Photosynthesis Rap VIDEO:

http://www.youtube.com/watch?v=Wi60tQa8jfE
Photosynthesis and Respiration in Plants

**Photosynthesis:** The process in which plants use CO$_2$, sunlight, and H$_2$O to produce sugars and Oxygen.
Photosynthesis and Respiration in Plants

Respiration: The process in which plants use the sugars produced by photosynthesis to create ATP.
Photosynthesis and Respiration in Plants

- **ATP**: The universal energy source, which all living things use to do work.
Photosynthesis

$6\text{CO}_2 + 12\text{H}_2\text{O} + \text{Light} = \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}$

**Input:**
- Sunlight
- $\text{CO}_2$ (Carbon Dioxide)
- $\text{H}_2\text{O}$ (Water)

**Output:**
- $\text{C}_6\text{H}_{12}\text{O}_6$ (Glucose)
- $\text{O}_2$ (Oxygen)
- $\text{H}_2\text{O}$ (Water)


2011 Science Education Resource Center, San Jose State University
Respiration

\[ C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + \text{energy} \]

**Input:**
- \( C_6H_{12}O_2 \)
- \( O_2 \)

**Output:**
- ATP
- CO\(_2\)
- H\(_2\)O


2011 Science Education Resource Center, San Jose State University
Where does photosynthesis take place?

Light-dependent Reaction

![Diagram of the light-dependent reaction](http://kevindmcmathon.com/Reseda/apbiology/AP%20Bio%20Lectures/Photosynthesis/Light_dependent_Rx.jpg)
2 Stages of Photosynthesis

1. Light-dependent Reaction

2. Light-independent Reaction
   (Calvin Cycle)
“Dark” Cycle

- It does NOT happen at night!
- It is **light-independent** (does not require photons).

- It requires ATP, NADPH and CO₂ to synthesize glucose (sugar) or other carbohydrates.

- Energy generated to “fix” carbon comes from these molecules generated from light reaction.
Light Independent Reaction

**Calvin Cycle**

- Carbon “fixed” by using RuBP (Ribulose bisphosphate) and RuBisCO
- **Fixed**: Convert C in the gaseous form (CO$_2$) into a solid structure using the energy created by ATP and NADPH

http://www.sciencegeek.net/Biology/review/U2PhotoFillin.htm
http://www.biotopics.co.uk/a2/light-independent_reactions.html
RuBisCO

- Crucial for carbon fixation
- Create organic carbon from inorganic carbon in the atmosphere
- Most abundant protein on earth because it is slow
- fixes three \( \text{CO}_2 \) molecules per second instead of 1,000

Temperature Affects RuBisCO

- **PROBLEM:** Rubisco binds with oxygen
  - attaches oxygen to the sugar chain, forming a faulty oxygenated product. The plant cell must then perform a costly series of salvage reactions to correct the mistake.

- **At HIGH temperatures:** the oxygenating reaction of RuBisCO increases more than the carboxylating one.

- **At LOW temperatures:** slows molecular motion, i.e. molecular collisions, which decrease enzyme activity.
For every 6 molecules of CO₂ entering the cycle, 12 molecules of G3P and 1 molecule of Glucose are produced.

The reaction occurs in a cycle.

- Fixation of carbon dioxide
- Reduction of 3-phosphoglycerate to G3P
- Regeneration of RuBP from G3P

Carbons are symbolized as red balls to help you follow them through the cycle.

- 3 CO₂
- 6 ATP
- 6 NADPH
- 5 G3P
- 1 G3P

Carbon atoms are transferred from CO₂ to G3P.

Figure 10-20b Biological Science, 2/e
http://www.uic.edu/classes/bios/bios100/f06pmlect08.htm
1. Carbon dioxide reacts with *ribulose bisphosphate* (RuBP), \( \text{P-C-C-C-C-C-P} \)

2. This occurs under the influence of the enzyme *ribulose bisphosphate carboxylase* (RuBisCO)
   - RuBisCO: the most abundant protein on the planet.

3. RuBP has 5 C atoms and 2 phosphate groups, and by accepting one more carbon atom from \( \text{CO}_2 \) it should be converted into a 6 carbon, 2 phosphate compound. However ...
(2) Carbon Dioxide Reduction

- This compound is immediately converted into 2 molecules of glycerate 3-phosphate (GP, G3P, or PGAL), C-C-C-P

- Since PGAL is at a HIGHER energy state than RuBP, the reduced NADP and ATP provide the reducing power (H and Pi) for energy.

- Two out of the twelve PGAL molecules are removed from the cycle, to be converted into glucose, or other molecules such as starch, lipid or protein.
(3) RuBP Regeneration

1. In a complex series of reactions, the remaining ten molecules of G3P are converted into 6 molecules of the 5-carbon compound **ribulose monophosphate**, \(\text{C-C-C-C-C-P}\)

2. Ribulose monophosphate is converted into RuBP, using a phosphate group from ATP.

3. RuBP reacts with carbon dioxide (becomes carboxylated), to keep the cycle operating again.
Conclusion
PHOTOSYNTHESIS

\[ 6\text{H}_2\text{O} + 6\text{CO}_2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \]
DEMOLUM

Go Green to Grow Green

Purpose: Be able to visualize and quantify the rate of photosynthesis under different temperature conditions.

Hypothesis???

http://www.ppws.vt.edu/scoti/weed_id/eldde.htm

2011 Science Education Resource Center, San Jose State University
Climate Change

- Driven by an increase in greenhouse gases
  - **Primary greenhouse gases include:** water vapor, carbon dioxide, methane, and nitrous oxide

- **Carbon Dioxide** is one of the key greenhouse gases affecting plant growth
Is an Increase in Carbon Dioxide a Good Thing?

Effects of Increased CO$_2$ Levels

- Plants can only absorb and process a limited amount of carbon dioxide because it is part of a system

- Limited by:
  - Rubisco availability
  - RuBP regeneration
  - Sugar build up within Calvin cycle
A-Ci Curve
Plants’ Photosynthetic Capacity

Rubisco limited
RuBP regeneration limited
Sugar accumulation limited

A = photosynthesis rate

Ci = CO₂ inside the leaf

Model Fit to Measured Data

2011 Science Education Resource Center, San Jose State University
An increase in carbon dioxide causes the atmosphere to increase in temperature.

Temperature effects on photosynthesis rates

How does climate change affect photosynthesis???

1. Change in temperature
   - Affects the rate of enzyme reactions
     - Rubisco
   - Affects water access
     - Drought
     - Freezing

2. Change in rain fall
   - Reduction in $H_2O$ availability

3. Seasonal plants
   - Adapted to specific climate cycles
QUESTIONS???
Works Cited


Figure 10-20b. Retrieved March 21, 2011 from <http://www.uic.edu/classes/bios/bios100/f06pmlect08.htm>


2011 Science Education Resource Center, San Jose State University