

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

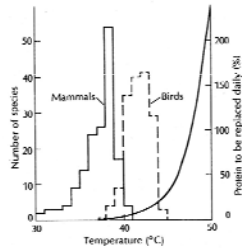


Why high temperature?

- Birds average $41C^{\circ}$
 - Cost = energy, O_2 , waste
 - 20 - 30X > reptiles
 - Proteins break down at $46 C^{\circ}$

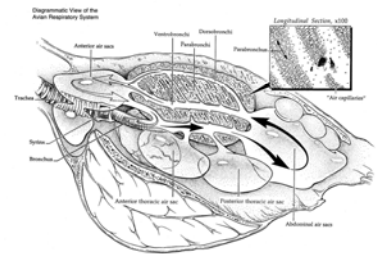
Why?

- Rates of physiological processes increase
 - Nerve impulses $1.8X/10 C^{\circ}$
 - Muscle contraction $3X/10C^{\circ}$



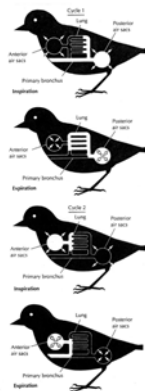
Adaptations of the respiratory system

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



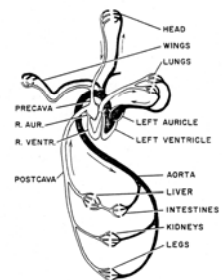
Flow-through lungs

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

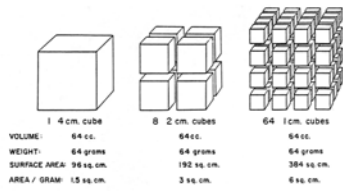


Adaptations of the circulatory system

- 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



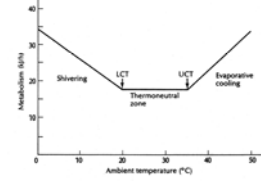
Metabolic adaptations



- 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

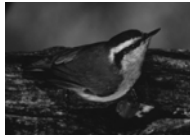
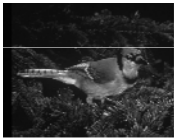


Response to cold stress

Acclimatization

Behavior

Hypothermia and torpor



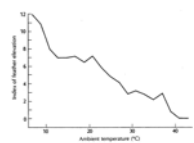
Response to heat stress

- 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



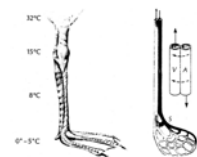
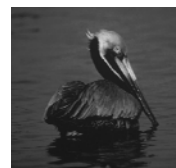
Response to heat stress

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



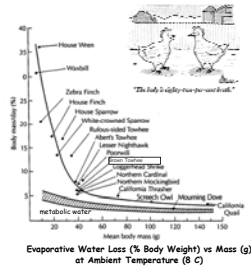
Response to heat stress

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



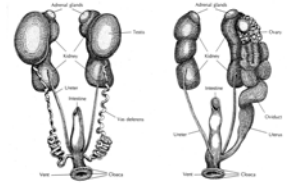
Water economy

- High body temperature and reliance on evaporative cooling require water
 - Small species loose > 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

