

Introduction to Botany. Lecture 20

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Outline

1 Questions and answers

2 Photosynthesis

- History
- Chloroplast
- Light stage: electron transport, synthesis of ATP and NADPH

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2 Photosynthesis

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Previous final question: the answer

Which conclusions can be drawn from Priestley's experiments?
Please list more than one.

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Please list more than one.

- Mouse and candle “spend” air
- Plant “revives” air



Photosynthesis

History

Blackman

- In 1905, Frederick Blackman discovered that if light intensity is low, increase of temperature has a little effect on the rate of photosynthesis
- Consequently, photosynthesis has two stages:
 - 1 Light stage which relates more with light intensity
 - 2 “Dark” (now called *enzymatic* or *light-independent*) stage which relates more with temperature



Light and enzymatic (“dark”) reactions

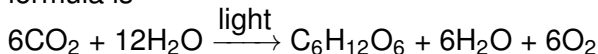
- Light reactions depend on the light and water, they produce oxygen and energy (in form of ATP)
- Enzymatic reactions depend on carbon dioxide and water, they take energy from light reactions and result in production of carbohydrates
- Main component of enzymatic reactions called Calvin cycle which fixates carbon dioxide



Equation

- $6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ is not a formula, but merely a general description of a process

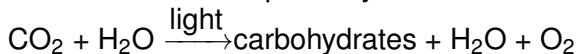
- Water molecules arise from both sides, and the better formula is



or even

carbon dioxide + hydrogen donor $\xrightarrow{\text{light}}$ carbohydrate + water + oxidized hydrogen donor

- And the best one is probably



Photosynthesis

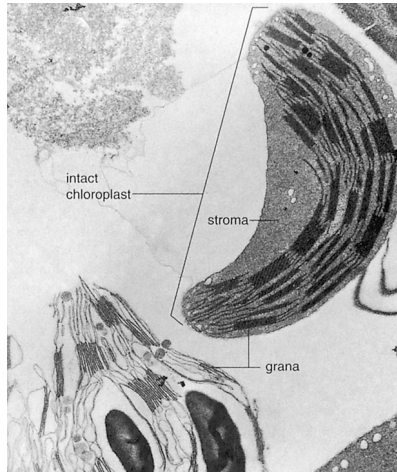
Chloroplast

Compartments of chloroplast

- Even isolated chloroplasts may take light and fixate carbon dioxide
- Photosynthesis is related with membrane system (thylacoids) of chloroplasts, which has two parts:
 - 1 grana
 - 2 stroma lamellum



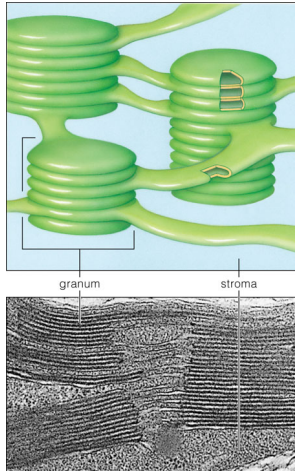
Stroma



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Tylacoids



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Division of labor in chloroplast

- Light reactions are concentrated around thylacoid membranes, thylacoids are also H^+ (protons, hydrogen ions) reservoir
- Enzymatic reactions run in stroma (chloroplast “cytoplasm”)

Photosynthesis

Light stage: electron transport,
synthesis of ATP and NADPH



Participants of light stage

- 1 Chlorophyll
- 2 Light
- 3 Water
- 4 ATP synthase
- 5 Protons (H^+)
- 6 Hydrogen carrier ($NADP^+$)

Where: around thylacoid membrane



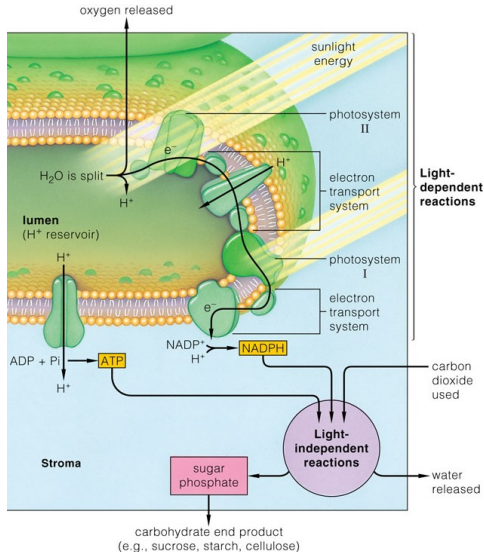
Main events of light stage

- 1 Chlorophyll + Light \longrightarrow Electron (e^-) + Chlorophyll $^+$
- 2 $H_2O \longrightarrow H^+ + OH^-$ (accumulates outside)
- 3 $e^- + H^+ + \text{Hydrogen carrier (NADP}^+) \longrightarrow \text{NADPH}$ (moves away)
- 4 $H_2O \longrightarrow H^+$ (accumulates inside) + $e^- + O_2$
- 5 H^+ (inside) + OH^- (outside) \implies gradient \implies PROTON PUMP $\implies H_2O$,
and $ADP + P_i$ (inorganic phosphate) \longrightarrow **ATP**



Scheme of light stage

Bird view of light stage

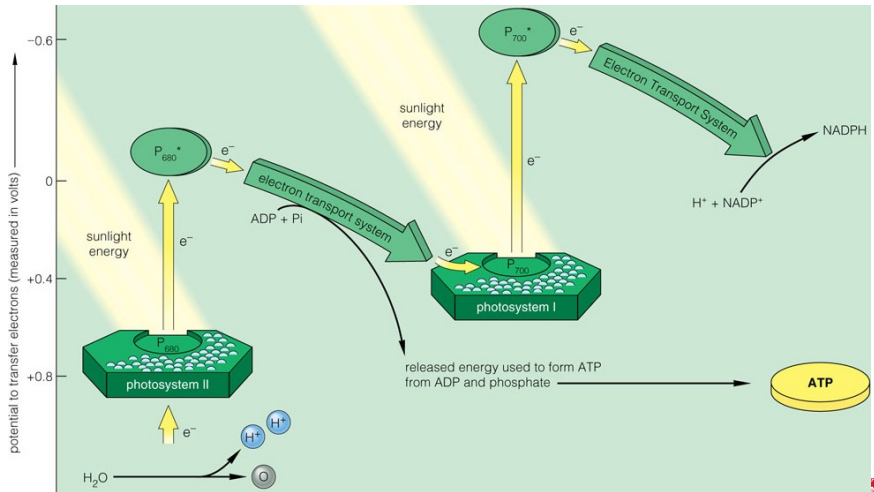


Photosystems I and II

- Photosystem II (P_{680} , contains chlorophylls and carotene) decomposes water and forwards electron to Photosystem I (P_{700} , contains only chlorophylls)
- P_{680} makes proton gradient and then ATP: this is a **photophosphorylation**
- P_{700} makes NADPH
- Processes above are an **noncyclic electron transport** and **noncyclic** photophosphorylation because electrons move from one photosystem to another and finally accepted by $NADP^+$
- **Cyclic** electron transport requires only P_{700} but do not produce any NADPH, only ATP



Two photosystems



Results of the light stage

At the start	At the end
H_2O Chlorophylls ADP and P_i (inorganic phosphate) NADP^+	H_2O (result of pump) and O_2 Chlorophylls ATP NADPH

Final question (1 point)

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List at least one difference between light and enzymatic stages of photosynthesis.

Summary

- **Light stage** of photosynthesis results in accumulation of energy and hydrogen, and release of oxygen
- **Enzymatic stage** of photosynthesis results in synthesis of organic molecules

For Further Reading



J. E. Bidlack, Sh. H. Jansky.
Stern's introductory plant biology. 12th edition.
McGraw-Hill, 2011.
Chapter 10.



Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.
Plant Biology. 2nd edition.
Thomson Brooks/Cole, 2006.
Chapter 10.

