

# Introduction to Botany. Lecture 5

Alexey Shipunov

Minot State University

September 8, 2014



- 1 Questions and answers
- 2 Photosynthesis
  - History of photosynthesis studies
  - Light stage: electron transport, synthesis of ATP and NADPH



- 1 Questions and answers
- 2 Photosynthesis
  - History of photosynthesis studies
  - Light stage: electron transport, synthesis of ATP and NADPH



# Previous final question: the answer

Name six biogenic elements.



# Previous final question: the answer

Name six biogenic elements.

- Carbon (C)
- Hydrogen (H) and oxygen (O)
- Nitrogen (N), phosphorous (P), sulfur (S)

There are other essential elements (Na, K, Ca, Cl) but they are not biogenic since they do not participate in making molecules with carbon skeleton (organic molecules).



# Photosynthesis

## History of photosynthesis studies



# van Helmont

- Johannes van Helmont (17th century) rejected the idea that plants take most of their biomass from soil
- Willow (*Salix* sp.) tree of 2.27 kg grew to 67.7 kg in five years, but weight of soil decreased only by 57 g
- van Helmont concluded that plants take most of their weight from water



# Pristley

- Famous Joseph Priestley in 1772, made series of experiments with mouse, candle and sprig of mint (*Mentha* sp.)
- Mouse behave similar to candle, they both “spent” air
- Plant revives the air for both candle and mouse





# Further history

- Jan Ingenhousz (1779–1796) and Jean Senebier (1780) found that:
  - Only in day time the air is reviving
  - CO<sub>2</sub> is assembled
- Antoin-Laurent Lavoiser (1783) found that the “revived air” is a separate gas, **oxygen**

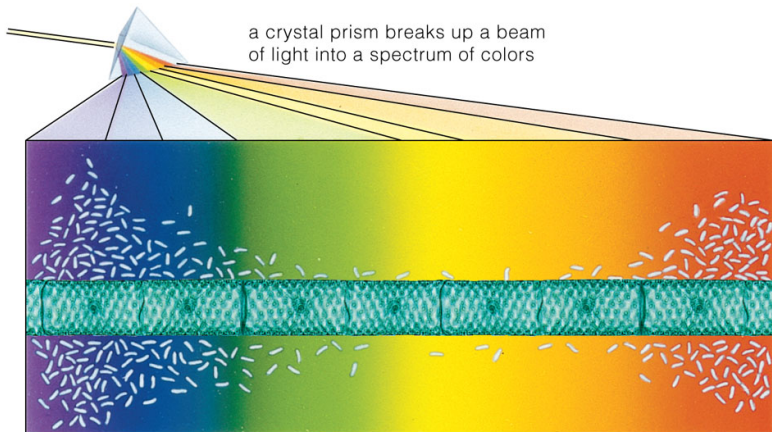


# Engelmann

- Thomas Engelmann in 1884 found that *Spirogyra* alga produce oxygen mostly in blue and red parts of spectrum
- Therefore, the key photosynthetic pigment should accept blue and red rays and reflect green rays
- Chlorophyll fits best to this description



# Experiment of Engelmann



# Blackman

- In 1905, Frederick Blackman discovered that if light intensity is low, increase of temperature has a little effect on the rate of photosynthesis
  - 1 If light and temperature were *independent*, this could not happen
  - 2 If temperature and light were *components of the chain*, than light was first and temperature second
- Consequently, photosynthesis has two stages:
  - 1 Light stage which relates more with light intensity
  - 2 “Dark” (now called *enzymatic*) stage which relates more with temperature



# Light and enzymatic (“dark”) reactions

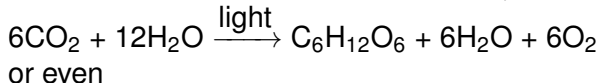
- Light reactions depend on the light and water, they produce oxygen and energy (in form of ATP)
- Enzymatic reactions depend on carbon dioxide and water, they take energy from light reactions and result in production of carbohydrates



# Four equations of photosynthesis

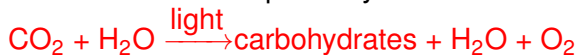
①  $6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$  is *not a formula*, but merely a general description of a process

② Water molecules arise from both sides, and the better formula is



③ carbon dioxide + hydrogen donor  $\xrightarrow{\text{light}}$  carbohydrate + water + oxidized hydrogen donor

④ And the best one is probably



# Photosynthesis

Light stage: electron transport,  
synthesis of ATP and NADPH



# Participants of light stage

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

**Where:** around thylakoid membrane





# Final question (2 points)



## Final question (2 points)

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



# Summary

- From 17th century, it constantly became clear that plants make their biomass from light, water and carbon dioxide
- **Photosynthesis** is a sum of light-dependent and light-independent reactions
- **Light stage** of photosynthesis results in accumulation of energy and hydrogen, and release of oxygen



# For Further Reading



A. Shipunov.

*Introduction to Botany* [Electronic resource].

2010—onwards.

Mode of access:

[http://ashipunov.info/shipunov/school/biol\\_154](http://ashipunov.info/shipunov/school/biol_154)



Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.

*Plant Biology*. 2nd edition.

Thomson Brooks/Cole, 2006.

*Chapters 2 and 10.*

