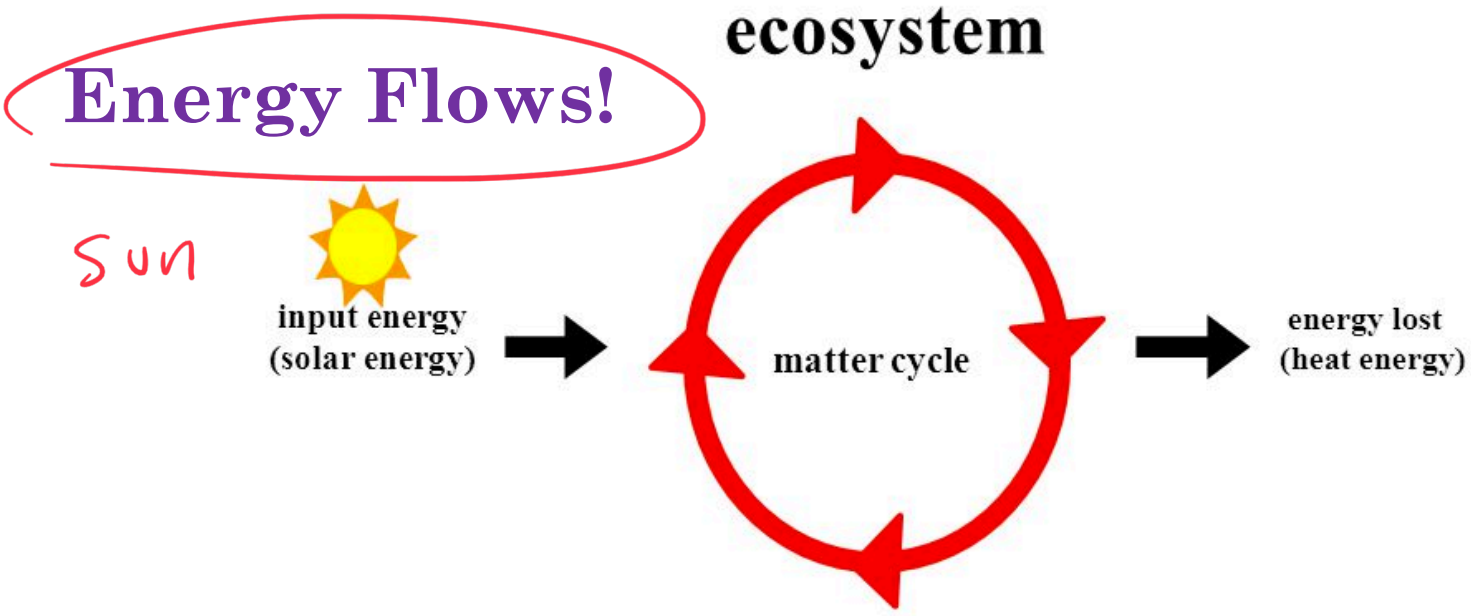
CHAPTER 6
An Introduction to Metabolism

WHAT YOU NEED TO KNOW:

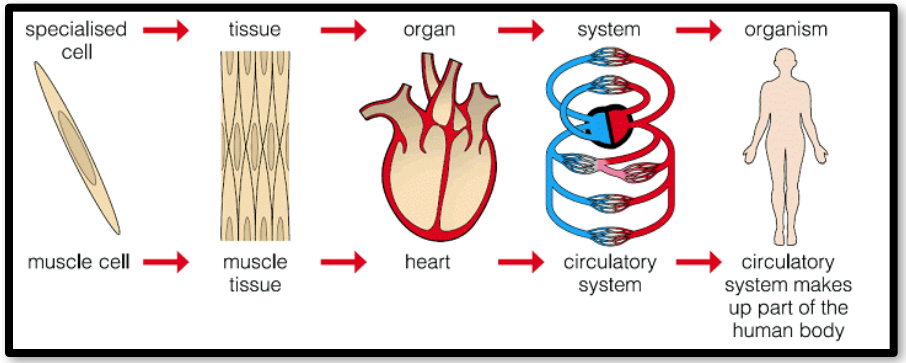
- Exergonic reactions release free energy (ΔG is negative); endergonic reactions store free energy (ΔG is positive).
- ATP powers cellular work by coupling exergonic reactions to endergonic reactions.
- Enzymes work by lowering the energy of activation.
- The catalytic cycle of an enzyme that results in the production of a final product.
- Enzymes are specific in the reactions they catalyze because of the molecular shape of their active site.
- Factors that change the shape of the active site of enzymes and how they influence enzyme activity.
- How feedback inhibition is used to maintain appropriate levels of enzymes and enzyme products in a pathway.

ENERGY DYNAMICS

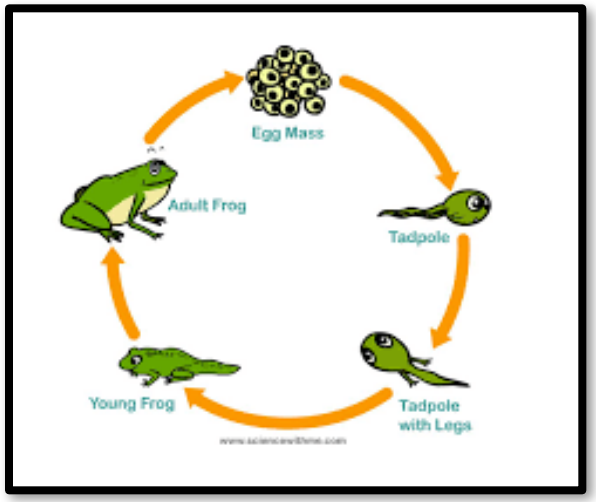
The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.



ORGANISMS USE **ENERGY** TO:

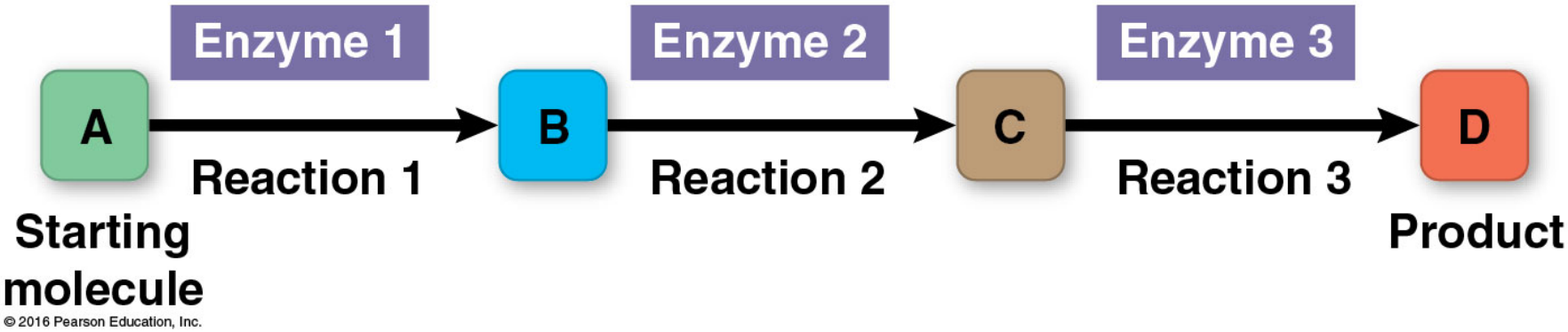


Maintain Organization



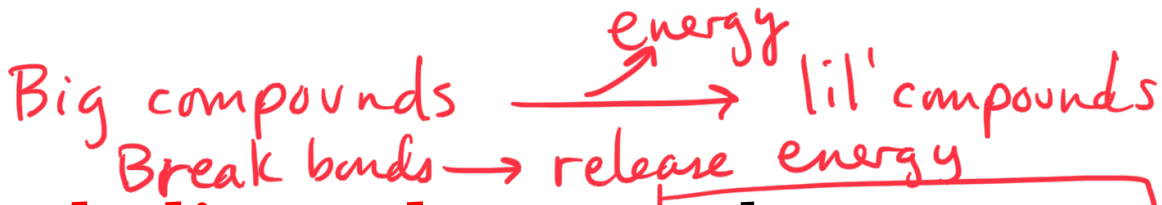
Reproduce

Grow



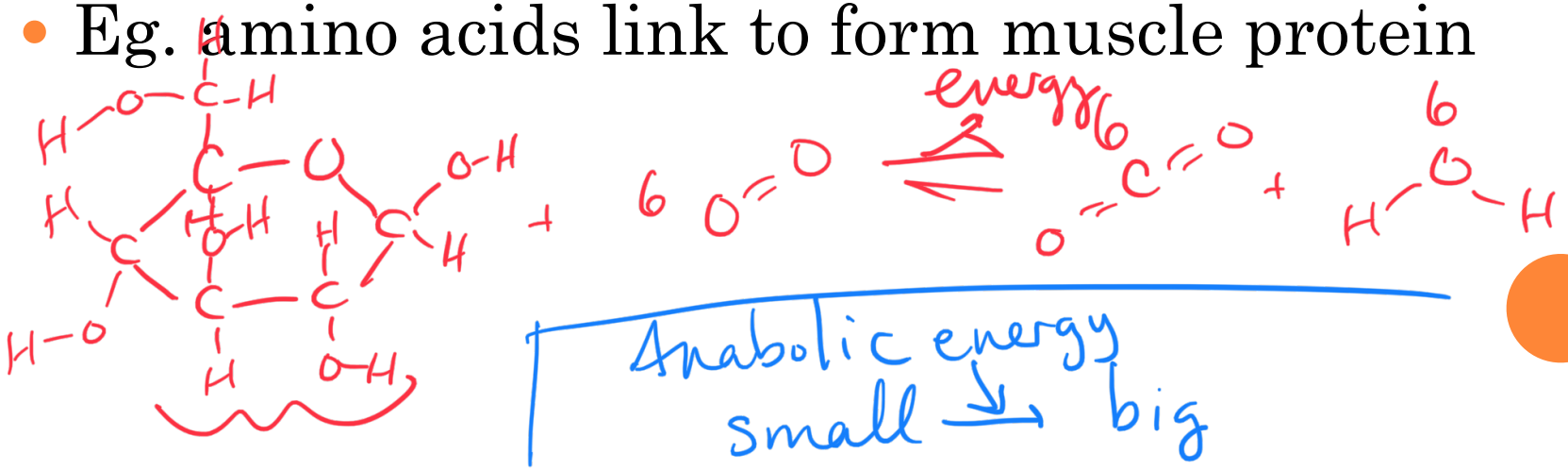
Metabolism is the totality of an organism's chemical reactions

- Manage the materials and energy resources of a cell
- **Metabolic rate** = total amount of energy an animal uses in a unit of time
- In general, the *smaller* the organism, the *higher* the metabolic rate



- **Catabolic pathways** release energy by breaking down complex molecules into simpler compounds
  - Eg. digestive enzymes break down food → release energy

- **Anabolic pathways** consume energy to build complex molecules from simpler ones
  - Eg. amino acids link to form muscle protein

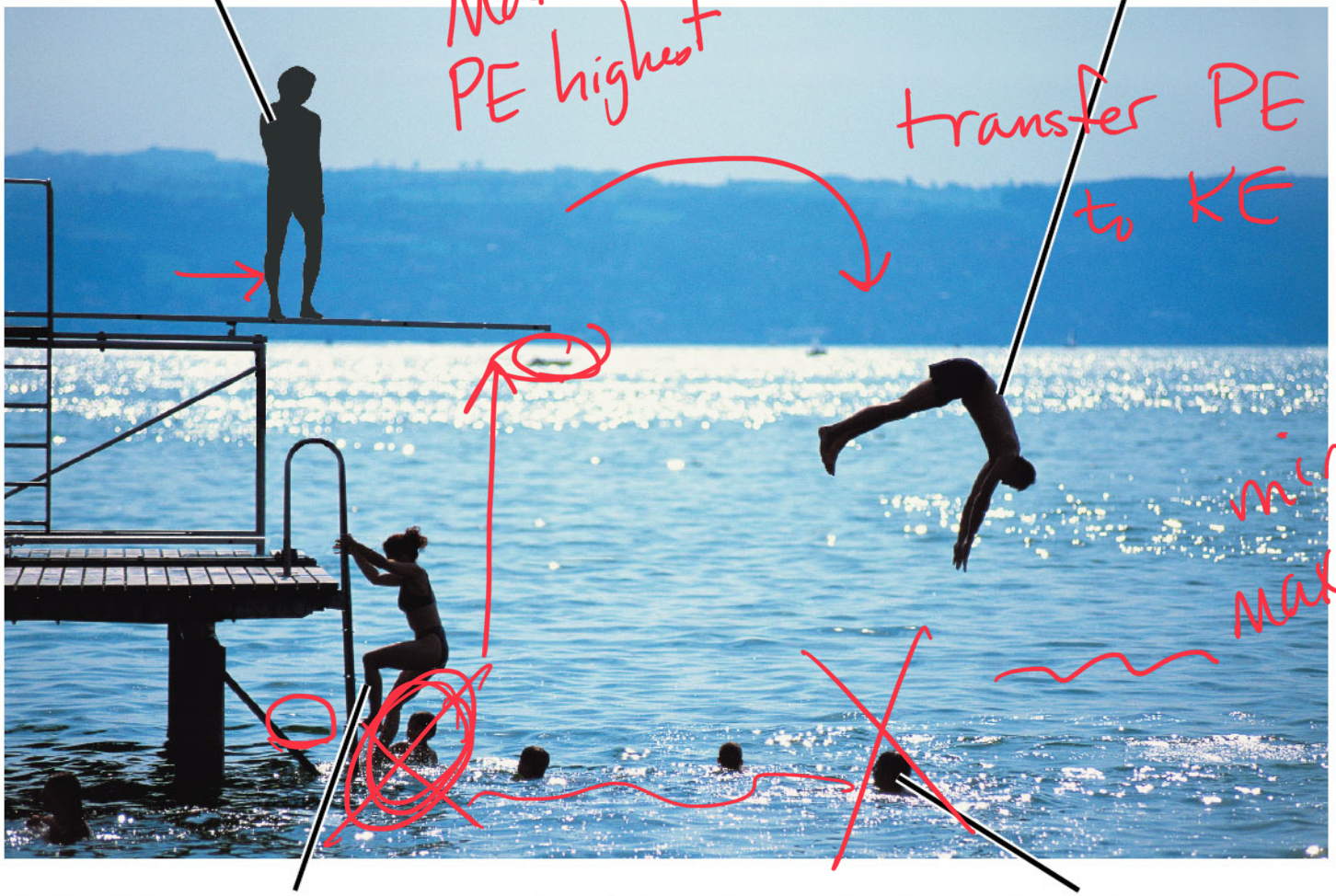


ENERGY = CAPACITY TO DO WORK

- **Kinetic energy (KE)**: energy associated with motion $KE = \frac{1}{2}mv^2$
  - *Heat* (thermal energy) is KE associated with random movement of atoms or molecules
- **Potential energy (PE)**: stored energy as a result of its position or structure $PE = mgh$
  - *Chemical energy* is PE available for release in a chemical reaction
- Energy can be converted from one form to another
  - Eg. chemical → mechanical → electrical

A diver has more potential energy on the platform.

Diving converts potential energy to kinetic energy.



Climbing up converts the kinetic energy of muscle movement to potential energy.

A diver has less potential energy in the water.

Thermodynamics is the study of energy transformations that occur in matter

Kinetics
↳ how quickly a reaction takes places

How a rxn looks at the beginning and end

- Closed system: isolated from its surroundings (eg. liquid in a thermos)
- Open system: energy and matter can be transferred between the system and its surroundings
- Organisms = Open Systems
  - A **net gain in energy** results in energy storage or the growth of an organism
  - A **net loss of energy** results in loss of mass, and/or death of an organism

energy released
↓
Spontaneous

THE FIRST LAW OF THERMODYNAMICS (CONSERVATION OF ENERGY)

Law of conservation of energy

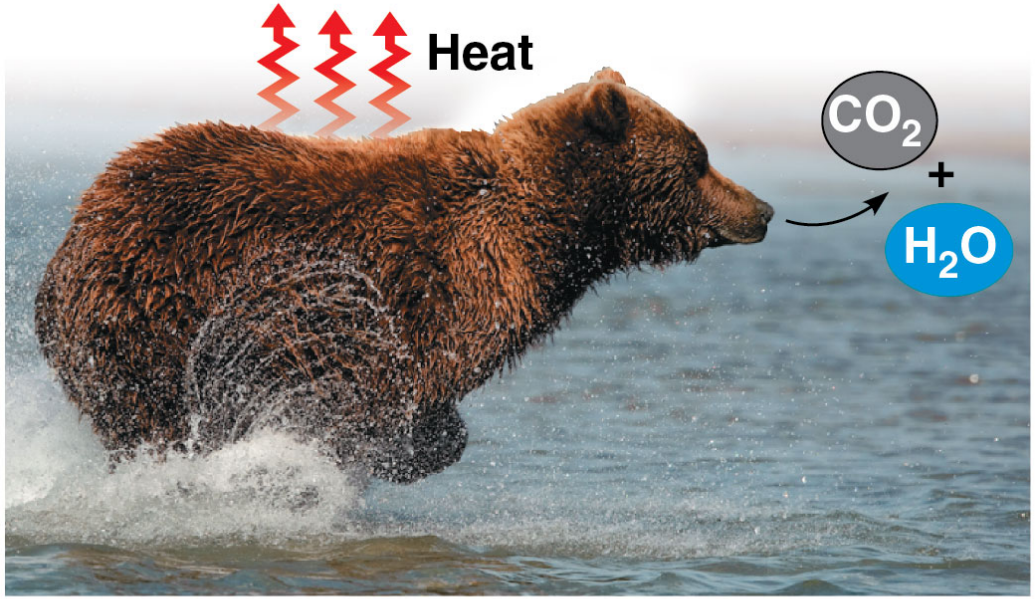
- The energy of the universe is constant
  - Energy **can** be transferred and transformed
  - Energy **cannot** be created or destroyed

(a) First law of thermodynamics

THE SECOND LAW OF THERMODYNAMICS

- Every energy transfer or transformation increases the entropy (disorder) of the universe

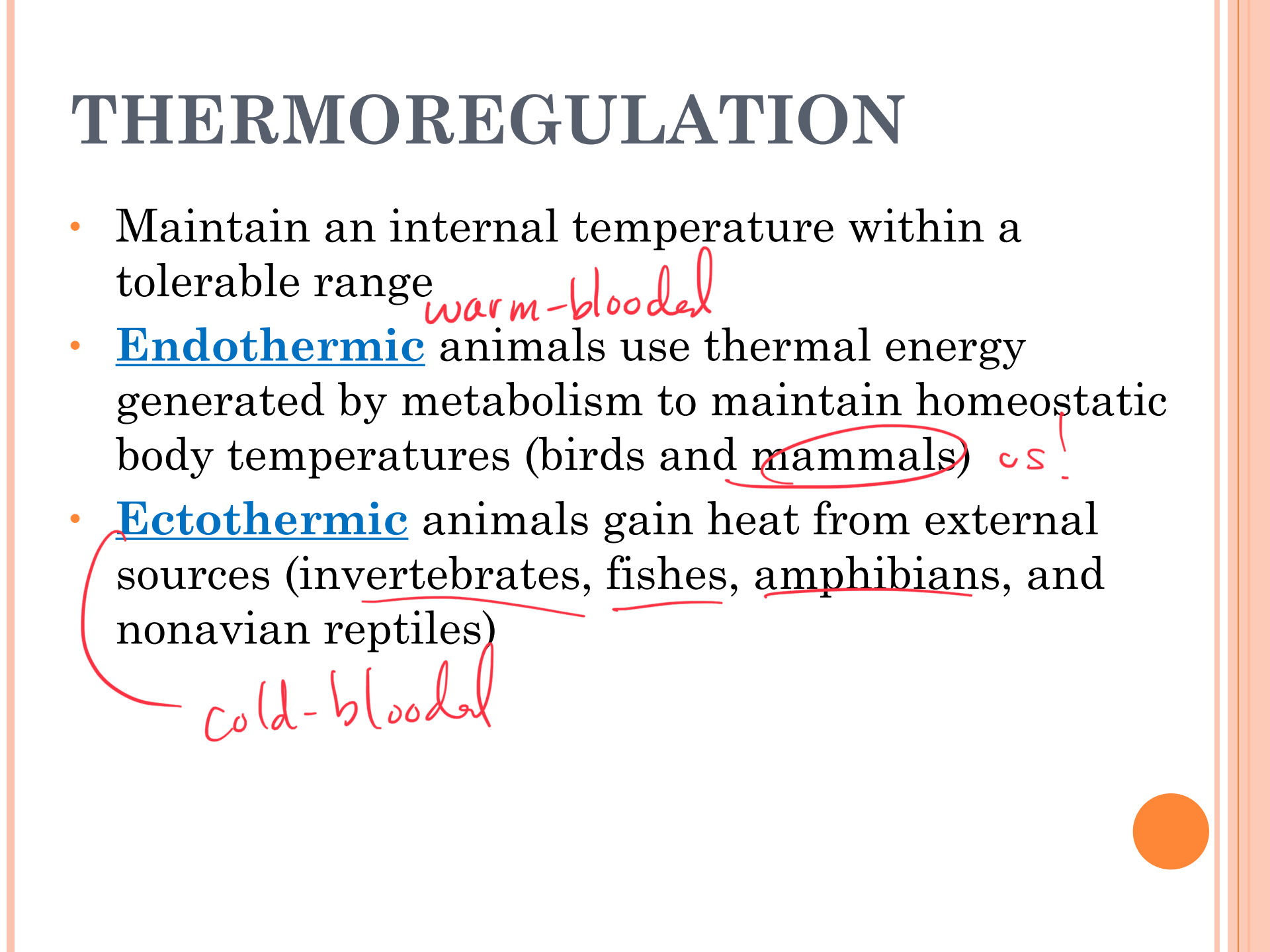
- During every energy transfer or transformation, some energy is *unusable*, often lost as **heat**



(b) Second law of thermodynamics

THERMOREGULATION

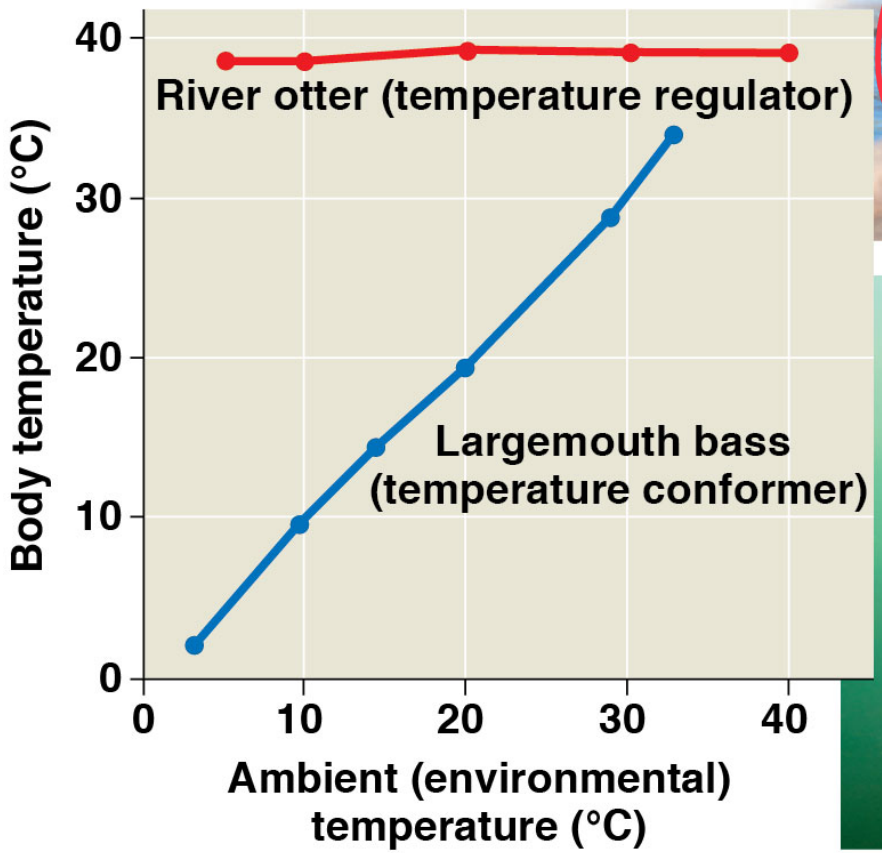
- Maintain an internal temperature within a tolerable range
- **Endothermic** animals use thermal energy generated by metabolism to maintain homeostatic body temperatures (birds and mammals)
- **Ectothermic** animals gain heat from external sources (invertebrates, fishes, amphibians, and nonavian reptiles)



(a) A walrus, an endotherm

(b) A lizard, an ectotherm

ENDOTHERMS VS. ECTOTHERMS



- **Free energy**: part of a system's energy available to perform work
  - ΔG = change in free energy
- **Exergonic reaction**: energy is released
  - Spontaneous reaction
  - $\Delta G < 0$
- **Endergonic reaction**: energy is required
  - Absorb free energy
  - $\Delta G > 0$