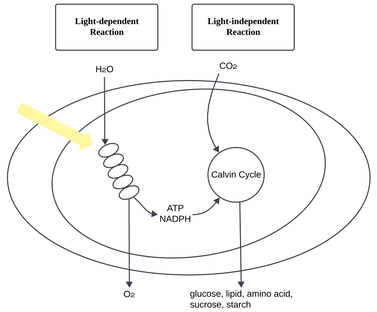
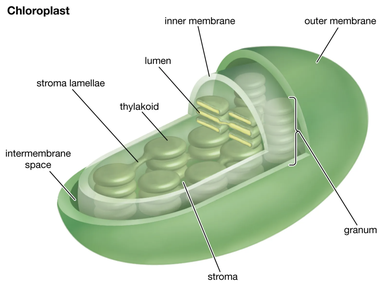
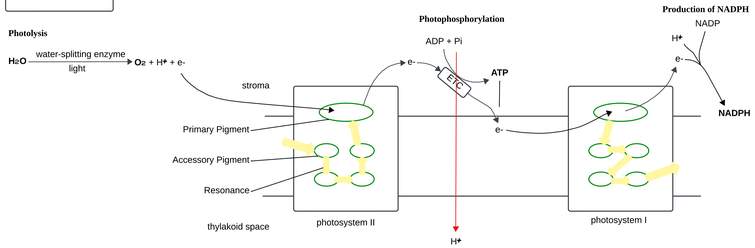
Photosynthesis



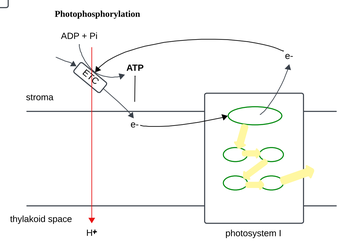


Light-dependent Reaction

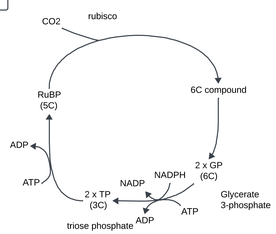
Non-cyclic Photophosphorylation

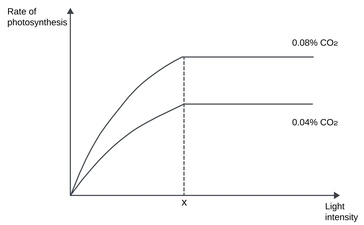


Cyclic Photophosphorylation



Light-independent Reaction





Description:

As light intensity increase from 0 to X, the rate of photosynthesis increase rapidly, light intensity is the limiting factor.

As light intensity increase above X, light intensity has little effect on the rate of photosynthesis, light intensity is no longer the limiting factor

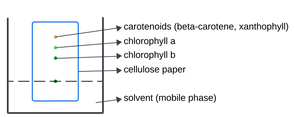
More light energy is absorbed by photosynthetuic pigment, more ATP and NADPH are produced in light dependent stage.

The Calvin ccucle cannot use up the ATP and NADPH as far as their rate if production. CO2 concentration and temperature can be the limting factor.

Photosynthesis

$6CO_2 + 6\,H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

- light-dependent reaction
  - photolysis
    - occurs in photosystem II
    - catalyzed by a water- splitting enzyme
  - photophosphorylation
    - non- cyclic
      - occurs in PSII and PSI
      - Light energy is absorbed by both photosystems, exciting electrons in primary pigment
      - Electrons from photosystem II are transferred to an electron acceptor and pass through a chain of carriers down the energy potential gradient, leading to ATP synthesis via chemiosmosis
      - Electrons from photosystem I are transferred to another acceptor, ultimately reducing NADP+ to NADPH
      - The electrons lost from the photosystems are replaced by electrons derived from the splitting of water molecules, a process called photolysis, which splits water molecules into oxygen, protons (H+), and electrons (e-).
      - Protons (H+) from water splitting combine with electrons from photosystem I and NADP+ to form NADPH
    - cyclic
      - occurs in PSI
      - Light energy is absorbed by photosystem I and passed to the primary pigment, exciting an electron in the chlorophyll a molecule to a higher energy level.
      - The high-energy electron is emitted from the chlorophyll molecule, a process known as photoactivation
      - The excited electrons are captured by an electron acceptor in the thylakoid membrane and passed along a chain of electron carriers.
      - The energy released is used to actively transport protons from the stroma, across the thylakoid membrane, into the thylakoid space, creating a proton gradient.
      - Protons move down their concentration gradient, through ATP synthase molecules, by facilitated diffusion
      - ATP is synthesized by adding a phosphate group to ADP, a process known as chemiosmosis.
  - production of NADPH — hydrogen carrier
- light-independent reaction (Calvin cycle)
  - Carbon Fixation — Carbon dioxide combines with a five-carbon compound, ribulose bisphosphate (RuBP), catalyzed by the enzyme rubisco, producing two molecules of Glycerate 3-phosphate (GP)
  - ATP and NADPH from the light-dependent reactions are used to convert GP into triose phosphate (TP), a three-carbon sugar.
  - Most of the TP molecules are used to regenerate RuBP, a process that requires ATP.
  - Some TP molecules are used to synthesize glucose and other carbohydrates needed by the plant.
  - TP can also be used to produce starch, sucrose, cellulose, lipids, and amino acids required by the plant for various purposes.
- structure of chloroplast
  - thylakoid
  - granum
  - stroma — 70s ribosome, cDNA
  - photosynthetic pigments
    - primary pigments — chlorophyll a
    - accessory pigment
      - chlorophyll b
      - beta-carotene
      - xanthophyll
    - chromatography of pigements
      - Rf value (retardation factor)
        - the ratio of distance travelled by pigments and distance travelled by solvent
        - greater Rf value, more soluble and smaller size of the pigment
      - action spectrum — a graph of rate of photosynthesis at different wavelength of light
      - absoption spectrum — a absorbance of different wavelength of light by a pigment



- rate of photosynthesis
  - variable change method
    - light intensity — change the distance between the light source and plant
    - light wavelength — use different colors of filter paper
    - concentration of CO2 — use different concentration of NaHCO3 solution
    - temperature — use waterbath
  - measure method — make chloroplast isolation
    - liquidize the leaves in ice-cold buffer — isolation buffer
      - cold: reduce enzyme activity to avoid digestion of chloroplast
      - optimum pH: prevent denaturation of enzymes in chloroplast
      - optimum osmostic pressure: prevent chloroplast from bursting
    - filter or centrifuge the suspension
    - add DCPIP/ methylene blue solution — oxidized DCPIP (blue) → reduced DCPIP (colorless); H2O; 1/2 O2