TWO LAWS OF THERMODYNAMICS

First law: ***law of conservation of energy***

- ✓ Energy cannot be created or destroyed, but can be changed from 1 form to another.
- ✓ In an ecosystem, solar energy is converted to *chemical energy* by the process of photosynthesis; some of the chemical energy in the plant is converted to chemical energy in an animal, which in turn can become *mechanical* energy or *heat loss.*

Second law:

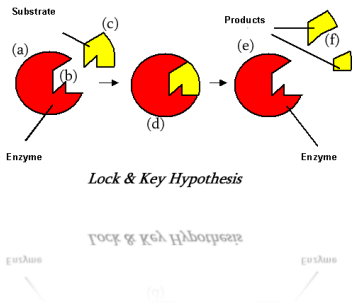
- ✓ Energy cannot be changed from one form into another without a loss of usable energy.
- ✓ Heat is a form of energy that **dissipates into the environment**; heat can never be converted back to another form of energy.

CELLS & ENTROPY

- Every energy transformation makes the universe less organized and more disordered.
- **Entropy:** used to indicate the relative amount of disorganization.
- **Organized**/usable forms of *energy* (in glucose molecule) have relatively low entropy; unorganized/less stable forms have **relatively high entropy**.
- **Energy conversions** result in heat ∴ entropy of universe is always increasing.

FORMS OF ENERGY

- **Energy:** capacity to do *work*; cells continually use *energy* to develop, grow, repair, reproduce, etc.
- **Kinetic energy:** energy of *motion*; **all moving objects have kinetic energy**.
- **Potential energy:** *stored* energy.
- **Food** is **chemical energy**; contains potential energy.
- Chemical energy can be converted into **mechanical energy**, e.g., muscle movement.



Lock & Key Hypothesis

- **Conversion** of energy is never 100% efficient; most lost as heat.
- **Automobiles:** gasoline (chemical energy) is converted to mechanical energy (efficiency 20-30%).
- **Cells:** capable of 40% efficiency; remaining energy converted to heat.

ATP: ENERGY FOR CELLS

- ATP → ADP + P + energy (7.3 kcal per mole).
- 39% of free energy of glucose transformed to ATP, rest lost as heat.
- ATP: **energy carrier** for **many different types of reactions** (common & universal energy currency).
- When ATP is **converted** into ADP + P, energy released is sufficient for biological reactions with little wasted.
- ATP **breakdown** coupled to endergonic reactions minimizes energy loss.

METABOLIC REACTIONS

- **Metabolism:** sum of all biochemical reactions in a cell.
- **Reactants:** substances that participate in a reaction. **Products:** substances that form as a result of a reaction.
- **Free energy:** amount of energy that is free to do work after a chemical reaction.
  - Change in free energy (ΔG) → subtract free energy content of R from P.
  - Negative ΔG → P have less free energy than R; reaction occurs *spontaneously*.
- **Exergonic reactions** → *negative* (ΔG), spontaneous; **energy is released**.
- **Endergonic reactions** → *positive* (ΔG), products have more free energy than reactants; occur only with an input of energy (e.g. protein synthesis, nerve conduction & muscle contraction). Uses ATP released by *exergonic* reactions.

COUPLED REACTIONS

- **Coupled reactions:** occur in same place, at same time, & in a way that an exergonic reaction is used to drive an endergonic reaction. *(diagram)*
- During **muscle contraction**, myosin filaments combine with ATP & actin filaments. ATP breaks down, ADP + P & energy released, resulting in **change in shape of myosin** which pulls actin filaments.