Photosynthesis/Respiration

**Photosynthesis:**
- Plants use carbon dioxide and produce starch and oxygen
  \[ H_2O + CO_2 = \text{Starch/sugar} + O_2 \]

**Respiration**
- Animals use starch/sugar and oxygen, and produce carbon dioxide
  \[ \text{Starch/sugar} + O_2 = H_2O + CO_2 \]

Photosynthesis

- The synthesis of organic compounds (sugars) from simple inorganic compounds (CO₂ and H₂O) in the presence of chlorophyll using light energy from the sun.
  - General Formula for PS
  - The Organs of Photosynthesis - Leaves and Chloroplasts
  - Chloroplast Structure and Photosynthesis
    - The Light Dependent Reactions
    - The Light Independent Reactions (Dark Reactions)
    - Coupling the Light and Dark Reactions
  - Photosynthetic Pigments and the Electromagnetic Energy Spectrum
Figure 35.17 Leaf anatomy

Guard cells open and close stomata, regulating intake of CO\(_2\), and loss of water and O\(_2\) by the plant.

An open (left) and closed (right) stoma of a spider plant (Chlorophytum colossum) leaf. When guard cells are turgid, the stoma is open (left). Notice the chloroplasts in the guard cells, the only epidermal cells that photosynthesize.

\[6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Sunlight} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2\]
The production of NADPH and ATP
Figure 10.12 Excited electrons are the key to photosynthesis.

Light Reactions

- Light boosts energy of electrons in Photosystem II, high energy electrons passed along chain of carriers
- Electrons replaced by splitting water
- Passage of electrons down chain releases energy used to generate ATP
- Chain ends in Photosystem I, electron energy boosted again, passed on to NADPH
- ATP, NADPH produced by light reactions provide energy to power Calvin Cycle
Figure 10.17 The thylakoid membrane.
The production of Sugar

The ATP and NADPH are used to make the sugar

Three Phases
1. CO₂ fixation-Rubisco
2. Reduction of PGA via NADPH electrons to G3P
3. Regeneration of RuBP

For 1 G3P: used 9 ATP and 6 NADPH

Rubisco

• The key enzyme in the Calvin Cycle or “C3 pathway”
• World’s most abundant enzyme!
• Contains lots of Nitrogen
• Catalyzes two competing and opposite reactions (photorespiration - we’ll get to this later)
Calvin Cycle

• Begins with Rubisco catalyzing reaction of 3 CO\(_2\) and 3 RuBP to form 6 3-carbon compounds
• Energy from ATP and NADPH is used to re-arrange 3-carbon compound into higher energy G3P
• G3P used to build glucose, other organic molecules
• Cyclic process: one G3P (of 6) released each pass through cycle, rest (5) regenerate (3) RuBP
Other ways to get to the CO$_2$ C$_4$ and CAM

C$_4$- adaptation to hot environments
- Carbon goes into 4-carbon molecule before Calvin.
- Two different PLACES
- Use 4-carbon as reservoir
- Ex. Sugarcane, Corn, grass

CAM- adaptation to hot and dry environments
- Carbon goes into 4-carbon molecule before Calvin.
- Two different TIMES, night and day
- Use 4-carbon as reservoir
- Ex. Pineapple, cacti, succulents