2008

Vertebrate Physiology
ECOL 437 (MCB/VetSci 437)
Univ. of Arizona, spring 2008

Kevin Bonine & Kevin Oh

1. Thermal Physiology (Ch 8)

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

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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

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Thermal Physiology

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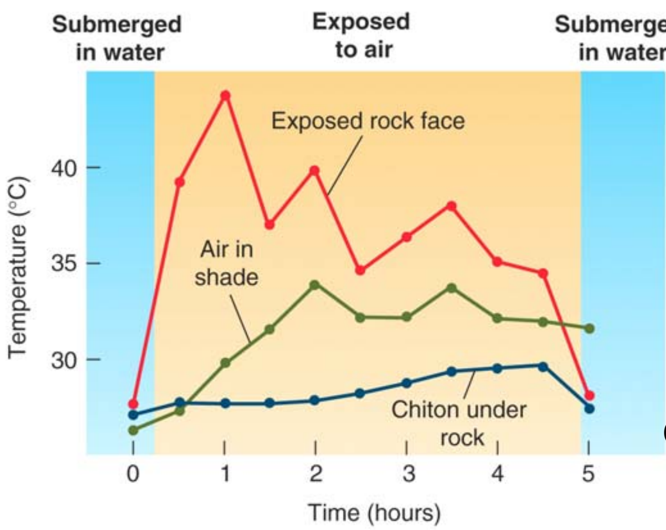
Microhabitat



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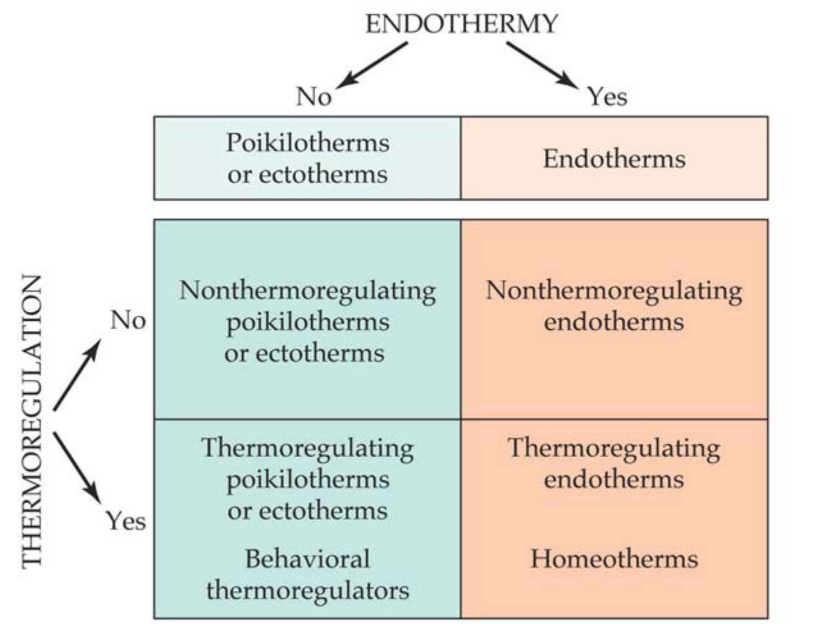
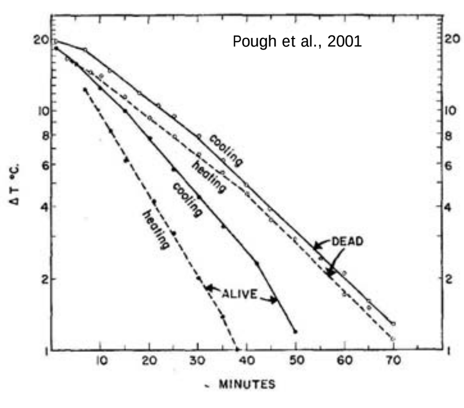
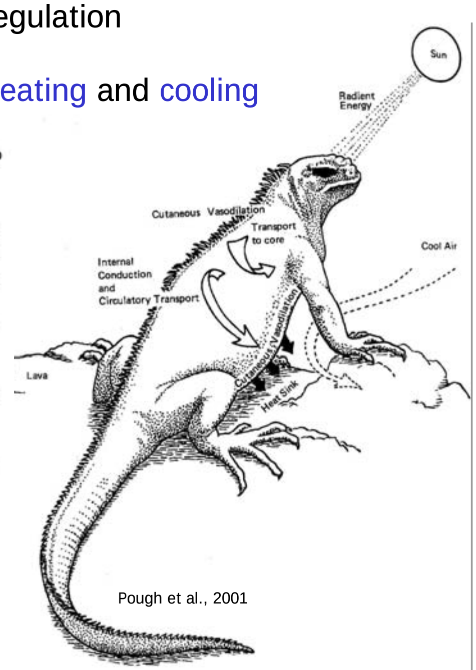


ANIMAL PHYSIOLOGY, Figure 8.1 © 2004 Sinauer Associates, Inc.

Thermoregulation

Cardiovascular control of heating and cooling

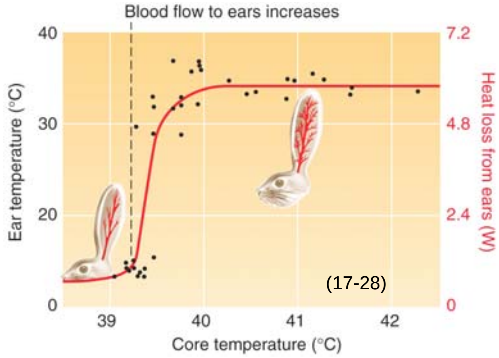




- Cardiac Shunts
- Peripheral Vasodilation

Heat Windows

Rabbit Ears



Guanaco

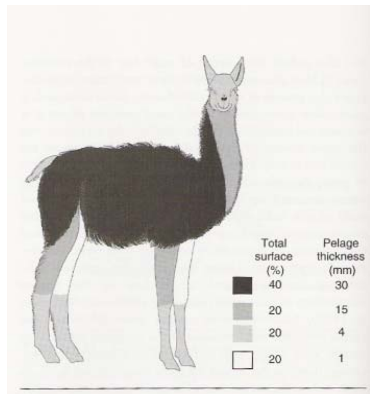
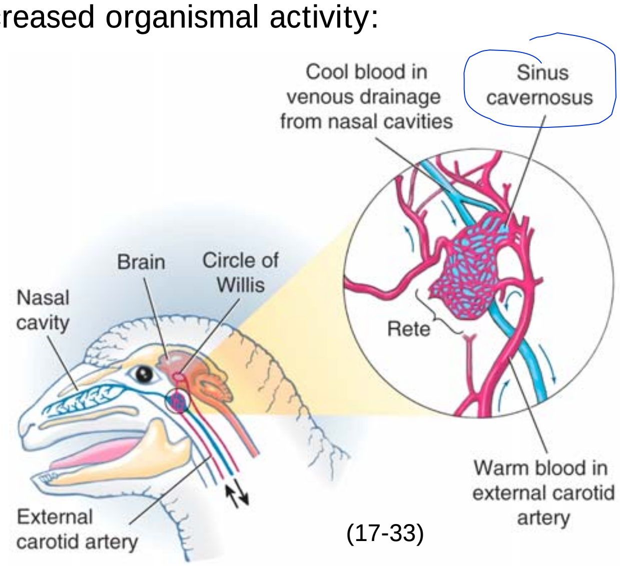


Figure 8.24 Thermal windows. Schematic representation of the distribution of wool of differing thickness in the guanaco, a South American member of the Family Camelidae. The white areas are thermal windows of almost bare skin.

Source: Data from P.R. Morrison, "Insulative Flexibility in Guanaco" in Journal of Mammalogy, 47:18-23, 1966.

Hot Body, Cool Brain

Keep brain cool during prolonged increased organismal activity:



-Countercurrent

-Carotid Rete

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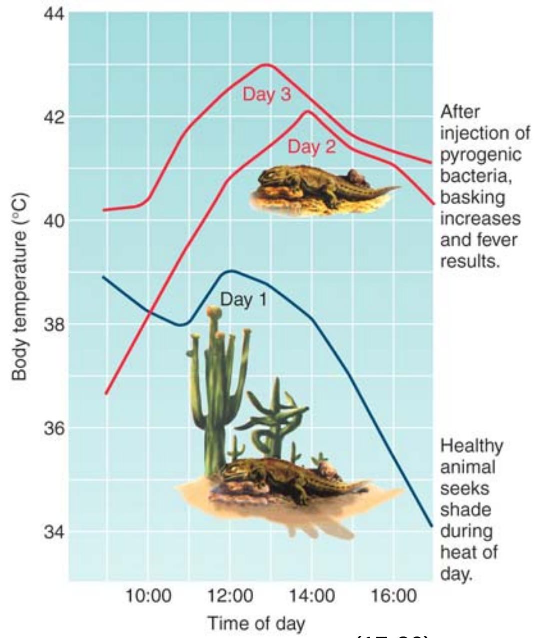
Pyrogens

Fever

Dipsosaurus dorsalis



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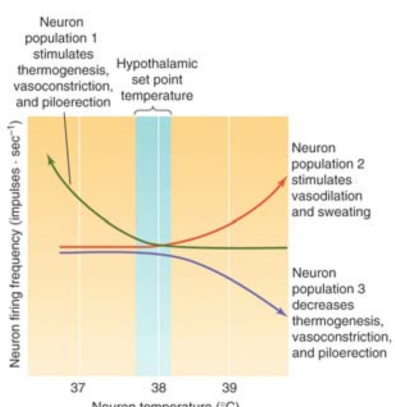
Neuronal Control of Thermoregulation

Temperature Set Point
(season, reproductive state, infection)

Hypothalamus functions as thermostat



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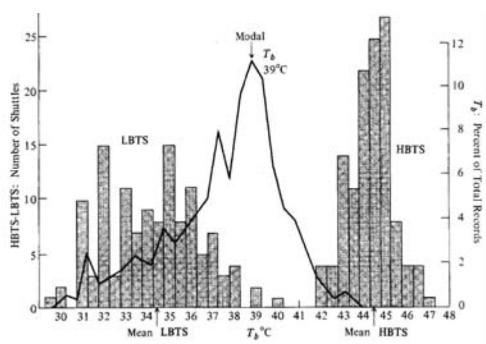

Pough et al., 2001

Physiology and Behavior

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Endotherms in the COLD…

Countercurrent Heat Exchange

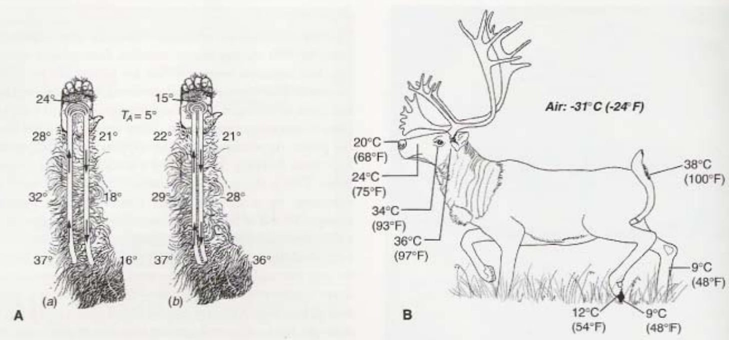

Figure 8.9 **Countercurrent heat exchange.** (A) A diagram representing the circulation in a limb of a mammal showing hypothetical temperature changes of the blood in the absence (a) and presence (b) of countercurrent heat exchange. Arrows indicate direction of blood flow. In (b), the venous blood takes up heat (thus cooling the arterial blood) all along its path of return because even as it becomes warmer and warmer, it steadily encounter arterial blood that is warmer yet. (B) Regulation of external body temperature in the caribou. Temperature regulation is accomplished in part by countercurrent heat exchange. An intricate meshwork of veins and arteries acts to keep the temperature of the legs near that of the environment so heat is not lost from the body.

(A) Source: Data from R.W. Hill and G.A. Wyse, Animal Physiology, *2nd edition, 1989, Harper & Row, New York. (B) Data from J.F. Merritt, "Animals of the Arctic" in* Arctic Life: Challenge to Survive, *(M.M. Jacobs & J.B. Richardson III, eds.), 1983, The Board of Trustees, Carnegie Institute, Pittsburgh, Pennsylvania.*

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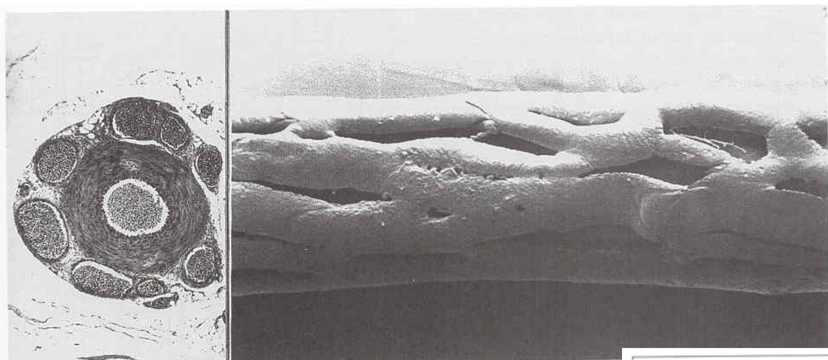

BLOOD VESSELS IN A BIRD LEG Cross section (left) and surface view of the blood vessels in the leg of a European rook (*Corvus frugilegus*), a crow-like bird. The thick-walled artery runs in the center and is surrounded by several thin-walled veins that branch and anastomose so that they virtually cover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

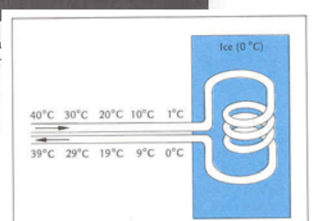

Figure 7.17 Model of a countercurrent heat exchanger. In this case heat is conducted from the incoming water to the outflowing water so that in the steady-state condition the outflowing water is pre-warmed to within 1 °C of the incoming water. For explanation, see text.

Knut Schmidt_Nielsen 1997

Thermogenesis

Endotherms in the COLD…

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

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Endotherms in the COLD…

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heat byproduct

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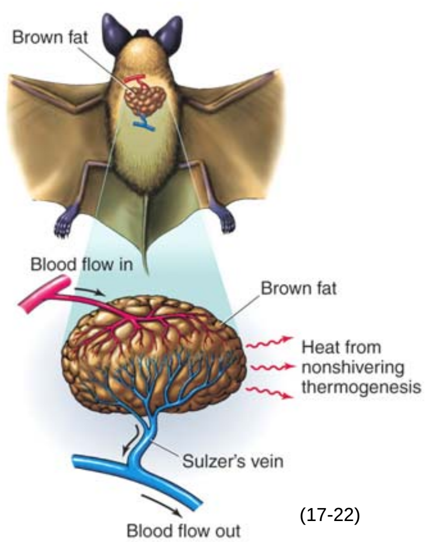

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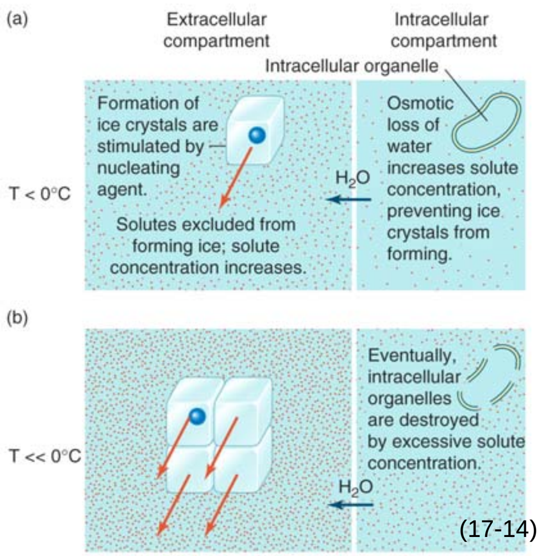
Ectotherms in the COLD

Freeze Tolerance vs. Supercooling/Antifreeze



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-Extracellular Nucleation

-[Solute]

-Rate

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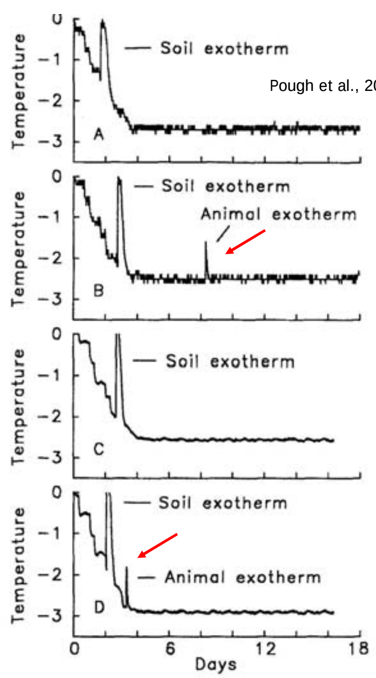
Thermoregulation

Freezing - ice crystal formation
-alter osmolality
-physical destruction

Freeze Resistance
supercool
prevent ice crystals
(Sceloporus jarrovii)
(Chrysemys picta)



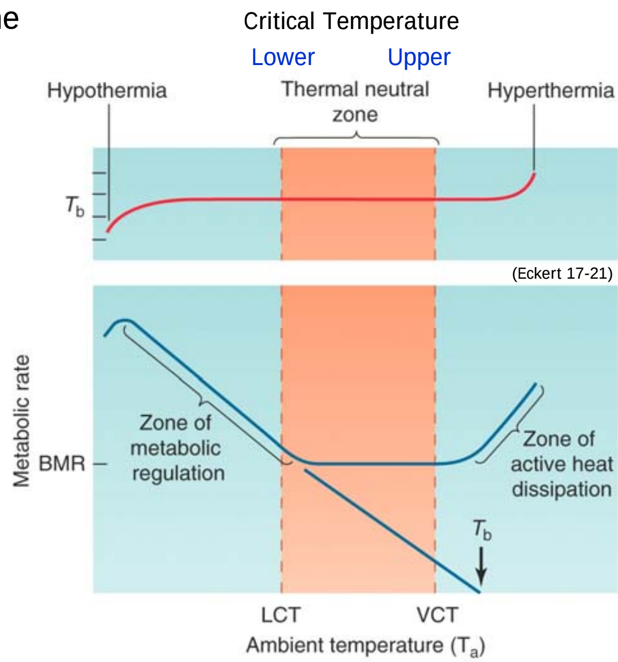
Pough et al., 2001

Thermal Neutral Zone

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

Below TNZ:
- -Increase metabolism
  above basal

Above TNZ:
- -Cool via evaporation



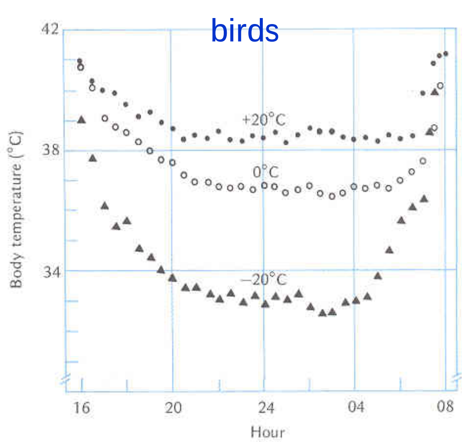
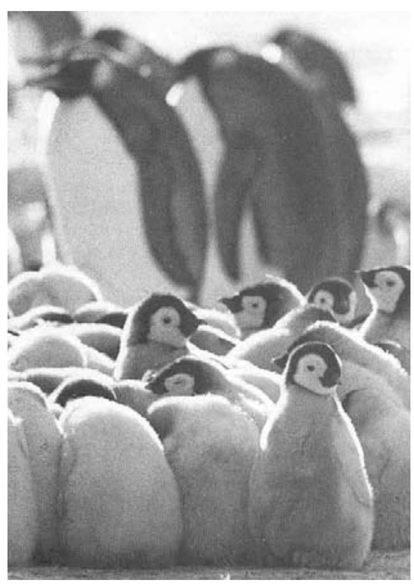


Figure 7.11 Body temperature of a willow tit (*Parus montanus*) during the night hours at three different ambient temperatures. The records are from midafternoon one day to the following morning. [Reinertsen and Haftorn 1986]

Knut Schmidt_Nielsen 1997



Knut Schmidt_Nielsen 1997

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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

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