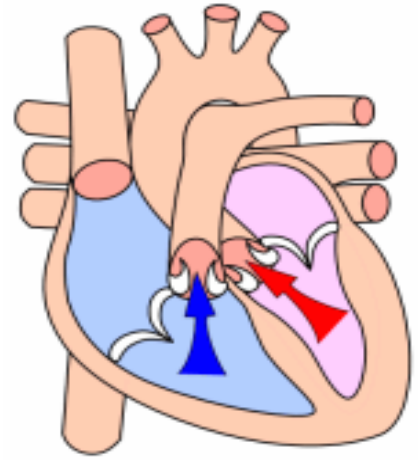

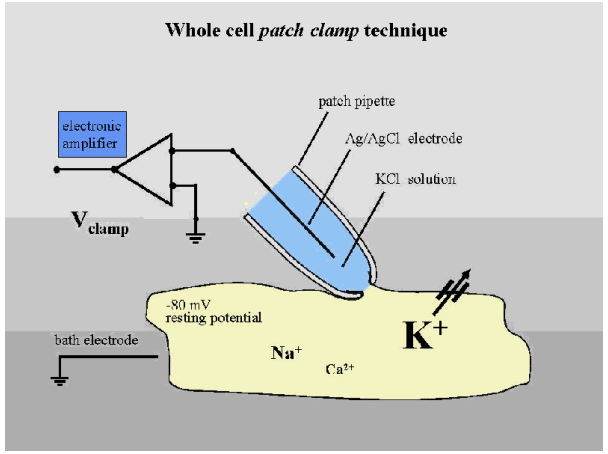

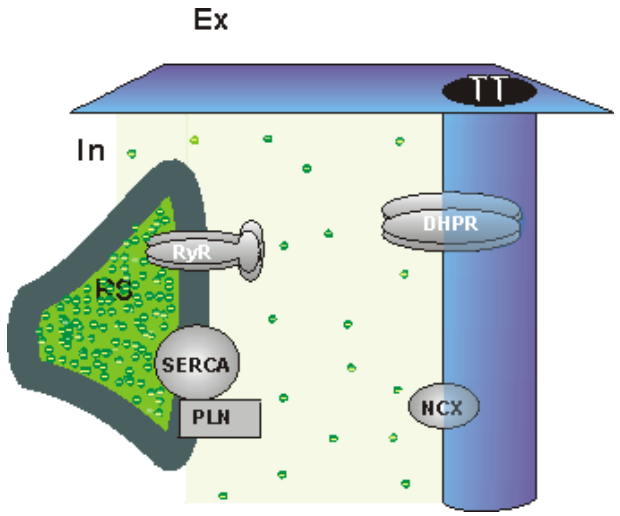

Thermodynamics

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BIOENERGETIC

A+B = C+D

Reactants product

Free energy, the energy in a physical system that can be converted to do work.

- Are you and open or closed system?

- You are an open system, meaning that you exchange both matter and energy with your environment. For instance, you take in chemical energy in the form of food, and do work on your surroundings in the form of moving, talking, walking, and breathing.

- Exchanges of energy that take place in living creatures must follow the laws of physics. In this regard, they are no different from energy transfers in, say, an electrical circuit.

THERMODYNAMICS

- **Thermodynamics** is defined as the branch of science that deals with the relationship between heat and other forms of energy, such as work. It is frequently summarized as three laws that describe restrictions on how different forms of energy can be interconverted.

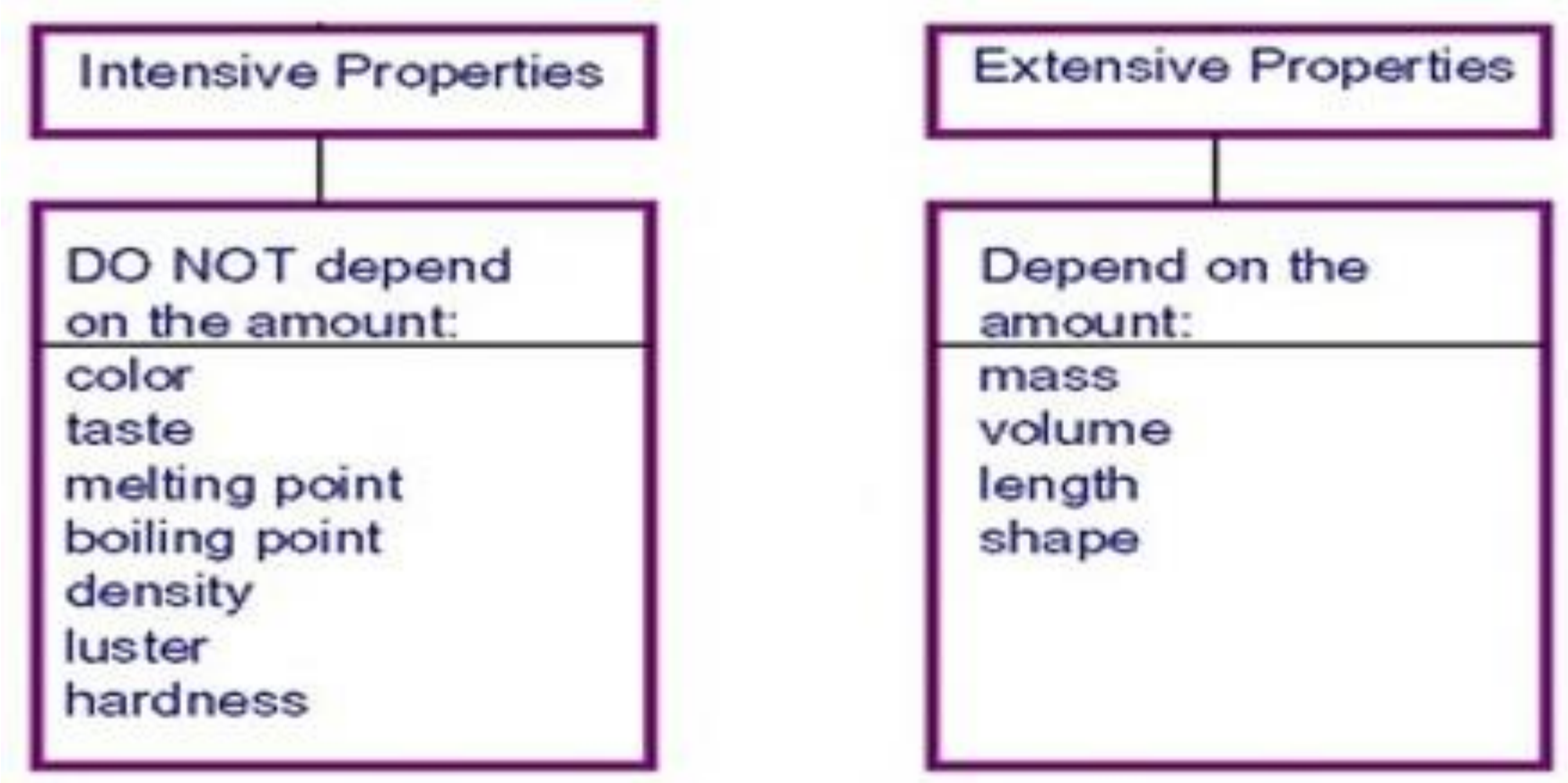
- Release of an energy as a heat (**δQ)**,
- Internal energy changes in the system **(dU)**
- **Work** (**δW**)

$$\delta Q = dU + \delta W$$

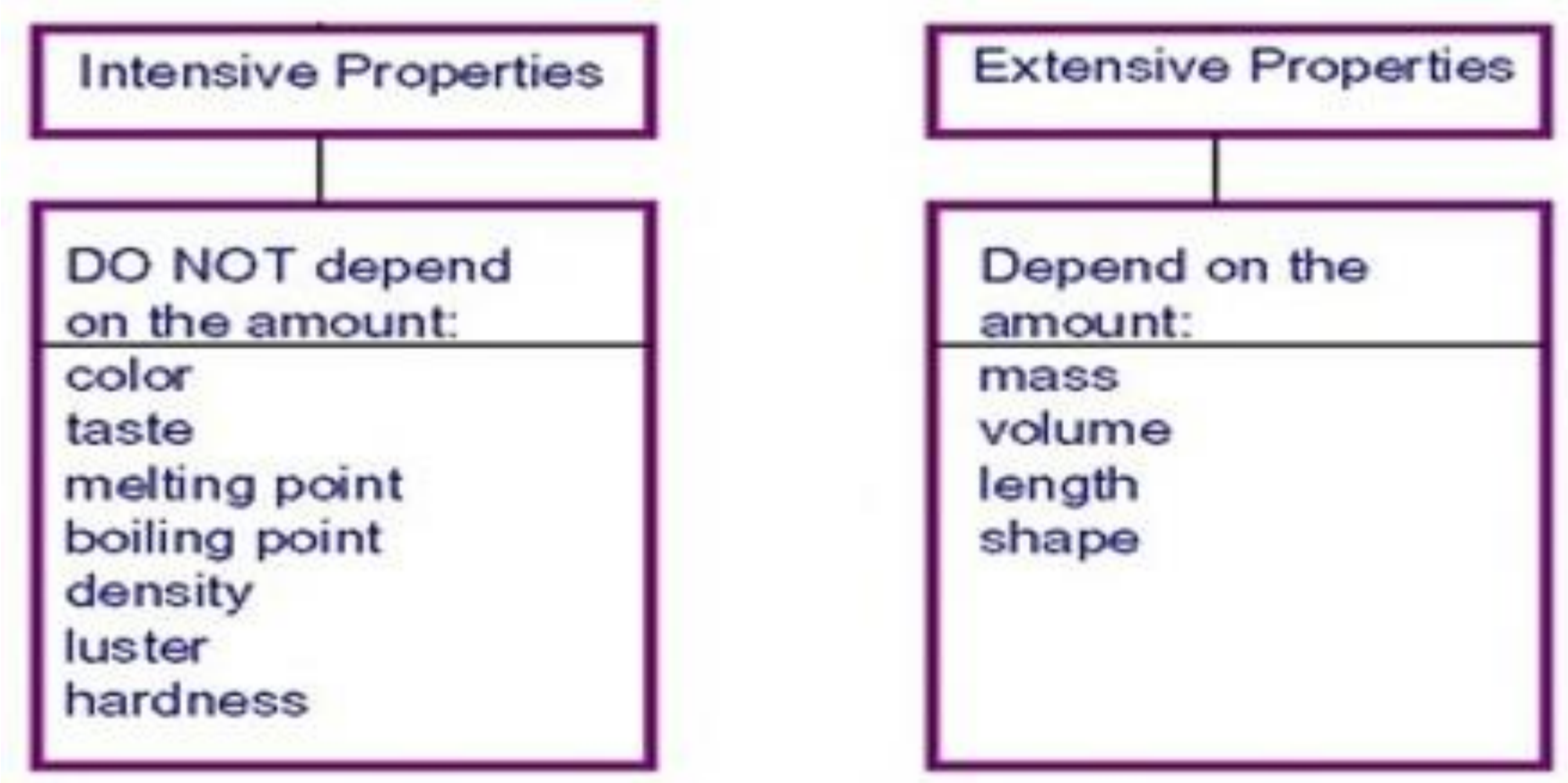
Intensive and extensive thermodynamic properties

- Thermodynamic properties of a system may be classified into two groups:
  1. Intensive properties and
  2. Extensive properties

Intensive and extensive thermodynamic properties



Intensive and extensive thermodynamic properties



The Laws of Thermodynamics

- **Zeroth law :** If two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other. This law helps define the notion of temperature.
- **First law:** Energy is conserved; it can be neither created nor destroyed.
- **Second law:** In an isolated system, natural processes are spontaneous when they lead to an increase in disorder, or **entropy**.

The First Law of Thermodynamics

The First Law of Thermodynamics is often called the *Law of conservation of energy*:

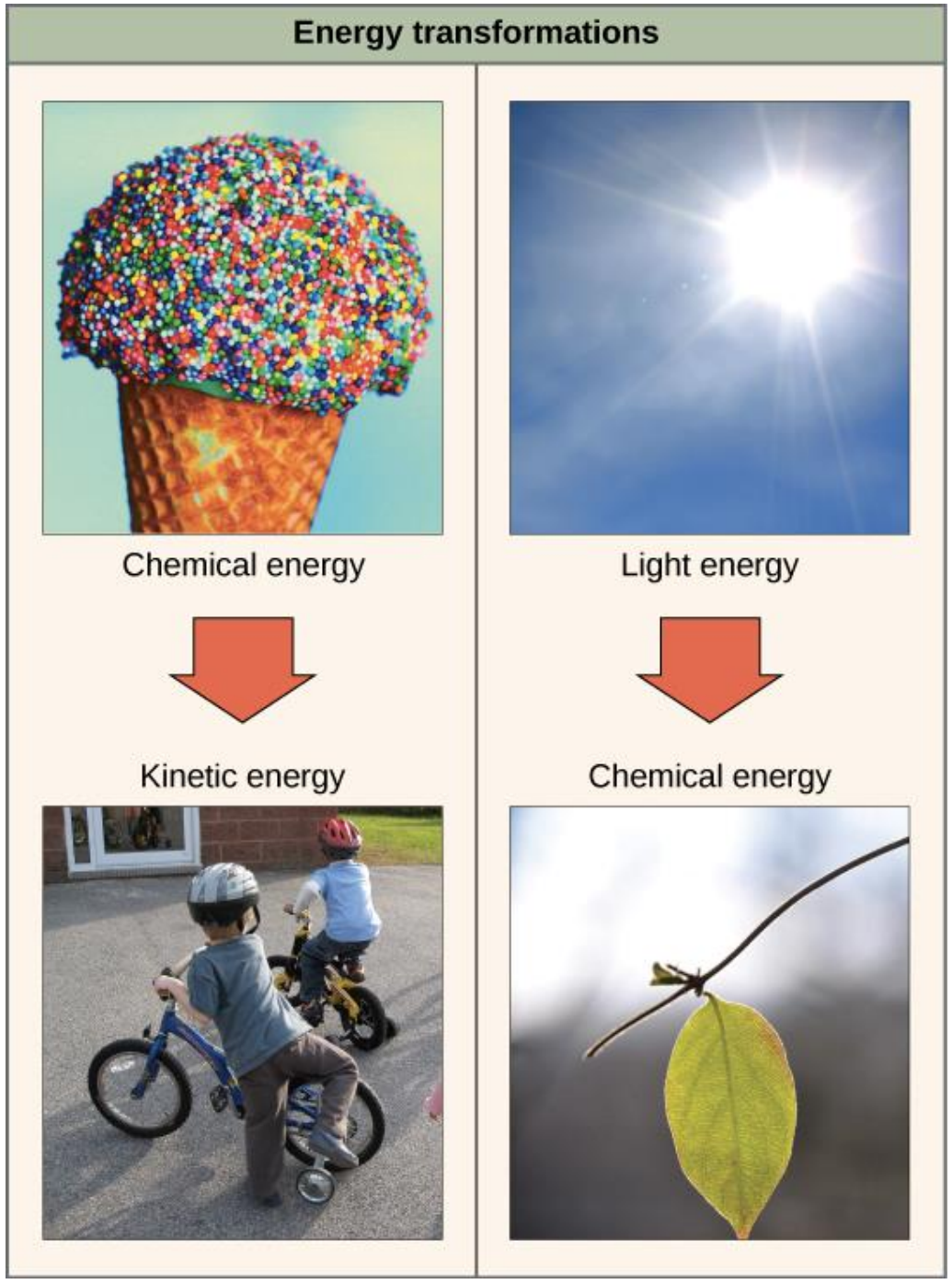
Energy can neither be created nor destroyed but only changed from one form to another.

OR

The energy of the universe is constant.

OR

The energy of a system which is isolated from its surroundings is constant.



Examples for the energy transform

- Light bulbs transform electrical energy into light energy (radiant energy).
- One pool ball hits another, transferring kinetic energy and making the second ball move.
- Plants convert the energy of sunlight (radiant energy) into chemical energy stored in organic molecules.
- You are transforming chemical energy from your last snack into kinetic energy as you walk, breathe, and move your finger to scroll up and down this page.

The First Law of Thermodynamics

- Energy transfer can be done in one of two ways:

1. work *w* can be done on the system by the surroundings (or *vice versa*). It can take the form of mechanical work or of electrical energy transfer.
2. Heat *q* flows from the system to the surroundings (or *vice versa*)

The First Law of Thermodynamics

sign convention

Enthalpy

- Enthalpy *H* is the energy transferred between a system and the surroundings under constant pressure.

δQ=dU+ δW=d(U+PV)

H=U+PV

$$\Delta H = H_f - H_i \ .$$

H_i, Initial states

H_f, final states

The Second Law of Thermodynamics

- Energy cannot be created or destroyed, but it can change from more-useful forms into less-useful forms.

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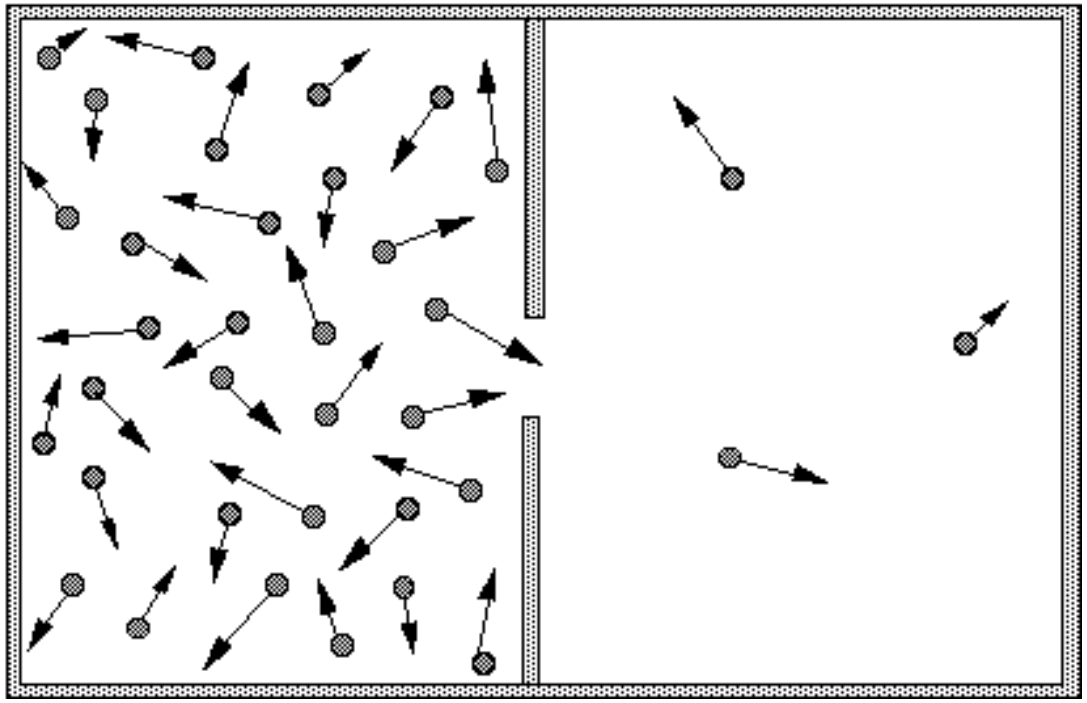
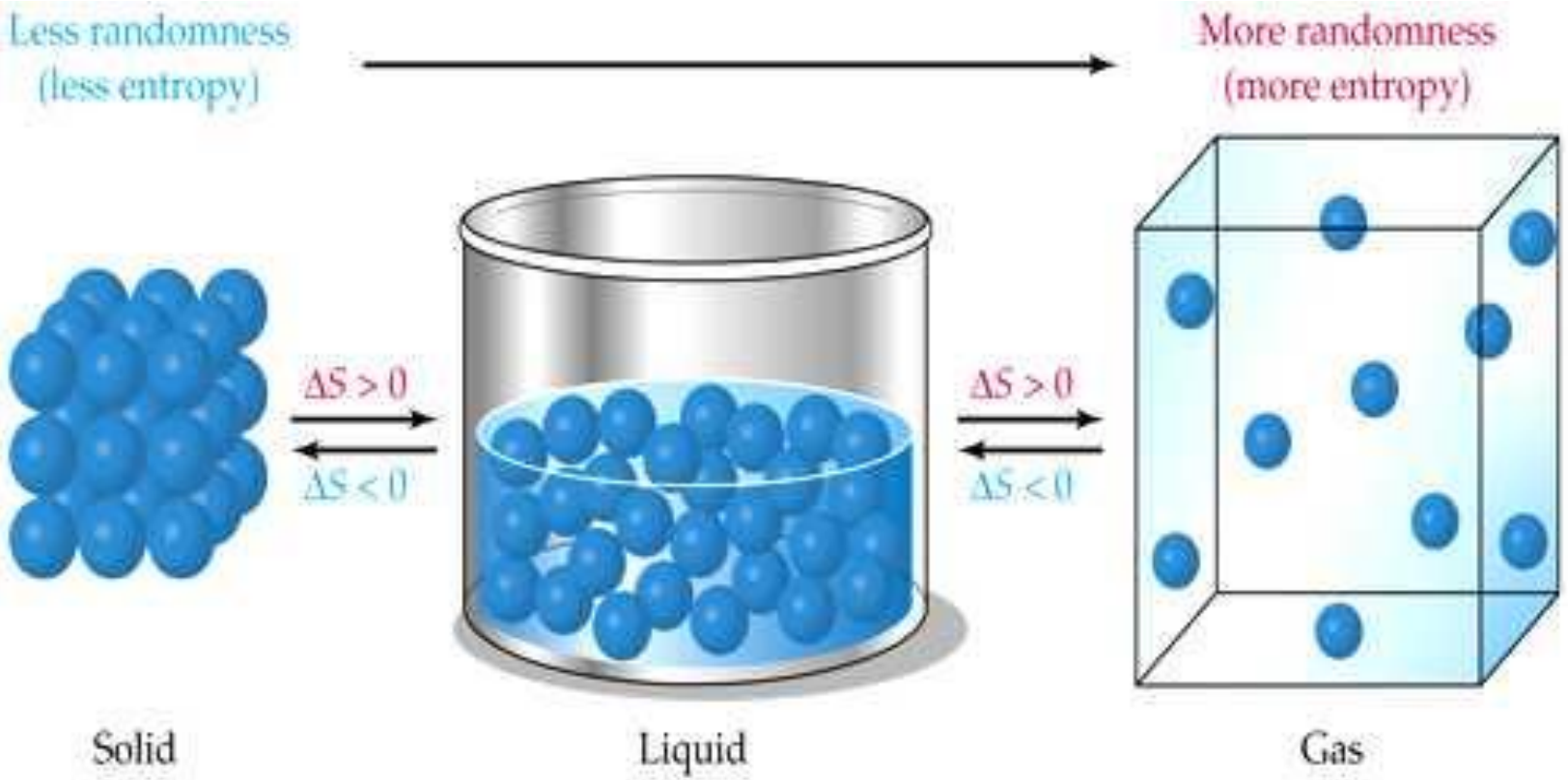
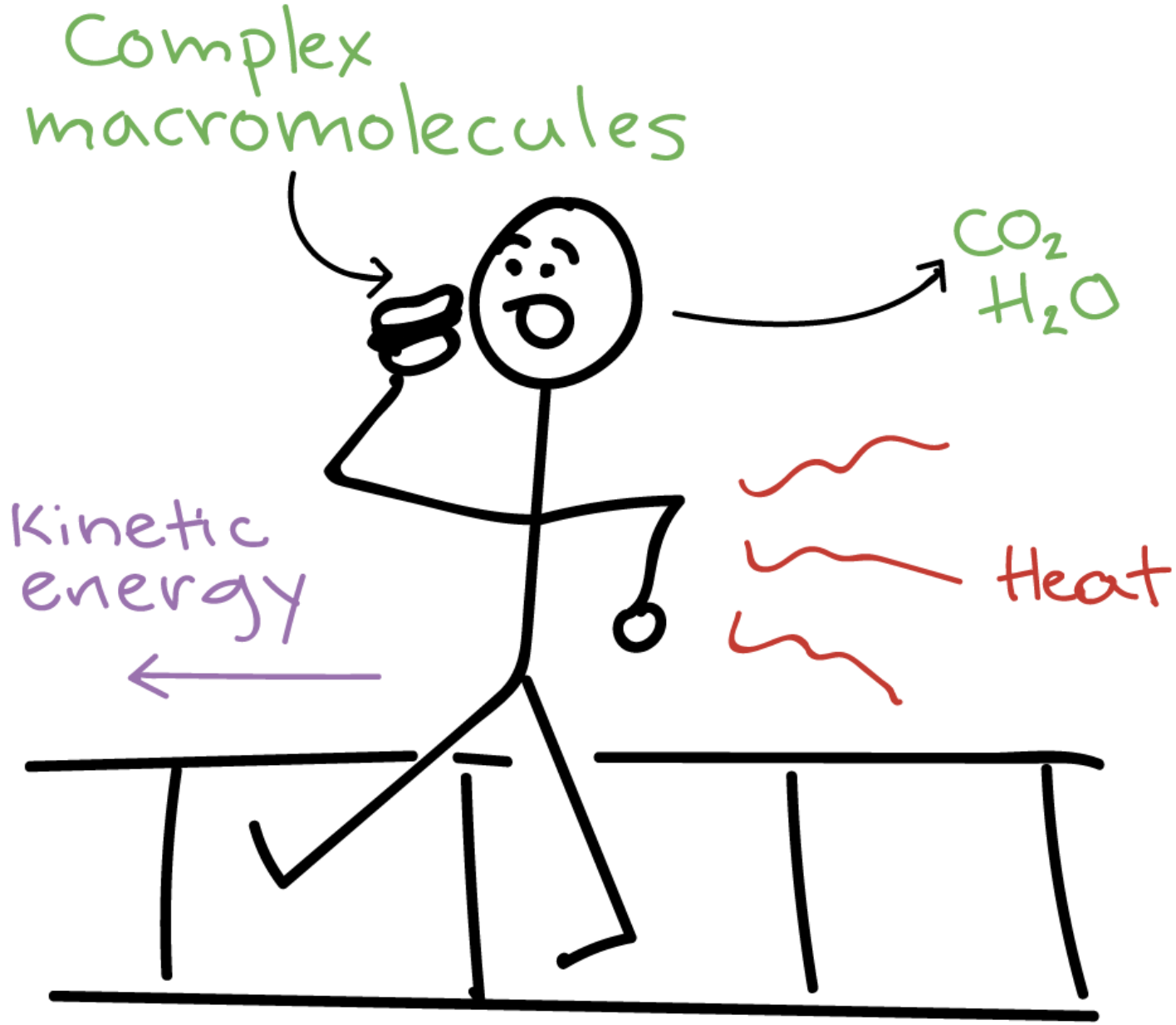




dQ=TdS; S=entropy


Complex macromolecules
CO_2
H_2O
Kinetic energy
Heat