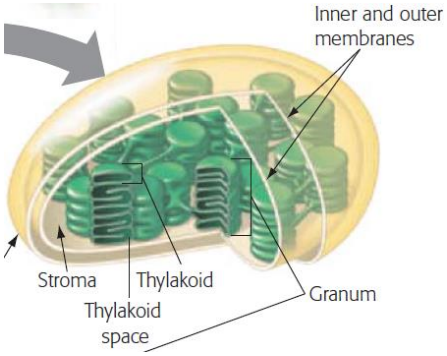
Chapter 7. Photosynthesis: Using Light to Make Food

- **Biofuels:** Bioethanol (生物乙醇); Cellulosic ethanol (纤维素乙醇); Biodiesel (生物柴油)
- **Photo-autotrophs** (光合自养生物) are the producers for most ecosystems(生态系统).
- **The Basics of Photosynthesis**

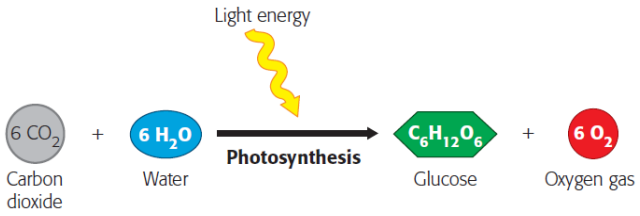
  Photosynthesis is a process whereby light energy is transformed into chemical energy stored as bonds in sugars made from carbon dioxide and water.

  - **Chloroplasts** (叶绿体): Sites of Photosynthesis

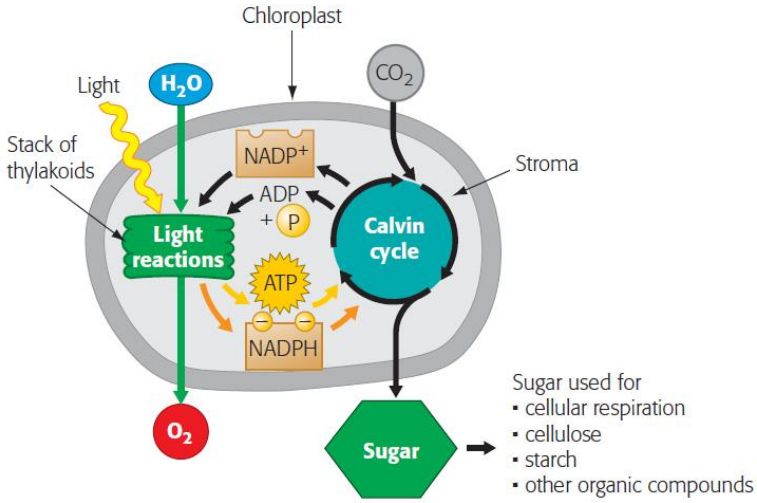
    Chloroplasts contain a thick fluid called stroma (基质) surrounding a network of membranes called thylakoids (类囊体). The thylakoids are concentrated in stacks called grana (基粒) (singular, granum).



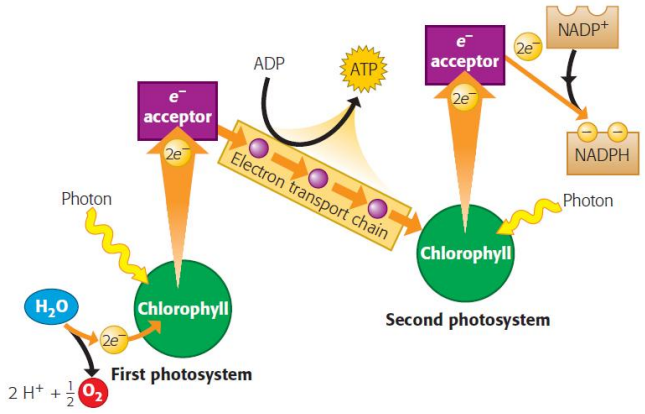
  - Energy Transformation: An Overview of Photosynthesis



  - The overall process of photosynthesis can be divided into two stages connected by energy-and electron-carrying molecules:
    - ✧ In the **light reactions**, chlorophyll (叶绿素) in the thylakoid membranes absorbs solar energy, which is then converted to the chemical energy of ATP and NADPH, and water is split, providing a source of electrons and giving off O_2 gas as a by-product.
    - ✧ The **Calvin cycle**, **ATP** generated by the light reactions provides the energy for sugar synthesis (from CO_2). The **NADPH** produced by the light reactions provides the high-energy electrons that drive the synthesis of glucose from carbon dioxide.
    - ✧ Thus, the Calvin cycle indirectly depends on light to produce sugar because it requires the supply of ATP and NADPH produced by the light reactions.



- **The Light Reactions: Converting Solar Energy to Chemical Energy**
  - **The Nature of Sunlight**
    Visible light is part of the spectrum of electromagnetic energy. It travels through space as waves. Different wavelengths of light appear as different colors; shorter wavelengths carry more energy.
  - **Chloroplast Pigments**
    Pigment molecules absorb light energy of certain wavelengths and reflect other wavelengths. We see the reflected wavelengths as the color of the pigment. Several chloroplast pigments absorb light of various wavelengths and convey it to other pigments, but it is the green pigment chlorophyll a that participates directly in the light reactions.
  - **How Photosystems Harvest Light Energy and How the Light Reactions Generate ATP and NADPH**
    1. Photons excite electrons in the chlorophyll of the first photosystem. These photons are then trapped by the primary electron acceptor. This photosystem then replaces the lost electrons by extracting new ones from water. This is the step that releases O2 during photosynthesis.
    2. Energized electrons from the first photosystem pass down an electron transport chain to the second photosystem. The chloroplast uses the energy released by this electron "fall" to make ATP.
    3. The second photosystem transfers its light- excited electrons to NADP+, reducing it to NADPH.



- **The Calvin Cycle: Making Sugar from Carbon Dioxide**
  Within the stroma (fluid) of the chloroplast, carbon dioxide from the air and ATP and NADPH produced during the light reactions are used to produce G3P, an energy-rich sugar molecule that can be used to make glucose and other organic molecules.

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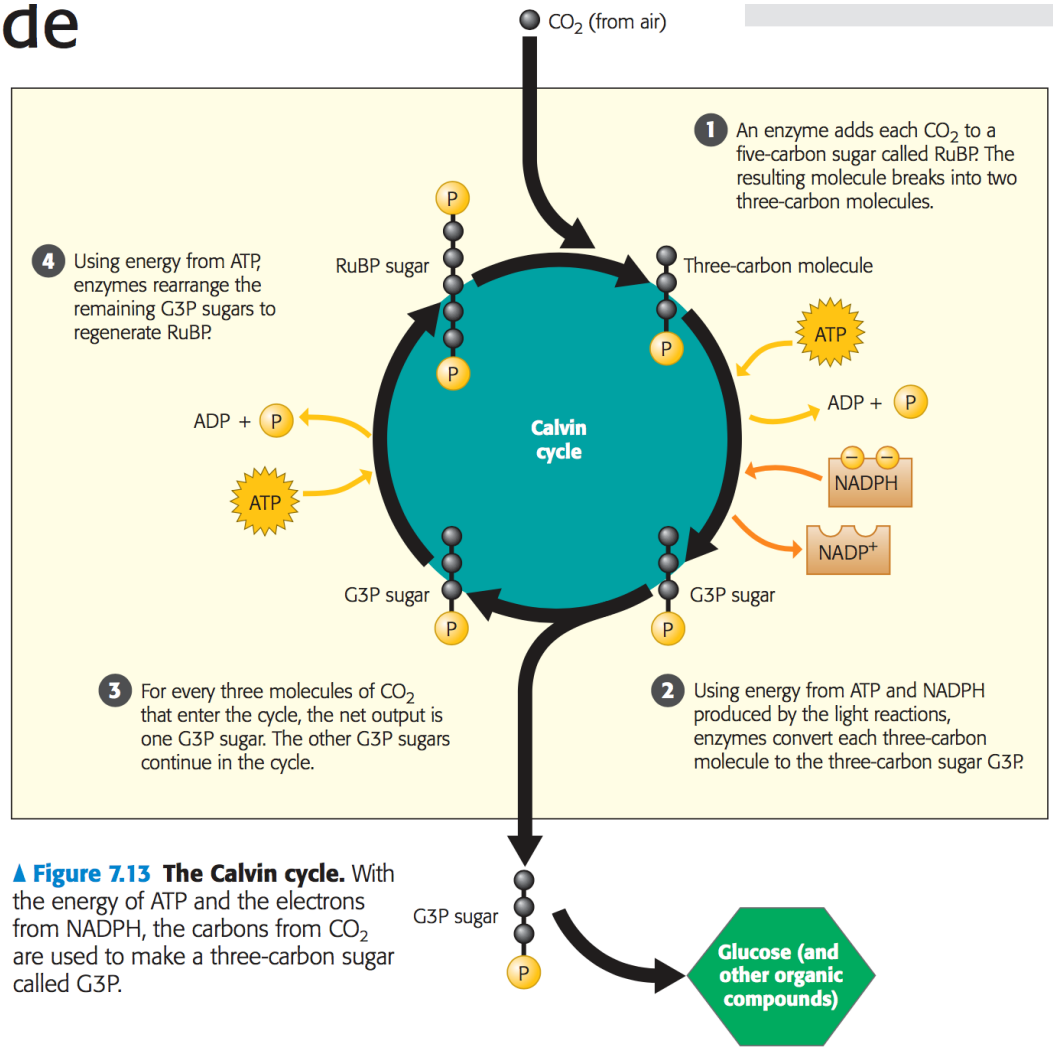

▲ Figure 7.13 The Calvin cycle. With the energy of ATP and the electrons from NADPH, the carbons from CO_2 are used to make a three-carbon sugar called G3P.