THE BASICS OF PHOTOSYNTHESIS

- **Photosynthesis**
  - is used by plants, algae (protists), and some bacteria,
  - transforms light energy into chemical energy, and
  - uses carbon dioxide and water as starting materials.
- The chemical energy produced via photosynthesis is stored in the bonds of sugar molecules.
- Organisms that use photosynthesis are
  - photosynthetic autotrophs and
  - the producers for most ecosystems.

Chloroplasts: Sites of Photosynthesis

- **Chloroplasts** are
  - the site of photosynthesis and
  - found mostly in the interior cells of leaves.
- Inside chloroplasts are interconnected, membranous sacs called **thylakoids,** which are suspended in a thick fluid called **stroma**.
- Thylakoids are concentrated in stacks called **grana**.

- The green color of chloroplasts is from **chlorophyll**, a light-absorbing pigment that plays a central role in converting solar energy to chemical energy.
- **Stomata** are tiny pores in leaves where
  - carbon dioxide enters and
  - oxygen exits.

The Simplified Equation for Photosynthesis

- In the overall equation for photosynthesis, notice that the reactants of photosynthesis are the waste products of cellular respiration.
- In photosynthesis,
  - sunlight provides the energy,
  - electrons are boosted "uphill" and added to carbon dioxide, and
  - sugar is produced.
- During photosynthesis, water is split into
  - hydrogen and
  - oxygen.
- Hydrogen is transferred along with electrons and added to carbon dioxide to produce sugar.
- Oxygen escapes through stomata into the atmosphere.

A Photosynthesis Road Map

- Photosynthesis occurs in two multistep stages:
  - the **light reactions** convert solar energy to chemical energy and
  - the **Calvin cycle** uses the products of the light reactions to make sugar from carbon dioxide.
- The initial incorporation of carbon from the atmosphere into organic compounds is called **carbon fixation**.
  - This lowers the amount of carbon in the air.

- Deforestation reduces the ability of the biosphere to absorb carbon by reducing the amount of photosynthetic plant life.

THE LIGHT REACTIONS: CONVERTING SOLAR ENERGY TO CHEMICAL ENERGY

- Chloroplasts
  - are chemical factories powered by the sun and
  - convert sunlight into chemical energy.

The Nature of Sunlight

- Sunlight is a type of energy called radiation, or electromagnetic energy.
- The distance between the crests of two adjacent waves is called a **wavelength**.
- The full range of radiation is called the **electromagnetic spectrum**.

Chloroplast Pigments

- Chloroplasts contain several pigments:
  - **Chlorophyll a**
    - absorbs mainly blue-violet and red light and
    - participates directly in the light reactions.
  - **Chlorophyll b**
    - absorbs mainly blue and orange light and
    - participates indirectly in the light reactions.
- Carotenoids
  - absorb mainly blue-green light,
  - participate indirectly in the light reactions, and
  - absorb and dissipate excessive light energy that might damage chlorophyll.
- The spectacular colors of fall foliage are due partly to the yellow-orange light reflected from carotenoids.

How Photosystems Harvest Light Energy

- Light behaves as **photons**, a fixed quantity of light energy.
- Chlorophyll molecules absorb photons.
  - Electrons in the pigment gain energy.
  - As the electrons fall back to their ground state, energy is released as heat or light.
- In the thylakoid membrane, chlorophyll molecules are organized with other molecules into photosystems.
- A **photosystem** is a cluster of a few hundred pigment molecules that function as a light-gathering antenna.
- The **reaction center** of the photosystem consists of chlorophyll *a* molecules that sit next to another molecule called a **primary electron acceptor**, which traps the light-excited electron from chlorophyll *a*.
- Another team of molecules built into the thylakoid membrane then uses that trapped energy to make
  - ATP and
  - NADPH.

How the Light Reactions Generate ATP and NADPH

- Two types of photosystems cooperate in the light reactions:
  - the water-splitting photosystem and
  - the NADPH-producing photosystem.
- The light reactions are located in the thylakoid membrane.
- An electron transport chain
  - connects the two photosystems and
  - releases energy that the chloroplast uses to make ATP.

THE CALVIN CYCLE: MAKING SUGAR FROM CARBON DIOXIDE

- The Calvin cycle
  - functions like a sugar factory within a chloroplast and
  - regenerates the starting material with each turn.
- Sugars are produced through four main steps in the Calvin cycle:
  - Carbon fixation combines CO_2 with RuBP;
  - ATP and NADPH are used to energize the carbon chains, producing G3P
  - Some G3P can exit the cycle, to produce anything in the plant;
  - Some G3P are reconfigured to produce RuBP, and the cycle can start again.