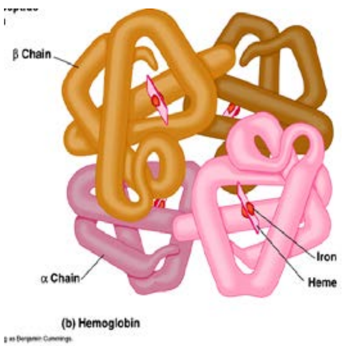
Controlling the Internal Environment



A. Proteins

1. What are the structural and functional characteristics that define proteins?
2. What is the key role of proteins in regulating biochemical interactions?
3. What happens when you heat-stress a protein?

B. What is homeostasis?

C. Bioenergetics

1. What is metabolic rate?
2. Metabolic rates of endo- versus ectotherms

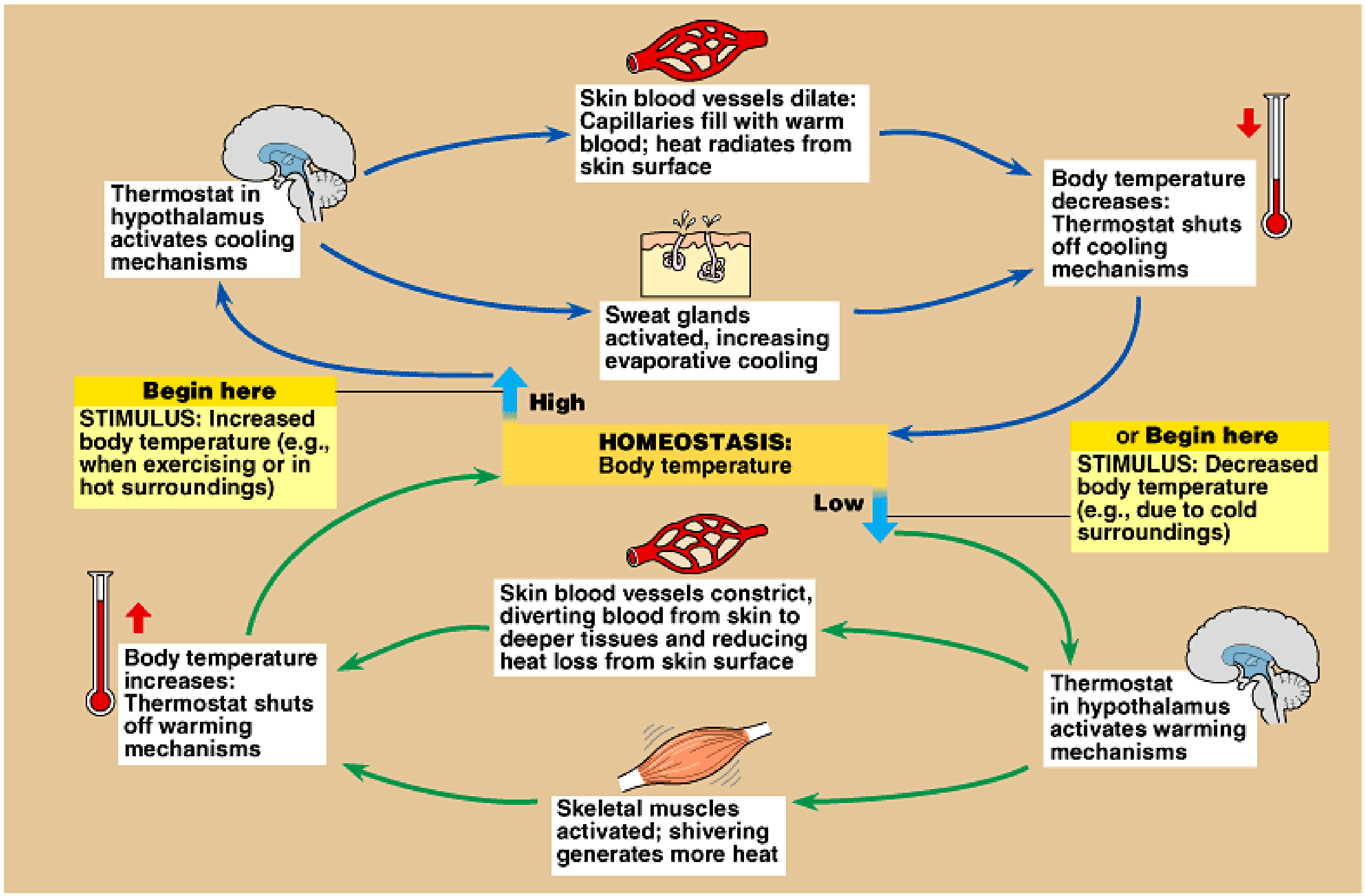
D. Thermoregulation – homeostatic regulation of the heat budget

1. Regulators versus conformers
2. Four physical processes achieve thermoregulation
3. Physiological and behavioral adaptations for thermoregulation
4. What are the costs of homeostasis with respect to thermoregulation?
5. Acclimatization
6. What if temperatures exceed range of tolerance?
7. Factors contributing to heat death.

B. What is homeostasis?

Maintenance of a physiological steady-state

What needs to be maintained? Temp, pH, blood sugar, inter- and intracellular ion concentrations



Feedback circuits: negative – triggers response that counteracts further change

(positive – triggers response that amplifies change (e.g. pregnancy hormones))

C. Bioenergetics – the flow of energy through an animal

Metabolic rate - the amount of energy an animal uses per unit time (kcal/year)

How is metabolic rate measured?

- heat evolved

- O_2 consumed

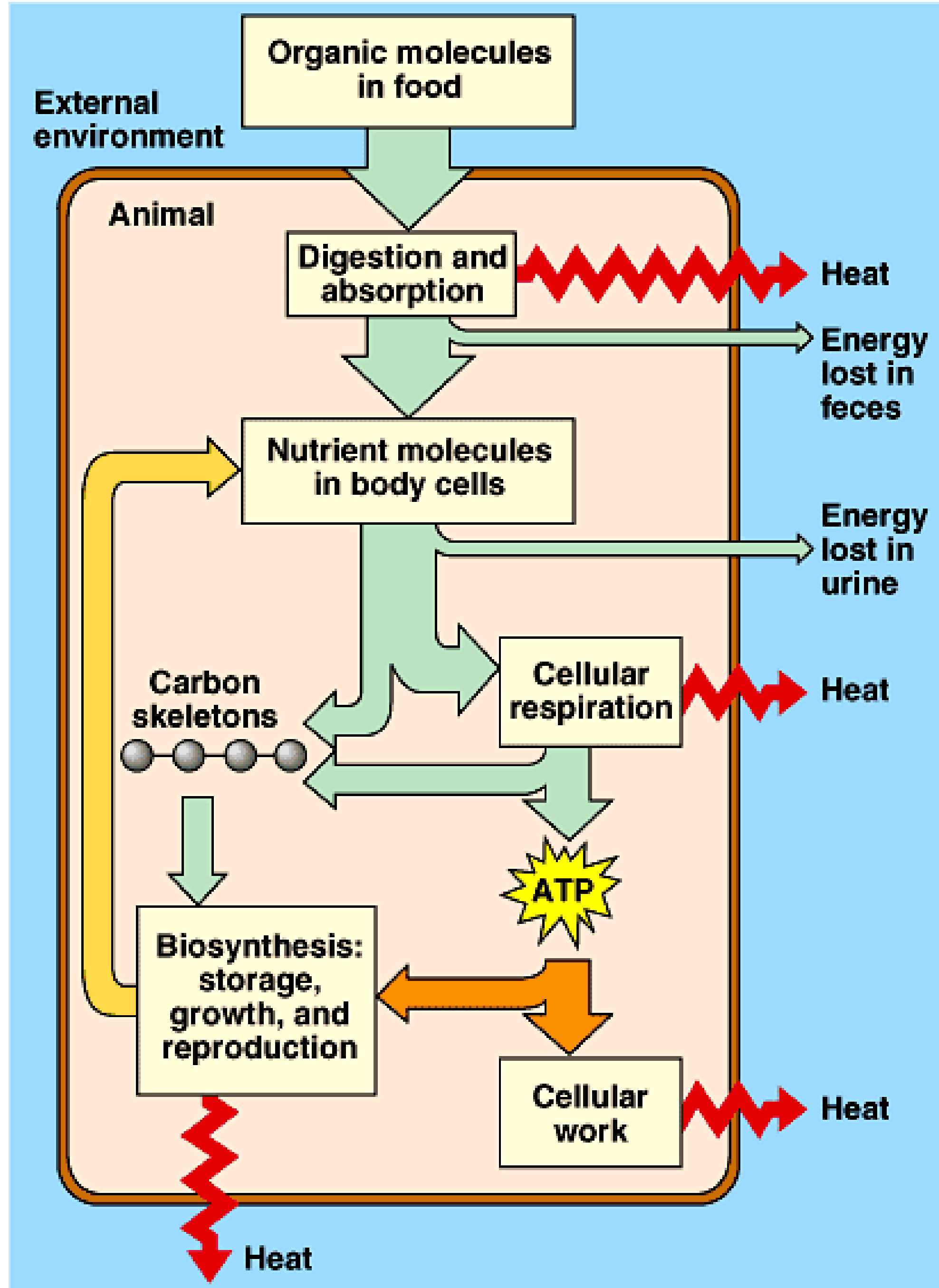
Why measure metabolic rate?

- how does organism function within it's environment?

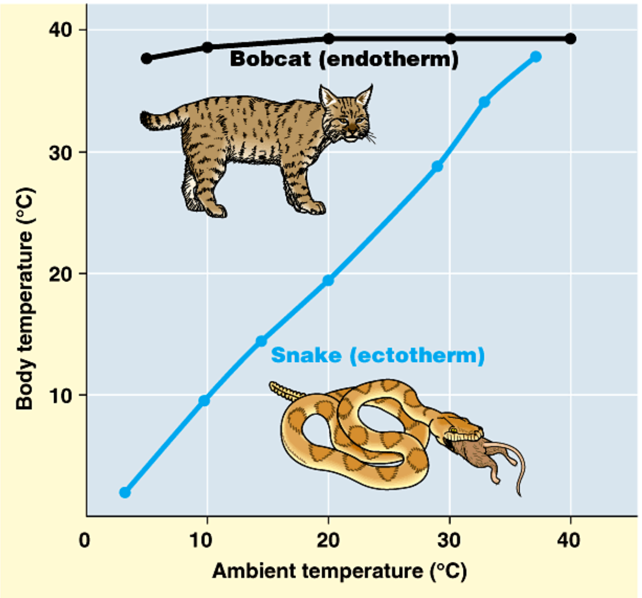
- environmental constraints on activity

- "principal of allocation"

a fixed energy budget



2. Two bioenergetic strategies used by animals: endothermic versus ectothermic



Endotherms (birds and mammals) maintain body temp. regardless of ambient temp.

Advantages?

Higher levels of cellular respiration generate greater supply of ATP, allowing longer activity at max. metabolic rate.

Disadvantages?

Energetically expensive, especially at temp. extremes

Ectotherms (reptiles, amphibians, invertebrates, fish)

- insufficient metabolic heat to maintain body temp.

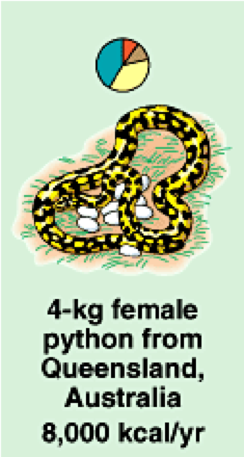
Disadvantages?

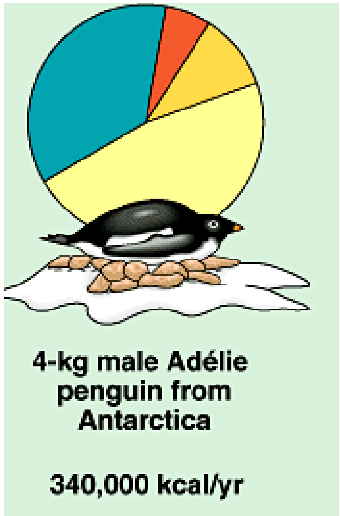
Lower rates of cellular respiration; inability to sustain long periods w/ max. metabolic rate

Inactive at extreme temp. , hence vulnerable to predators

Advantages?

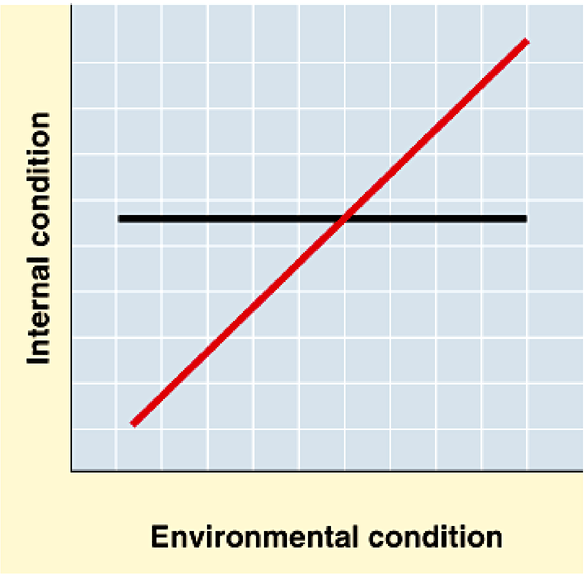
An economic energy strategy – less expenditure on energy acquisition





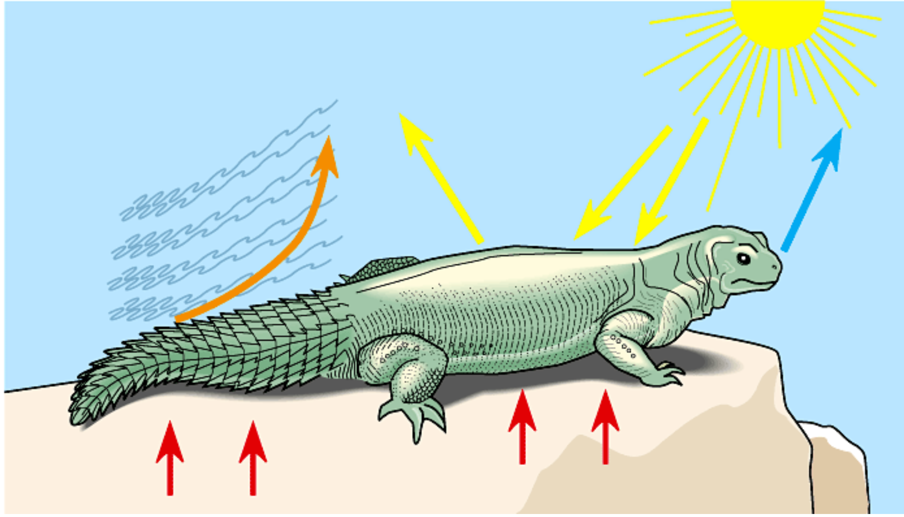
D. Thermoregulation – maintaining the heat budget

1. Regulators versus conformers



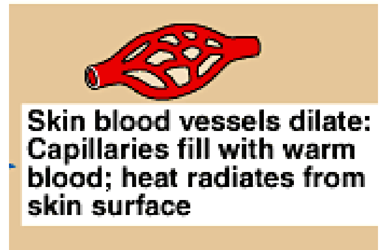
2. Four physical processes achieve thermoregulation

- conduction
- convection
- radiation
- evaporation

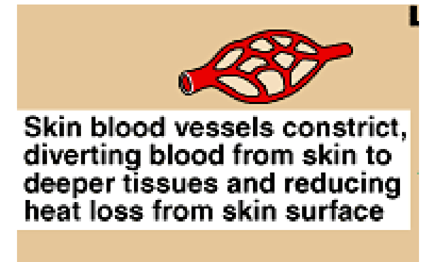


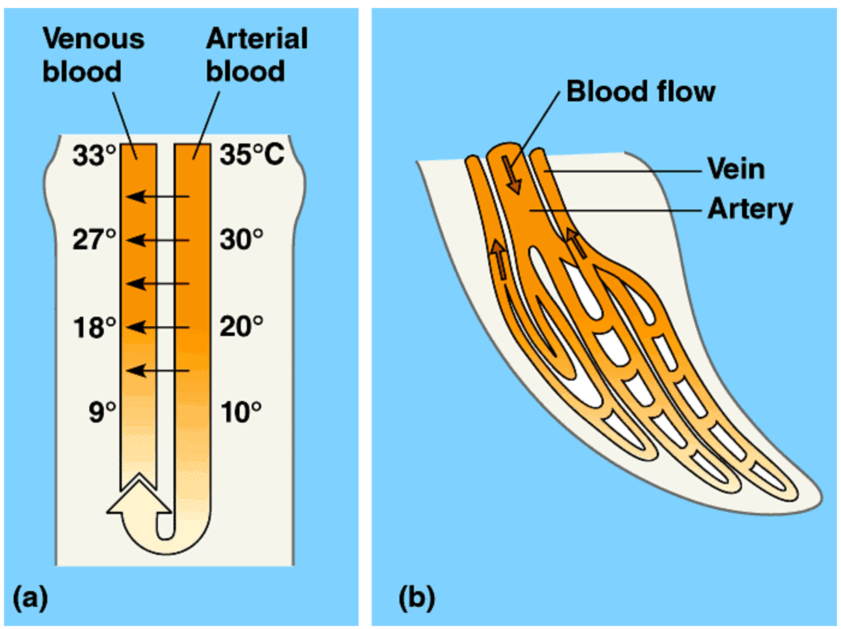
3a. Physiological adaptations for thermoregulation -

- vasodilation



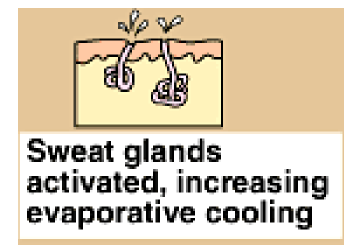
- vasoconstriction

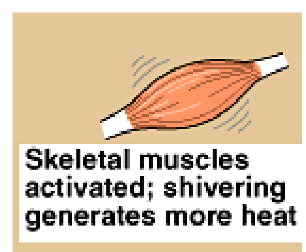




- countercurrent heat exchangers

- evaporative heat loss





shivering -changing metabolic rate

3b. Some behavioral adaptations for thermoregulation -

- changes in posture ??

- moving around in environment ??

- migrations - for extreme seasonal changes in temperatures

4. What are the costs of homeostasis with respect to thermoregulation?

   - costs of thermoregulation in light of global warming?

5. Acclimatization – physiological adjustment to a new thermal range (days – weeks)

   - increased enzyme production
   - different enzymes with different thermal optima
   - membrane changes
   - cryoprotectants
   - heat-shock proteins

6. What if temperatures exceed range of tolerance?

Torpor – physiological and behavioral response: drop in heart rate and respiration

Hibernation – winter – cold and food scarcity

Estivation – summer = heat and water scarcity

Daily torpor – hummingbirds and bats

Duration of exposure is critical – many organisms can tolerate high temps for short periods.

Temps at which organisms can survive vs. complete life cycle

Effect of life stage on stress tolerance

7. Factors contributing to heat death

1. Denaturation of proteins, thermal coagulation
2. Thermal inactivation of enzymes at rates exceeding formation
3. Denaturation of membrane structure
4. Different effects of temp on interdependent metabolic reactions

$$\begin{tikzcd} A \arrow[r] & B \arrow[r] & C \arrow[r] \arrow[d] & D \\ & & E & \end{tikzcd}$$

If $C \rightarrow D$ accelerated more than $B \rightarrow C$, C is depleted, no E production