Section A: An Overview of Homeostasis

1. Regulating and conforming are the two extremes in how animals cope with environmental fluctuations
2. Homeostasis balances an animal’s gains versus losses for energy and materials
Introduction

- One of the most remarkable characteristics of animals is **homeostasis**, the ability to maintain physiologically favorable internal environments even as external conditions undergo dramatic shifts that would be lethal to individual cells.
  - For example, humans will survive exposure to substantial changes in outside temperature but will die if their internal temperatures drift more than a few degrees above or below 37°C.
  - Another mammal, the arctic wolf, can regulate body temperature even in winter when temperatures drop as low as -50°C.
• Three ways in which an organism maintains a physiological favorable environment include:
  
  • **thermoregulation**, maintaining body temperature within a tolerable range
  
  • **osmoregulation**, regulating solute balance and the gain and loss of water
  
  • **excretion**, the removal of nitrogen-containing waste products of metabolism such as urea.
1. Regulating and conforming are the two extremes of how animals cope with environmental fluctuations

- An animal is said to be a regulator for a particular environmental variable if it uses mechanisms of homeostasis to moderate internal change in the face of external fluctuations.
  
  - For example, endothermic animals such as mammals and birds are thermoregulators, keeping their body temperatures within narrow limits in spite of changes in environmental temperature.
In contrast to regulators, many other animals, especially those that live in relatively stable environments, are **conformers** in their relationship to certain environmental changes.

Such conformers allow some conditions within their bodies to vary with external changes.

![Diagram](Fig. 44.1a)
• Many invertebrates, such as spider crabs of the genus *Libinia*, live in environments where salinity is relatively stable.

• These organisms do not osmoregulate, and if placed in water of varying salinity, they will lose or gain water to conform to the external environment even when this internal adjustment is extreme enough to cause death.

![Fig. 44.1b](image-url)
• Conforming and regulating represent extremes on a continuum.
  
  • No organisms are perfect regulators or conformers.
  
  • For example, salmon, which live part of their lives in fresh water and part in salt water, use osmoregulation to maintain a constant concentration of solutes in their blood and interstitial fluids, while conforming to external temperatures.
Even for a particular environmental variable, a species may conform in one situation and regulate in another.

- Regulation requires the expenditure of energy, and in some environments that cost of regulation may outweigh the benefits of homeostasis.

- For example, temperature regulation may require a forest-dwelling lizard to travel long distances (and risk capture by a predator) to find an exposed sunny perch.

- However, this same lizard may use behavioral adaptations to bask in open habitats.
2. Homeostasis balances an animal’s gains versus losses for energy and materials

- Like all organisms, animals are open systems that must exchange energy and materials with their environment.
  
  - These inward and outward flows of energy and materials are frequently rapid and often variable, but as they occur animals also need to maintain reasonably constant internal conditions.
  
  - Normally, an animal’s inputs of energy and materials only exceed its outputs where there is a net increase in organic matter due to growth or reproduction.
• Consider some exchanges during ten years in the life of a typical woman weighing 60 kg.

• Over the decade, she will eat about 2 tons of food, drink 6 to 10 tons of water, use almost two tons of oxygen, and metabolically generate more than 7 million kilocalories of heat.

• This same quantity of material and heat must be lost from the woman’s body to maintain its size, temperature, and chemical composition.
Oxygen gas used: 2 tons (1,400 cubic meters)

Heat generated by metabolism: 7 million kilocalories, the amount of heat needed to raise 90 tons of water (symbolized by the volume of this box) from 22°C to 100°C

Food eaten: 2 tons

Water drunk: 6–10 tons

Fig. 44.2
• If the woman produces two children (and breast-feeds each for two years) during this ten year span, she will need to increase the total flow of energy and materials by only 4-5% compared to her basic maintenance needs.

• Reproduction is a larger part of the energy and material flow in many other species.
  • For example, a female mouse rearing two litters per year invests 10-15% of its annual energy budget on reproduction.

• Regardless of reproductive costs, every animal’s survival depends on accurate control of materials and energy exchange.
Because homeostasis requires such a careful balance of materials and energy, it can be viewed as a set of budgets of gains and losses.

These may include a heat budget, an energy budget, a water budget, and so on.

Most energy and materials budgets are interconnected, with changes in the flux of one component affecting the exchanges of other components.

For example, when terrestrial animals exchange gases with air by breathing, they also lose water by evaporation from the moist lung surfaces.

This loss must be compensated by intake (in food or drink) of an equal amount of water.