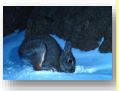
Chapter 40
Homeostasis


Animal Form and Function

- Animals provide examples of biology's major themes
  - diversity & unity of life
  - form & function are interwoven
  - evolution is the thread that ties it all together
    - adaptations observed in a comparative study of animals evolved by natural selection



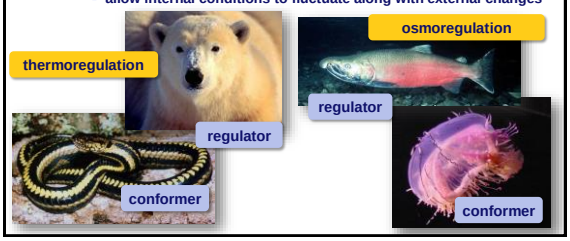
The cold-adapted rabbit has short ears and extremities to reduce heat lost, while the heat-adapted jackrabbit has longer ears that act as heat exchangers with ambient air.

Big Idea #2

Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.

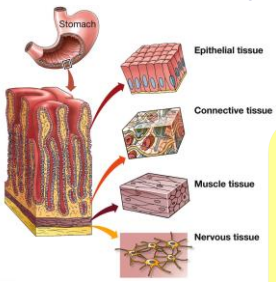
Conformers vs. Regulators

- 2 evolutionary paths for organisms
  - regulate internal environment
    - maintain relatively constant internal conditions
  - conform to external environment
    - allow internal conditions to fluctuate along with external changes



Hierarchy of Structure

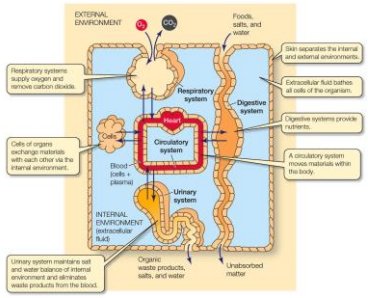
- cells → tissues → organs → organ systems



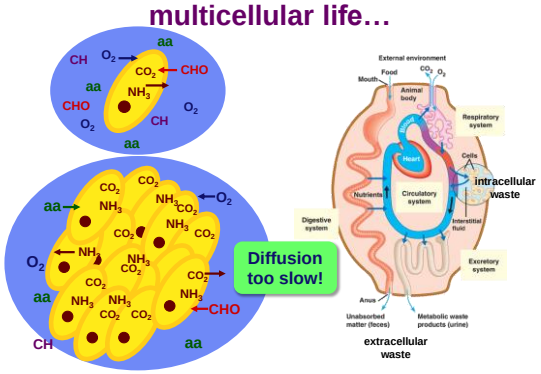
- tissues = groups of cells with common structure and function
- organs = composed of different tissue types
- organ systems = organs working towards the same function

Organ Systems

cells
↓
tissues
↓
organs
↓
organ system
↓
organism



Animal systems evolved to support multicellular life…

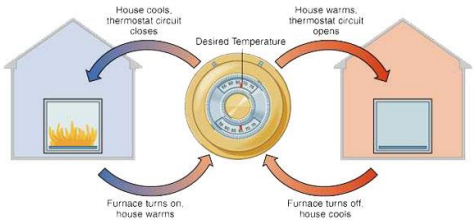


Homeostasis

- Keeping the balance
  - animal body needs to coordinate many systems all at once
    - temperature
    - blood sugar levels
    - energy production
    - water balance & intracellular waste disposal
    - nutrients
    - ion balance
    - cell growth
  - maintaining a "steady state" condition

Homeostasis

- systems work to maintain a balance
  - integrated open and closed systems
  - requires monitoring, feedback, and response

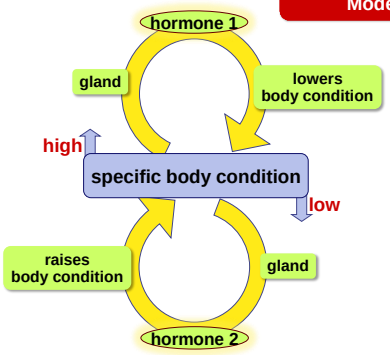


Feedback Circuits

- Negative feedback
  - stimulus triggers control mechanism counteracting further change
    - reverse effect
- Positive feedback
  - stimulus triggers control mechanism amplifying effect
    - much less common
- Feed-forward control
  - changing the set point at which the desired equilibrium should be

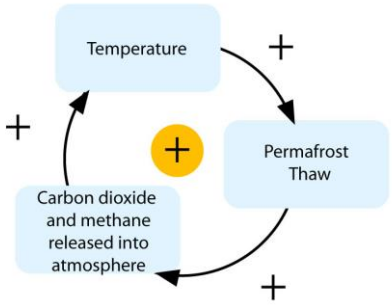
Negative Feedback

Negative Feedback Model



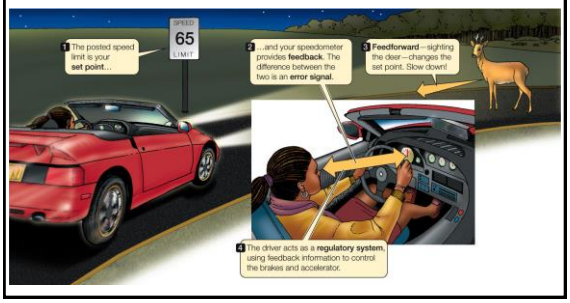
Positive Feedback

not that common in living systems



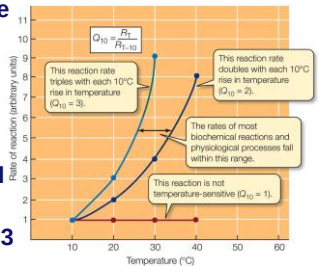
Feedforward Information

- using feedback from senses, the driver regulates the speed of a car



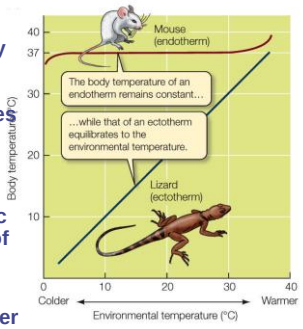
Q_{10}

- the temperature sensitivity of a reaction or process
- $= R_T/R_{T-10}$
- most biological Q_{10} values are between 2 and 3



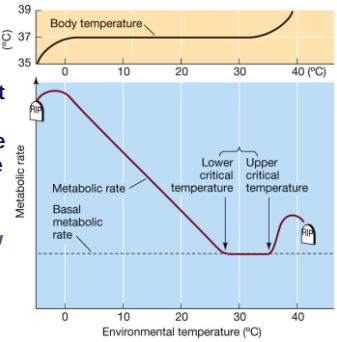
What -therm are you?

- ectotherm
  - animals whose body temperature are determined by external heat sources
- endotherm
  - regulate body temperature by producing metabolic heat or prevention of heat loss
- heterotherm
  - can behave like either
    - hibernating mammals

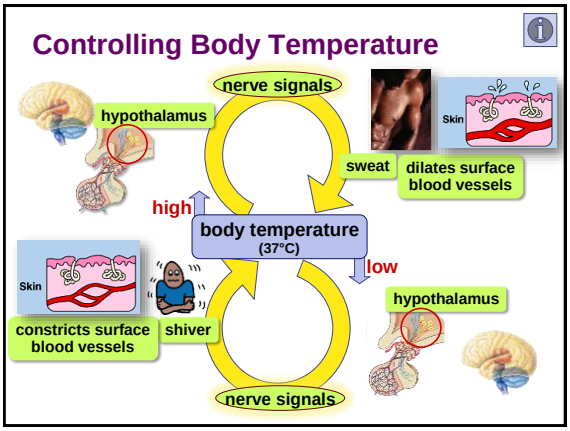


BMR (Basal Metabolic Rate)

- measured when a resting animal is consuming just enough to carry out its minimal life functions within the thermoneutral zone
  - when the metabolic rate of endotherms is low and independent of temperature

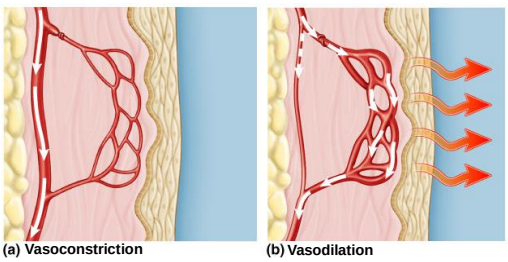


Controlling Body Temperature



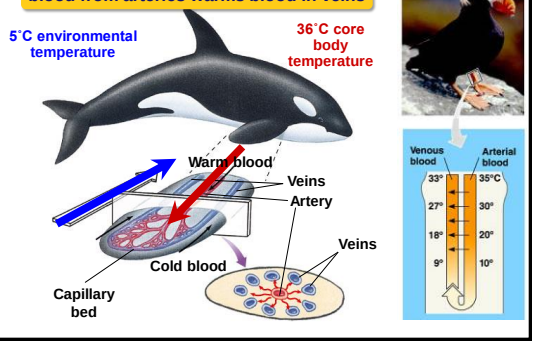
Thermoregulation

- Vasodilation & vasoconstriction
  - adjusts blood flow
  - evaporative cooling



Temperature Management

blood from arteries warms blood in veins

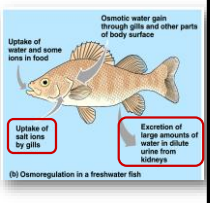


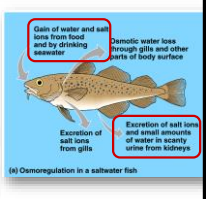
Osmoregulation

- Water balance
  - freshwater
    - hypotonic
    - water flow into cells & salt loss
  - saltwater
    - hypertonic
    - water loss from cells
  - land
    - dry environment
    - need to conserve water
    - may need to conserve salt

Why do all land animals have to conserve water?

- always lose water (breathing & waste)
- may lose 'life' while searching for water



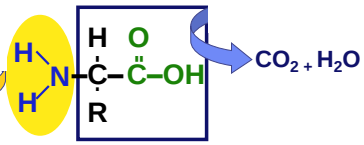


Waste Disposal

- What waste products?
  - what do we digest our food into…
    - carbohydrates = CHO → $CO_2 + H_2O$
    - lipids = CHO → $CO_2 + H_2O$
    - proteins = CHON → $CO_2 + H_2O$ + N
    - nucleic acids = CHOPN → $CO_2 + H_2O$ + P + N
      - relatively small amount in cell

cellular digestion… cellular waste

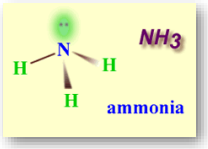
NH_2 into ammonia



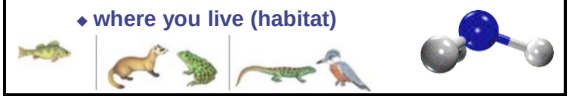
$CO_2 + H_2O$

Nitrogenous Waste Disposal

- Ammonia (NH_3)
  - very toxic
    - carcinogenic
  - very soluble
    - easily crosses membranes
  - must dilute it & get rid of it… *fast!*



- How you get rid of nitrogenous wastes depends on:
  - who you are (evolutionary relationship)
  - where you live (habitat)



Nitrogen Waste

- Aquatic organisms
  - can afford to lose water
  - ammonia
    - most toxic
- Terrestrial
  - need to conserve water
  - urea
    - less toxic
- Terrestrial egg layers
  - need to conserve most water
  - uric acid
    - least toxic