

Physiology

- The internal systems of metabolism and excretion, which sustain daily activities and adapt individuals to their environment, are collectively called physiology



Birds are high performance vertebrates

- The power and endurance for flight are made possible by **high metabolic rates**
- High metabolic rates are costly – they require
 - High constant **body temp**
 - High **energy** consumption
 - High **water** consumption
- Many unique adaptations
 - Temperature** regulation
 - Water** conservation
 - Respiratory** system
 - Circulatory** system

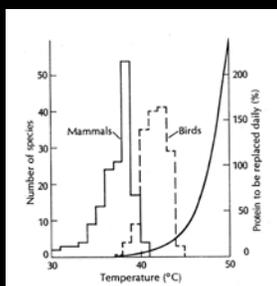


Why high temperature?

- Birds average 41C⁰
 - Cost = energy, O₂, waste
 - 20 – 30X > reptiles
 - Proteins break down at 46 C⁰

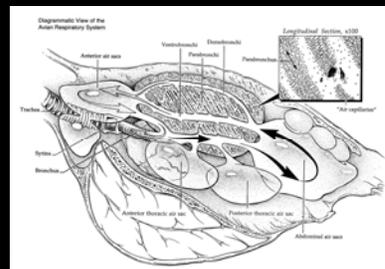
Why?

- Rates of physiological processes increase
 - Nerve impulses 1.8X/10 C⁰
 - Muscle contraction 3X/10C⁰



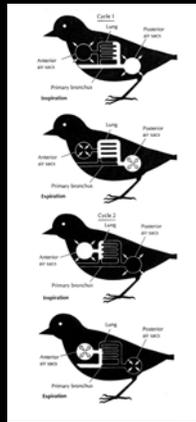
Adaptations of the respiratory system

- Air sacs**
 - Throughout body, even wing and leg bones
 - 1-2 cells thick
 - Allows unidirectional air flow



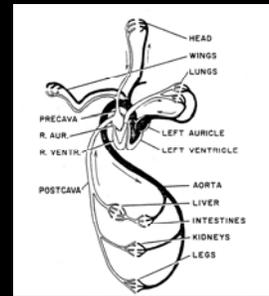
Flow-through lungs

- Two full in/out respirations required before air is exhaled
- Fresh air passes over the lungs continuously

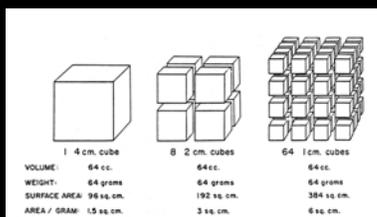


Adaptations of the circulatory system

- 4-chambered heart
- Compared to mammals
 - 50 – 100% larger
 - Heart rates slower but blood flow similar due to larger stroke volume
 - Blood pressure 2X higher



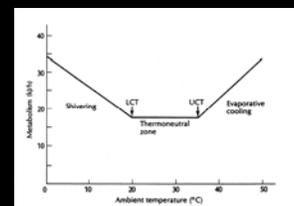
Metabolic adaptations



- Metabolic rate is inversely related to mass
- The primary cause is the relationship between surface area and volume

Temperature regulation

- TNZ – metabolic rate does not change with temp
- <LCT – metabolic rate increases to raise temp, shivering
- >UCT metabolic rate increases to lower temp, evaporative cooling



Response to cold stress

Acclimatization



Behavior



Hypothermia and torpor



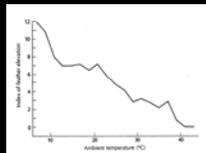
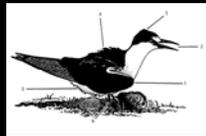
Response to heat stress

- Adaptations
 - Evolutionary
 - Behavioral
 - Anatomical
- Evolutionary
 - Downy Woodpecker body size increases with latitude, but birds in hot humid Mississippi Valley are smaller than birds at similar latitudes to the east or west



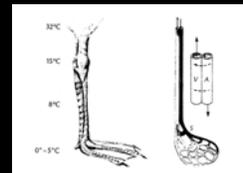
Response to heat stress

- Behavioral
 - Exposing bend of wing
 - Panting
 - Wetting abdomen
 - Exposing legs
 - Raising or lowering feathers



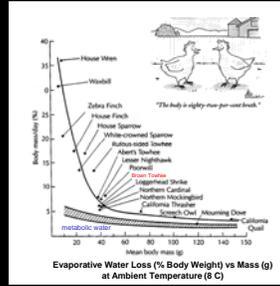
Response to heat stress

- Anatomical Adaptations
 - Gular fluttering
 - Shunt and counter-current blood flow to feet



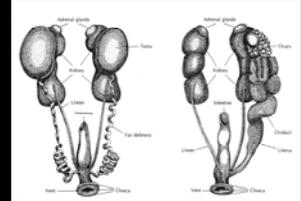
Water economy

- High body temperature and reliance on evaporative cooling require water
 - Small species lose > 35% of body weight/day due to evaporative cooling
 - Rates of water loss increase dramatically when temperature increases



Excretory system aids water economy

- Birds excrete nitrogen as uric acid vs urea (mammals)
 - Uric acid is a paste with 2X concentration of nitrogen and 20X savings in water vs urea
 - Cloaca reabsorbs water to yield concentrations of uric acid 3000X that found in blood



Salt glands conserve water

