Energy Transformation: Photosynthesis (Outline)

1. Current Connections & Overview of photosynthesis
2. Producers, consumers, and decomposers of the ecosystem (source of carbon and energy): Autotrophs & Heterotrophs
3. Plant structures: organ, tissue, cells, sub-cellular organelle, and molecules.
4. Visible Light and its wavelengths
5. Chloroplast structure
6. Overview of the two processes or pathways of photosynthesis
   - Light reaction: Substrates, products, cellular components and their location
   - Calvin cycle: Substrates, products, cellular components and their location
6. Specifics of the Light reaction and the Calvin Cycle
   - Light Reaction: Pigments within Photosystems, Location within chloroplast, Photophosphorylation, Flow of energy
   - The Calvin cycle: Energy molecules, Carbon source, G3P
Photosynthesis, Solar Radiation, and Earth’s Atmosphere

Two current global issues would affect life as we know it on earth:
- Global warming- CO$_2$ emission (Greenhouse effect)
- Sources of energy (fossil fuel & Biofuel)

Greenhouses used to grow plant trap solar radiation, raising the temperature inside
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Excess CO$_2$ in the atmosphere traps solar energy raising the temperature on earth contributing to global warming.
Living organisms interact with their environment transforming energy

Energy flow and recycling of material
Overall equation for photosynthesis

Overall equation for cellular respiration
Producers of the ecosystem

**Auto*trophs**

Produce their own food and sustain themselves without eating other organisms

Bacteria
Algae
Plants

Figure 7.1A–D
In plant cells, energy of light is converted to ATP and reducing power (NADPH), which are then used for converting CO$_2$ into sugar.
In plants, photosynthesis takes place in green leaves.
Overview of Photosynthesis

1. Light
2. Chloroplast

Thylakoids (stacked as grana)

*The Light Reaction*

Stroma

*The Calvin Cycle*
**The Light reaction**

- Converts light energy to chemical energy (ATP & NADPH)
- Produces $O_2$ from breakdown of water

**The Calvin cycle**

- uses ATP & NADPH from light reaction to assemble sugar molecules from $CO_2$

Figure 7.5
Chloroplasts

Thylakoids (stacked as grana)
Thylakoid membrane
Photosystems: PS
Chlorophyll

Stroma
Figure 7.5

Light

H₂O

CO₂

Chloroplast

Light REACTIONS (in thylakoids)

NADP⁺

ADP + P

ATP

NADPH

CALVIN CYCLE (in stroma)

ATP

Electrons

O

Sugar
Figure 7.8B

**Splitting of water**

Photosystem II

Photosystem I

NADPH

ATP

Mill makes ATP

Splitting of water

Photon
Thylakoid space

Stroma

Thylakoid membrane

Photosystem II

Photosystem I

Photon

H₂O → O₂ → H⁺

Electron transport chain

Provides energy for synthesis of ATP by photophosphorylation

NADP⁺ + H⁺ → NADPH

Figure 7.8A
Light Reaction/Photosystem II

Light releases electrons captured by primary electron acceptor

Water is split to replace the lost electrons

Acceptors pass electrons to ETC

Proton gradient is generated

Photophosphorylation turns ADP + Pi into ATP
Figure 7.9
Chemiosmosis powers ATP synthesis (photophosphorylation)

The electron transport chain pumps H\(^+\) into the thylakoid space

H\(^+\) diffuse back into the stroma across the membrane through ATP synthase

Passage of H\(^+\) activates phosphorylation of ADP to produce ATP (photophosphorylation)
Summary of the Light Reaction
THE CALVIN CYCLE: CONVERTING CO$_2$ TO SUGARS

Calvin cycle

– Occurs in the chloroplast’s stroma
– ATP and NADPH power sugar synthesis
  • The first sugar molecule is G3P (3C) that is used to build glucose and other organic molecules
Summary of Calvin Cycle
Review: Photosynthesis uses light energy to make food molecules

**Light Reactions**

- Water ($H_2O$) is split by light energy, releasing oxygen ($O_2$) and generating high-energy electrons.
- These electrons travel through the electron transport chains, driving the synthesis of ATP and NADPH.

**Calvin Cycle**

- In the stroma, the electrons from NADPH reduce carbon dioxide ($CO_2$) to form a sugar (3-PGA).
- The sugar is then converted into glyceraldehyde 3-phosphate (G3P), which feeds into the Calvin cycle.
- ATP is used to drive the conversion of G3P to sugars.

**Products**

- Sugars are used for cellular respiration, cellulose production, starch formation, and other organic compounds.

**Chloroplast**

- Contains thylakoid membranes where light reactions occur.
- Contains the Calvin cycle where carbon fixation takes place.

**Equations**

- Light + $H_2O$ + $CO_2$ → ATP + NADPH + G3P + $O_2$
- ATP + ADP → ATP
- G3P + ATP → Sugar
- Sugar → Sugars, Cellulose, Starch, Other organic compounds