Homeostasis
Regulating temperature, fluids, and wastes

Regulators vs. conformers
- A continuum really

Ins vs. outs
- Maintaining homeostasis requires balancing inputs and outputs
- Quantifying these ins and outs as a budget can be very informative

Thermoregulation
- Heat exchange: high to low temperature

Ectotherms vs. endotherms
- Pros and cons

Thermoregulation adaptations (1)
- Controlling heat exchange between body and environment
  - Insulation (hair, feathers, fat)
  - Vasodilation (Incr. diameter of blood vessels near skin)
  - Vasoconstriction (reverse)
  - Countercurrent heat exchanger (arteries to veins)

Thermoregulation adaptations (2)
- Evaporative heat loss
- Behavior
- Changing the rate of metabolic heat production (e.g., moving, shivering)
  - Nonshivering thermogenesis: heat production vs. ATP production by mitochondria

Torpor
- Reduced activity and metabolism
- Daily torpor: undergo short-term torpor while not feeding
- Estivation: summer torpor when too hot and dry
- Hibernation: winter torpor when too cold and little food

Hibernation
- Belding's ground squirrel

Osmoregulation
- Managing the water content and solute composition in the body
- Rely on specialized organs (**kidneys**) and tissues (**transport epithelium**)
- Transport epithelium: layer of specialized cells regulating movement of specific solutes

Transport epithelium in action
- Albatross
- Countercurrent exchange of salt between blood and secretory tubules
- Exchange occurs across transport epithelium cells

Nitrogenous wastes, osmoregulation, and habitat

- Metabolic wastes are dissolved in water in order to remove them from the body
- Thus, waste removal greatly impacts water regulation
- Focus is on nitrogenous wastes
  - Ammonia vs. urea vs. uric acid

Nitrogenous wastes

- NH_3—lots of water for dilution
- Urea—less water; more energy
- Uric acid—insoluble; most energy
- Eggs with hard shells retain insoluble uric acid

Osmoregulation in fishes

- Life in a world of salt water vs. freshwater
- Water moves by osmosis from a hypoosmotic solution to a hyperosmotic one

Life in temporary waters

- **Anhydrobiosis** in water bears (Tardigrada)
- Probably use a sugar (trehalose) to protect cell membranes

Water balance example

- Problems of osmoregulation when living on land

Excretory system overview

- Urine production usually requires two steps:
  - Collection and filtration
    - Powered by blood pressure
  - Selective reabsorption or secretion
    - Powered by active transport

Excretory system diversity

- **Protonephridia**: flame-bulb systems
  - Flatworms (Platyhelminthes); osmoregulation mostly
- **Metanephridia**
  - Earthworms (Annelida); osmoreg. and excretory
- **Malpighian tubules**
  - Insects (Arthropoda); osmoreg. and excretory
- **Kidneys**
  - Vertebrates; osmoreg. and excretory

Protonephridia

- Network of dead-end tubules <u>without</u> internal openings
- Beating cilia inside the flame bulb moves fluid through the bulb, which filters the fluid
- Resembles a flickering flame

Metanephridia

- Tubule network <u>with</u> internal openings that collect fluids

Malpighian tubules

- Outfoldings of the midgut
- Good at reabsorption of water for life on land

Kidneys

- Urine exits kidney through the **ureter**, collects in the **urinary bladder**, and exits body through the **urethra**
- The '**renals'**: outer **medulla**, inner **cortex**, **pelvis**

Nephrons of the kidney

- The workhorse of the kidney; each human kidney contains about 1 million nephrons
- A long **tubule** + the **glomerulus**

The nephron in action (1)

- Nephron and collecting duct lined by transport epithelium
- **Proximal tubule** alters the volume and composition of the filtrate

The nephron in action (2)

- Changes in permeability…
- **Descending limb of loop of Henle**: passive reabsorption of water
- **Ascending limb of loop of Henle**: passive & active reabsorption of salt. Why?

The nephron in action (3)

- **Distal tubule**: altering the composition again
- **Collecting duct**: more reabsorption

Concentrating urine

- What type of physiological system?
- Maintenance of a steep osmotic gradient
- Active or passive?
- Result: hyperosmotic urine

Kangaroo rats vs. birds

- Can you think of a major structural adaptation in the kidneys for water conservation in a:
  - Kangaroo rat?
  - Bird?