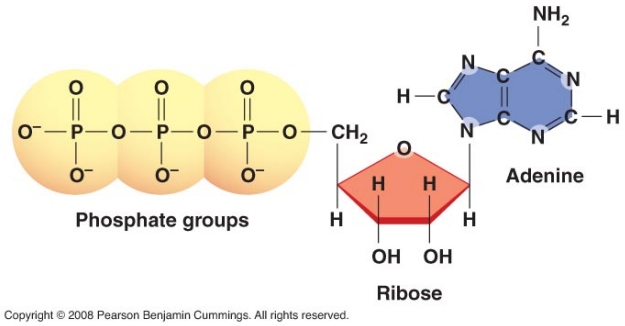
Chapter 5. The Working Cell

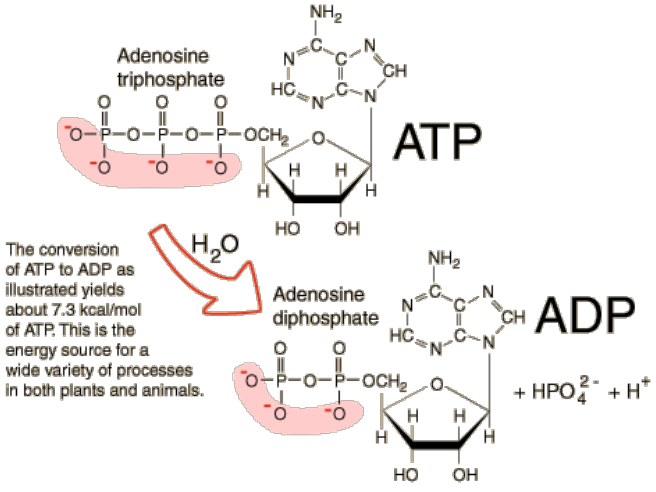
- **Glycolysis(糖酵解)**

  During glycolysis, the energy released from the breakdown of glucose is used to produce molecules of ATP.
- **Energy** is defined as the capacity to cause change.
- **Conservation of Energy**
  Machines and organisms can transform kinetic energy (energy of motion) to potential energy (stored energy) and vice versa. In all such energy transformations, total energy is conserved. Energy cannot be created or destroyed.
- **Heat**
  Every energy conversion releases some randomized energy in the form of heat. Entropy is a measure of disorder, or randomness.
- **Chemical Energy**
  Molecules store varying amounts of potential energy in the arrangement of their atoms. Organic compounds are relatively rich in such chemical energy. The combustion of gasoline within a car's engine and the breakdown of glucose via cellular respiration within living cells are both examples of how the chemical energy stored in molecules can be converted to useful work.
- **Food Calories**
  Food Calories, actually kilocalories, are units used to measure the amount of energy in our foods and the amount of energy we expend in various activities.
- **ATP** (adenosine triphosphate)
  - **Function:** Acts like an energy shuttle, stores and releases energy
  - **Structure**

    (a) ATP consists of three phosphate groups, ribose, and adenine.

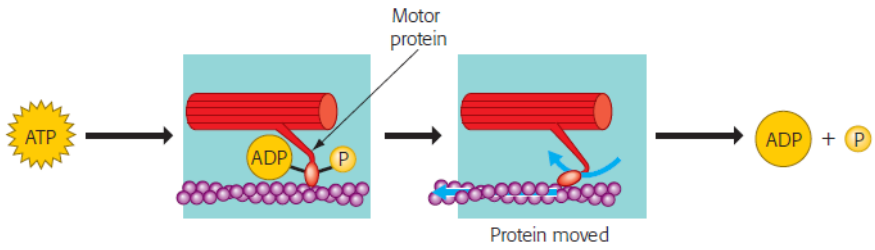
    

  - **ATP to ADP**
    The release of the phosphate at the tip of the triphosphate tail makes energy available to cells.

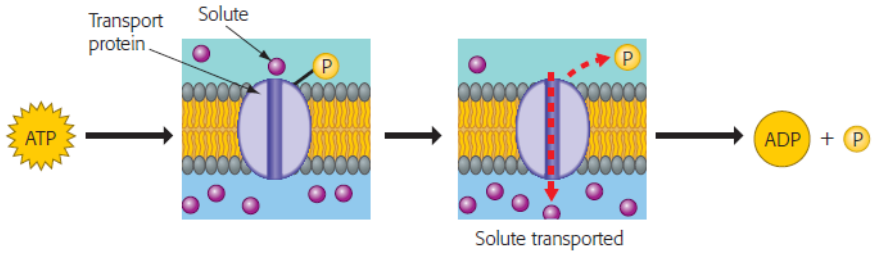
    

- **Phosphate Transfer**
  ATP energizes other molecules in cells by transferring phosphate groups to those molecules.

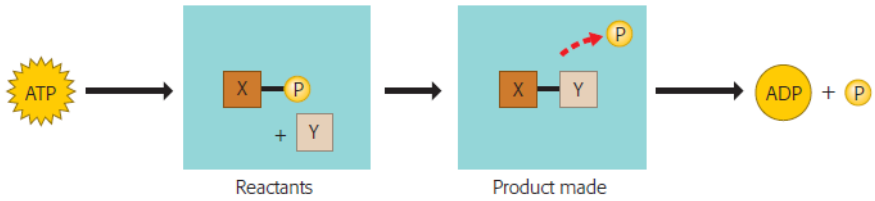
Figure 5.5 How ATP drives cellular work. Each type of work shown here is powered when an enzyme transfers phosphate from ATP to a recipient molecule.



(a) Motor protein performing mechanical work (moving a muscle fiber)



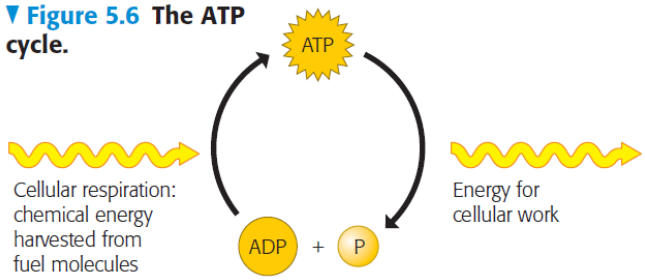
(b) Transport protein performing transport work (importing a solute)



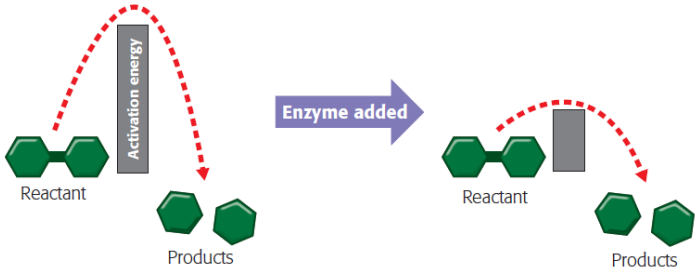
(c) Chemical reactants performing chemical work (promoting a chemical reaction)

- **The ATP Cycle**

Figure 5.6 The ATP cycle.

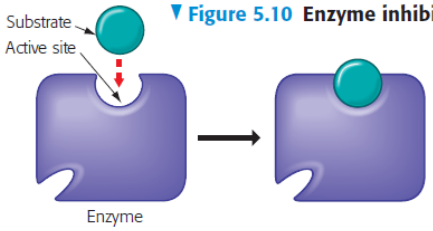


- **Enzyme**
  - **Metabolism** is the total of all chemical reactions in an organism.
  - **Activation Energy**
    Enzymes are biological catalysts that speed up metabolic reactions by lowering the activation energy required to break the bonds of reactant molecules.

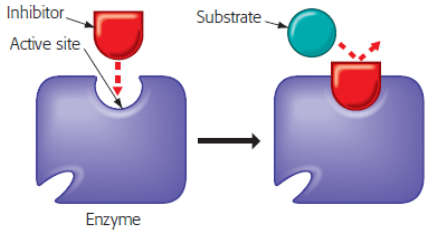


- **Enzyme Activity**
  The entry of a substrate into the active site of an enzyme causes the enzyme to change shape slightly, allowing for a better fit and thereby promoting the interaction of enzyme with substrate.
- **Enzyme Inhibitors**
  Enzyme inhibitors are molecules that can disrupt metabolic reactions by binding to enzymes, either at the active site or elsewhere.

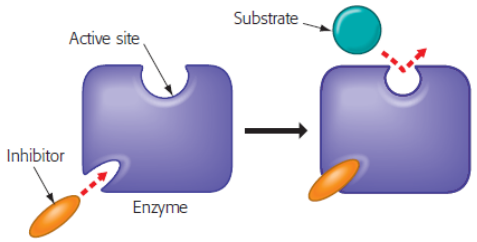
Figure 5.10 Enzyme inhibitors.



(a) Enzyme and substrate binding normally



(b) Enzyme inhibition by a substrate imposter



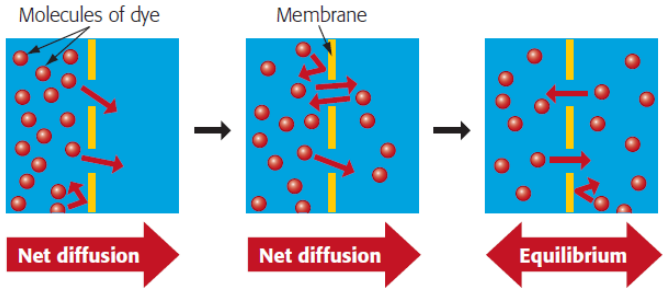
(c) Inhibition of an enzyme by a molecule that causes the active site to change shape

- **Membrane Function**

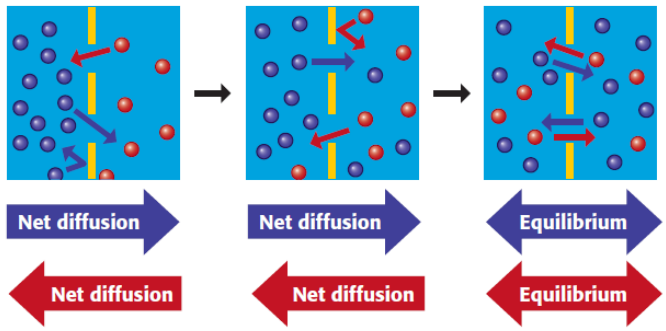
  Proteins embedded in the plasma membrane perform a wide variety of functions, including regulating transport, anchoring to other cells or substances, promoting enzymatic reactions, and recognizing other cells.

  - **Passive Transport**: Diffusion across Membranes
    - **Diffusion** is the movement of molecules spreading out evenly into the available space, from a region where the molecules are more concentrated to a region where they are less concentrated (**concentration gradient**).
    - **Passive transport**—*passive* because the cell does not expend any energy for the diffusion to happen (*cell membrane is selectively permeable*).

▼ Figure 5.12 Passive transport: diffusion across a membrane. A substance will diffuse from where it is more concentrated to where it is less concentrated. Put another way, a substance tends to diffuse down its concentration gradient.



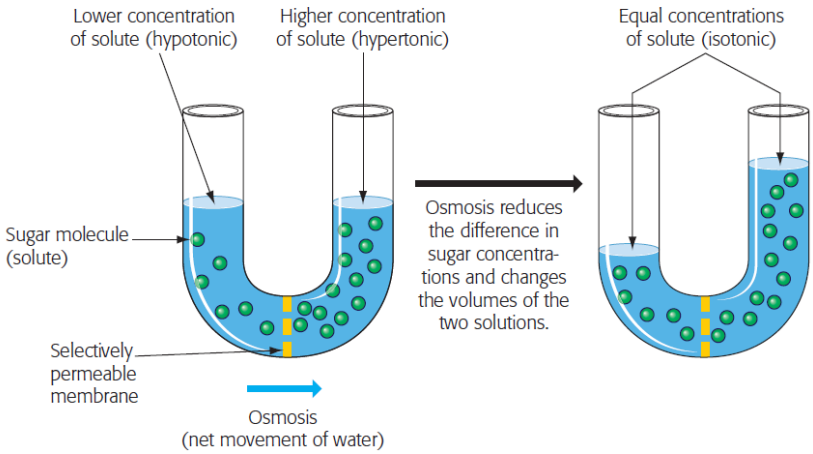
(a) Passive transport of one type of molecule. The membrane is permeable to these dye molecules, which diffuse down the concentration gradient. At equilibrium, the molecules are still restless, but the rate of transport is equal in both directions.



(b) Passive transport of two types of molecules. If solutions have two or more solutes, each will diffuse down its own concentration gradient.

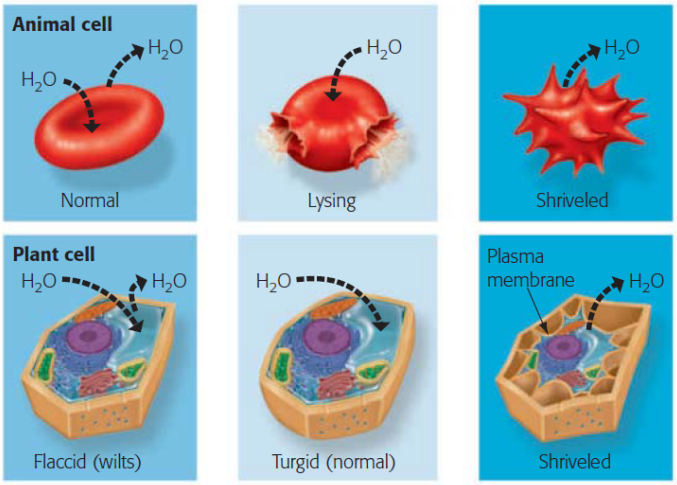
- Substances that do not cross membranes spontaneously—or otherwise cross very slowly—can be transported via proteins that act as corridors for specific molecules. This assisted transport is called **facilitated diffusion** (no energy needed).
- **Osmosis** (渗透) **and Water Balance**
  - ✧ The diffusion of water across a selectively permeable membrane is **osmosis**.
  - ✧ A **hypertonic** solution has a higher concentration of solute,
    A **hypotonic** solution has a lower concentration of solute, and
    An **isotonic** solution has an equal concentration of solute

▼ Figure 5.13 Osmosis. A membrane separates two solutions with different sugar concentrations. Water molecules can pass through the membrane, but sugar molecules cannot.



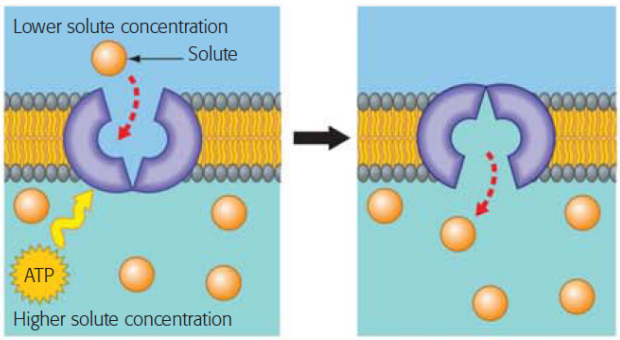
  - ✧ **Water Balance in Animal Cells and Plant Cells**
    For an animal to survive a hypotonic or hypertonic environment, the animal must have a way to

balance the uptake and loss of water. The control of water balance is called **osmoregulation**.



(a) Isotonic solution **(b) Hypotonic solution** **(c) Hypertonic solution**

- **Active Transport:** The Pumping of Molecules across Membranes
  - ✧ **Active transport** requires that a cell expend energy (ATP) to move molecules across a membrane.
  - ✧ **Active transport** allows cells to maintain internal concentrations of small solutes that differ from environmental concentrations.



▲ **Figure 5.16 Active transport.** Transport proteins are specific in their recognition of atoms or molecules. This transport protein (purple) has a binding site that accepts only a certain solute. Using energy from ATP, the protein pumps the solute against its concentration gradient.

- **Exocytosis and Endocytosis: Traffic of Large Molecules**

  Exocytosis is the secretion of large molecules within vesicles. **Endocytosis** is the import of large substances via vesicles into the cell.