LAWS OF THERMODYNAMICS: FIRST AND SECOND LAW

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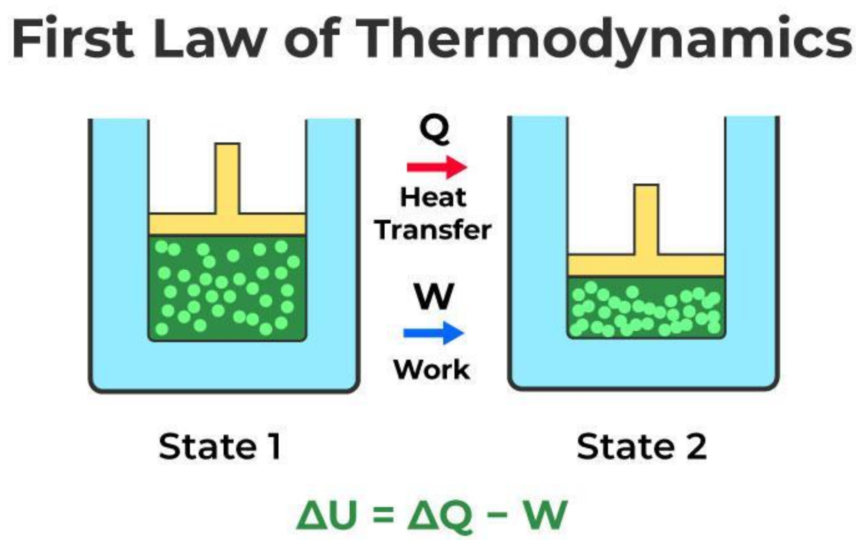
LAWS OF THERMODYNAMICS : FIRST AND SECOND LAW

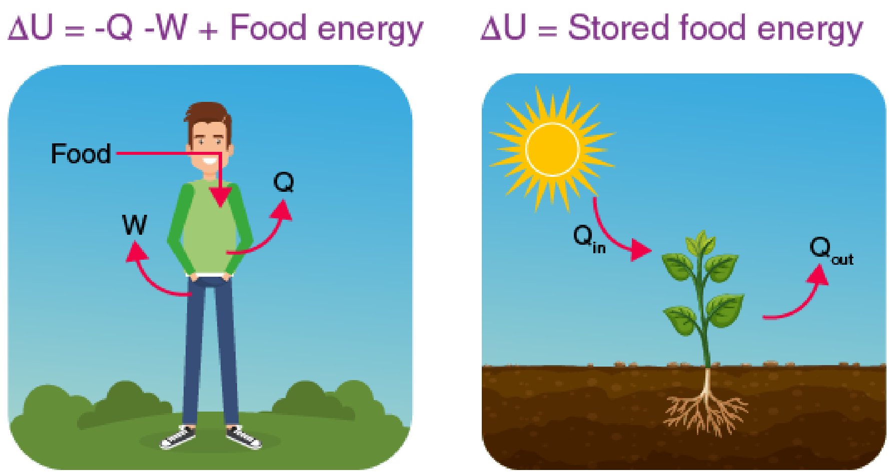
1. **Thermodynamics** refers to the study of energy and energy transfer involving physical matter.
2. The matter and its environment relevant to a particular case of energy transfer are classified as a system, and everything outside of that system is called the surroundings.
3. For instance, when heating a pot of water on the stove, the system includes the stove, the pot, and the water. Energy is transferred within the system (between the stove, pot, and water).
4. There are two types of systems: open and closed. An open system is one in which energy can be transferred between the system and its surroundings. The stovetop system is open because heat can be lost into the air. A closed system is one that cannot transfer energy to its surroundings.
5. Biological organisms are open systems. Energy is exchanged between them and their surroundings, as they consume energy-storing molecules and release energy to the environment by doing work.
6. Like all things in the physical world, energy is subject to the laws of physics. The laws of thermodynamics govern the transfer of energy in and among all systems in the universe.

The First Law of Thermodynamics

1. The first law of thermodynamics deals with the total amount of energy in the universe.
2. According to the first law of thermodynamics, energy may be transferred from place to place or transformed into different forms, but it cannot be created or destroyed
3. The transfers and transformations of energy take place around us all the time.
4. Light bulbs transform electrical energy into light energy. Gas stoves transform chemical energy from natural gas into heat energy.
5. Plants perform one of the most biologically useful energy transformations on earth: that of converting the energy of sunlight into the chemical energy stored within organic molecules
6. The challenge for all living organisms is to obtain energy from their surroundings in forms that they can transfer or transform into usable energy to do work.
7. Living cells have evolved to meet this challenge very well.

8. Chemical energy stored within organic molecules such as sugars and fats is transformed through a series of cellular chemical reactions into energy within molecules of ATP.
9. Energy in ATP molecules is easily accessible to do work.
10. Examples of the types of work that cells need to do include building complex molecules, transporting materials, powering the beating motion of cilia or flagella, contracting muscle fibers to create movement, and reproduction.
11. Shown are two examples of energy being transferred from one system to another and transformed from one form to another. Humans can convert the chemical energy in food, like this ice cream cone, into kinetic energy (the energy of movement to ride a bicycle).
12. Plants can convert electromagnetic radiation (light energy) from the sun into chemical energy.



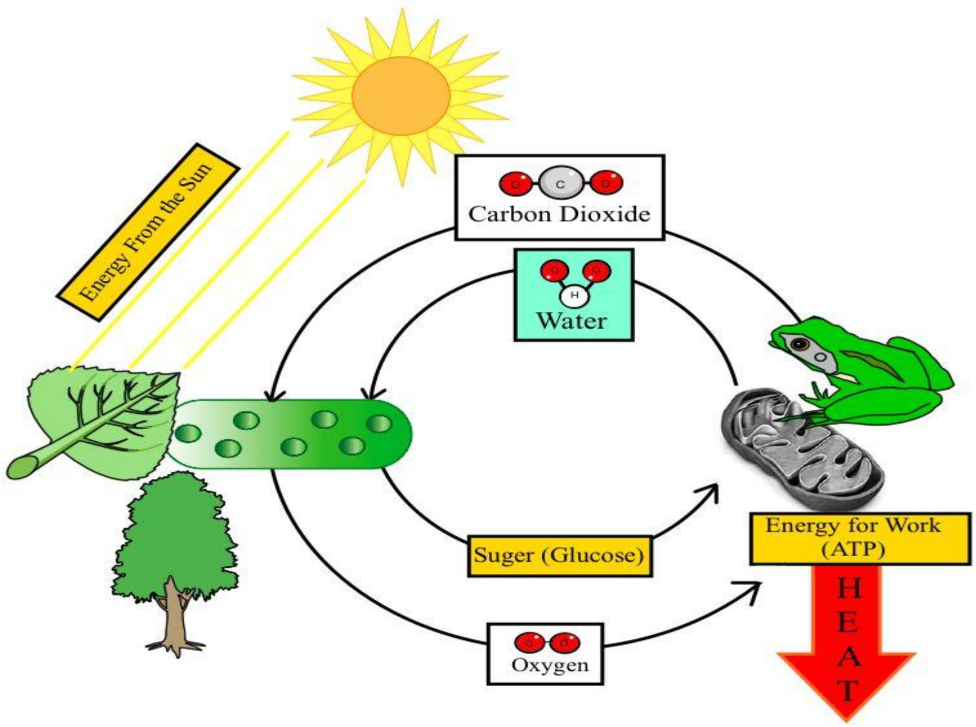


(a) (b)

The Second Law of Thermodynamics

1. A living cell's primary tasks of obtaining, transforming, and using energy to do work may seem simple.
2. However, the second law of thermodynamics explains why these tasks are harder than they appear.
3. along with all energy transfers and transformations in the universe, is completely efficient.
4. In every energy transfer, some amount of energy is lost in a form that is unusable. In most cases, this form is heat energy.
5. Thermodynamically, **heat energy** is defined as the energy transferred from one system to another that is not doing work.
6. For example, when an airplane flies through the air, some of the energy of the flying plane is lost as heat energy due to friction with the surrounding air.
7. This friction actually heats the air by temporarily increasing the speed of air molecules.
8. Likewise, some energy is lost as heat energy during cellular metabolic reactions.
9. This is good for warm-blooded creatures like us, because heat energy helps to maintain our body temperature..
10. An important concept in physical systems is that of order and disorder (also known as randomness).
11. The more energy that is lost by a system to its surroundings, the less ordered and more random the system is. Scientists refer to the measure of randomness or disorder within a system as **entropy**. High entropy means high disorder and low energy

12. To better understand entropy, think of a student's bedroom. If no energy or work were put into it, the room would quickly become messy.
13. It would exist in a very disordered state, one of high entropy. Energy must be put into the system, in the form of the student doing work and putting everything away, in order to bring the room back to a state of cleanliness and order.
14. This state is one of low entropy. Similarly, a car or house must be constantly maintained with work in order to keep it in an ordered state.
15. Left alone, the entropy of the house or car gradually increases through rust and degradation.
16. Molecules and chemical reactions have varying amounts of entropy as well. For example, as chemical reactions reach a state of equilibrium, entropy increases, and as molecules at a high concentration in one place diffuse and spread out, entropy also increases.



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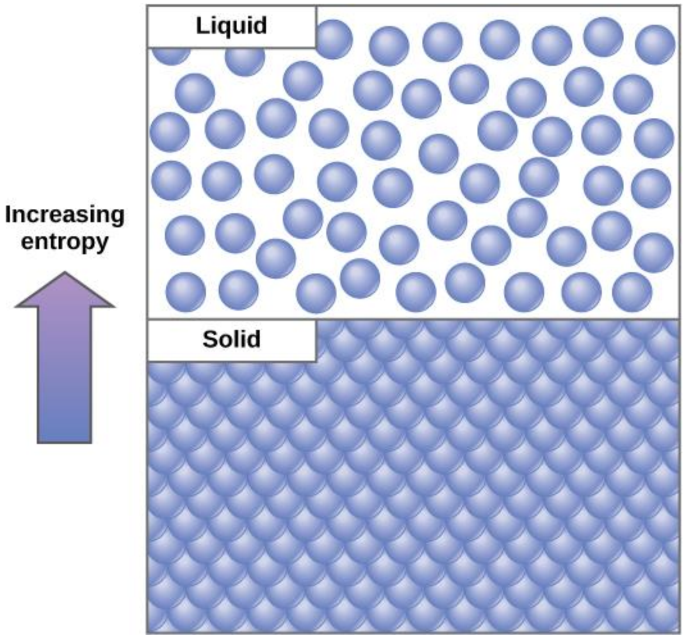
Liquid
Solid
Increasing entropy