Thermoregulation

and Water Balance

Heat & Water Exchange Occurs on The Surface

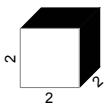
- Surface area to volume ratio (SVR)
  - Bigger size causes lower SVR
  - Appendages increase SVR
- Adaptations to increase heat loss can also increase water loss

Importance of Body Size

Bigger Body → More surface, but

Bigger Body → Less surface per unit volume

Volume = 1 x 1 x 1 = 1
surface area = (1 x 1) x 6 = 6
s. a. / V. = 6



Volume = 2 x 2 x 2 = 8
surface area = (2 x 2) x 6 = 24
s. a. / V = 3

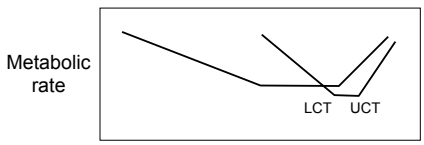
Mechanisms of Heat Exchange

- Radiation
- Convection
- Conduction
- Evaporation

- Most animals regulate body temperature
  - Ectotherms: primarily through behavior
  - Endotherms: through both behavior and physiology
  - All animals produce heat
    - muscular activity
    - metabolism
    - digestion
  - Animals shed heat through
    - evaporation
    - bloodflow to surface

Thermal Neutral Zone

- Range of ambient temperatures over which metabolic rate is minimal and constant
  - Lower critical temperature
  - upper critical temperature



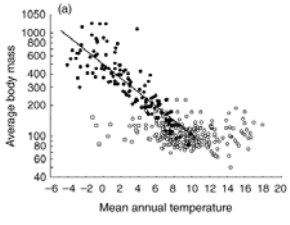
Thermal Neutral Zone

- TNZ is the condition where
  heat production or absorption at rest
  is balanced by
  heat loss
- Humans
  - Body temperature is around 37°C
  - TNZ (in air) is around 21°C
  - This difference (thermal gradient) results in heat loss equal to heat production by resting metabolism.

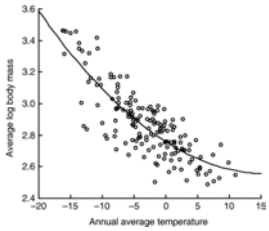
Thermal Adaptations

- Surface area to volume ratio (SVR)
  - bigger size causes lower SVR
  - Bergmann's Rule: polar animals tend to be larger than related animals in warmer climes
  - long appendages increase SVR

Bergmann's Rule



Mammals in Europe
Rodriguez et al. 2006



Mammals in North America
Blackburn & Hawkins 2004

Adaptations to **Radiation**:

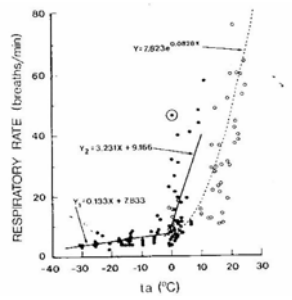
- dark coat that absorbs energy
- light coat that reflects energy
- other needs often select for different traits
  - e.g., need for camouflage

Convection

- Adaptations
  - Fur and feathers increase boundary layer
  - Fat slows heat transfer between core & surface

Thermal Neutral Zone

Moose in winter coat
Renecker & Hudson 1986.
Canadian Journal of Zoology 64:322-327

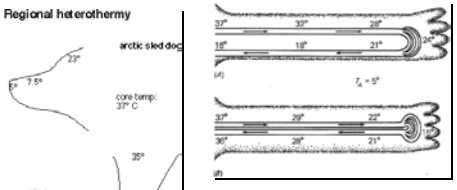


Conduction

- The flow of heat between objects through direct contact
- Depends on contact area and magnitude of temperature gradient, thermal conductivity

Thermal Adaptations

- Countercurrent exchange



Evaporation

- Sweating
- Panting
- Ponds & streams
- Whatever works….

Heat and Habitat

- **Thermal Cover**: vegetation or landform that provides shelter from heat or cold
  - Radiation: reduces radiation to cold sky, blocks radiant heat from sun
  - Convection & Evaporation: reduces wind
- Important habitat component for many animals
- Deer "yards" – areas of dense conifers where deer congregate in harsh winters
  - Leaving the yard to find food may actually cost calories

Guthery et al. 2000
Wildlife Monographs 159

- Thermal ecology of bobwhite quail in Texas
- Bobwhite choose microsites to reduce hypo and hyperthermia

Water

Necessary for life

Foraging habitat

Lush vegetation

Protection from land predators

Water Gain

- Water comes from 3 sources
  - Free water
    - Streams, lakes, puddles, dewdrops
  - Preformed water
    - Water in food
  - Oxidative or metabolic water

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

Water Loss

- Evaporation
  - from skin or lungs
- Excretion
  - kidneys
  - sweat, milk & other glandular secretions
- Feces, vomit

Adaptations to Evaporation

- How do animals reduce water loss?
  - Body shape & size
    - larger body has lower SVR
    - **CONFLICT WITH THERMOREGULATION!**
  - Fur/feathers
    - **CONFLICT WITH THERMOREGULATION!**
  - Camel reduces water loss due to breathing
    - exhaled air is cooled, causing condensation
  - Behavior
    - select moist / sheltered microsites
    - be nocturnal
    - aestivate during dry season

Excretion

- Protein catabolism produces nitrogenous waste
  - Fish & immature amphibians: **ammonia**
  - Birds & most reptiles: **uric acid** (the white stuff on your windshield)
  - Mammals & adult amphibians: **urea**

Kangaroo Rats (*Dipodomys* spp.)

Can survive indefinitely on dry seeds, no free water

- nocturnal
- very concentrated urine (2X sea water)
- low evaporation from skin
  - No sweat glands
  - Fur
- low-moisture feces

Swamp Rabbits (*Sylvilagus aquaticus*)

Habitat: bottomland hardwood forests

Rarely found >1 km from water

Water and Habitat

A moist environment increases growth of plants and abundance of invertebrates

•Affects habitat (FOOD & COVER) as well as individual hydration

•Changes in precipitation from year to year can affect wildlife populations

Things to Remember

- Mechanisms of heat & water transfer
- Thermal Neutral Zone
- Adaptations related to thermoregulation, water balance
- Thermal cover & water as components of habitat
- Importance of body size