Photosynthesis: Harvesting Light Energy

Importance of Photosynthesis
A. Ultimate source of energy for all life on Earth
   1. All producers are photosynthesizers
   2. All consumers and decomposers are dependent upon producers

Origin of Photosynthetic Organisms
A. Heterotrophs
   1. Preceded autotrophs
   2. Fed on “Primordial Soup”
B. Early Producers
   1. Probably also were able to consume when nutrients were available
C. Modern Parallels
   1. Cyanobacteria (Old name was Blue-Green algae)
      a. Consume food and photosynthesize

Leaf Structure
A. Function
   1. Food supply system of plants
Leaf Structure
B. Structures
  1. Mesophyll
     a. Tissue made of photosynthetic cells containing chloroplasts
     b. Contains air spaces for CO₂ and H₂O vapor
  2. Epidermis
     a. Covers upper and lower surfaces of the leaf
     b. Secretes a waxy covering called the cuticle
  3. Stomates
     a. Pores in the epidermis through which gases diffuse
     b. Water and oxygen escape from leaf when stomates are open
       (1) Loss of water from the leaf is called Transpiration
  4. Guard Cells
     a. Cells that open and close the stomates
     b. CO₂ can only enter the leaf when stomates are open

Chloroplast Structure
A. Thylakoids
   1. Flattened sacs stacked in piles called grana
   2. Grana stacked to maximize absorption of light
B. Membrane
   1. Similar to other cellular membranes
C. DNA
   1. Similar to bacterial DNA
D. Chlorophyll
   1. Light absorbing pigment
     a. Form “A” absorbs light in the violet/blue range
     b. Form “B” absorbs light in the orange/red range

Process of Photosynthesis
An Overview
A. Three Major Events
   1. Absorption of light energy
   2. Conversion of light energy into chemical energy
   3. Storage of chemical energy in sugars
B. Reaction summary

$$3\text{CO}_2 + 3\text{H}_2\text{O} \rightarrow \text{C}_3\text{H}_6\text{O}_3 + 3\text{O}_2$$
The Light Reactions
A. Light Energy
   1. Absorbed by pigments
   2. Used to split water

   \[ H_2O \rightarrow 2H^+ + 2e^- + 1/2 O_2 \]

   3. Electrons used to power the synthesis of ATP and NADPH
   4. Oxygen gas is a product

B. ATP and NADPH
   1. Energy currency used to convert carbon dioxide into sugars in the Calvin cycle

The Calvin Cycle
A. Energy Source
   1. ATP and NADPH

B. Location of process
   1. Stroma (fluid) surrounding the thylkoids

C. Products
   1. ADP + NADP+
   2. 3-carbon sugar
      a. PGAL - Phosphoglyceraldehyde

D. Limitations
   1. Calvin cycle only works during daylight

Products of Photosynthesis
A. Uses for PGAL
   1. Synthesis of other molecules
      a. Sucrose
      b. Starch
      c. Lipids
      d. Amino acids - proteins
   2. Plant energy and growth
Rate of Photosynthesis

A. Light Intensity
   1. Rate + with + in light intensity
   2. Rate doesn’t + infinitely, but levels off when reactions reach a maximum rate

B. Temperature
   1. Rate + to a maximum and then [ as the temperature continues to +

C. Level of CO₂
   1. + in CO₂ will + the rate up to a maximum

D. Level of O₂
   1. + in the level of O₂ will [ the rate to a minimum where it levels off

E. Limiting Factors
   1. Factor that limits the rate of photosynthesis the most

Photorespiration and Photosynthesis

A. Photorespiration
   1. Light dependent uptake of O₂ and release of CO₂
   2. Hinders photosynthesis by releasing previously fixed CO₂
   3. Function of the process is unknown

B. Role of Rubisco
   1. O₂ binds to enzyme rubisco when O₂ levels are high and CO₂ is low
   2. CO₂ binds when O₂ level is low and CO₂ is high

Special Adaptations

A. C₄ Photosynthesis
   1. Function
      a. Fixes CO₂ into a 4-carbon acid
      b. Releases it later for use in photosynthesis
   2. Advantages
      a. Allows photosynthesis to occur when stomates are closed
      b. Allows rapid growth and minimal water loss
   3. C₄ Plants
      a. sugarcane, corn, crabgrass

B. CAM Plants (Crassulacean Acid Metabolism)
   1. Function
      a. Fixes CO₂ into organic acids at night
      b. Makes it available for photosynthesis during daylight
   2. Advantages
      a. Stomates are closed during the day when temperature is high
   3. Disadvantage
      a. Process is inefficient, so plant growth is slow
   4. CAM plants
      a. Desert plants, especially succulents

The Largest Chemical Process on Earth
A. Stats
   1. Plants use 140 billion metric tons of CO₂ annually
   2. Plants use 110 billion metric tons of H₂O annually
   3. Produce 90 billion metric tons of organic matter and O₂ gas

B. Concerns
   1. What effect will increasing CO₂ levels have on photosynthesis?
   2. What effect will deforestation have on O₂ available for heterotrophs?
   3. What effect will global warming have on the rate of photosynthesis?