

Introduction to Botany. Lecture 12

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Outline

1 Leaf morphology again

2 Photosynthesis

- History
- Chloroplast

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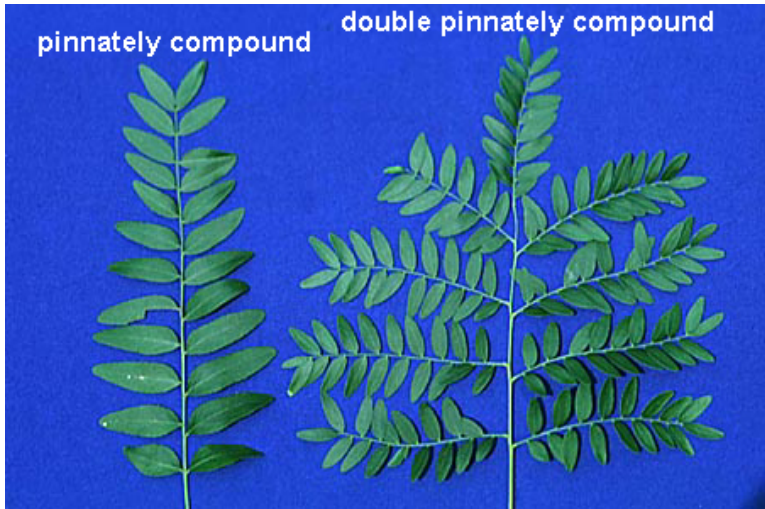
Compound leaves and repetitive characters

Open discussion*

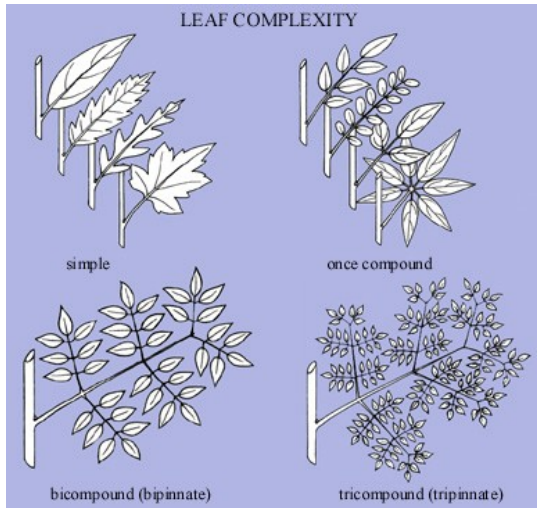
Simple and compound leaves



Double pinnate leaf



Levels of complexity



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

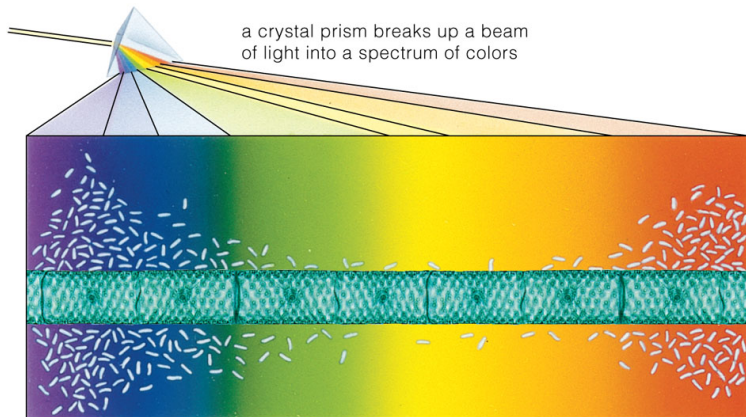
Further history

- J. Senebier (1780) discovered the role of CO_2
- J. Ingen-Houst (1796) found that carbon moved into plant body
- N. de Saussure (1804) observed that water also involved in plant nutrition

Engelmann

- T.W. 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



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Blackman

- In 1905, F.F. 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 hydrocarbonates
- 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

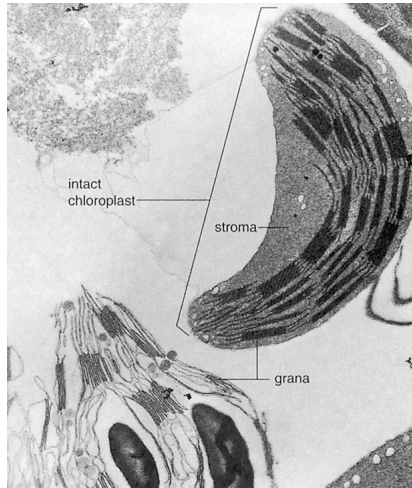
$$6\text{CO}_2 + 12\text{H}_2\text{O} \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2$$
or even

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

Compartments of chloroplast

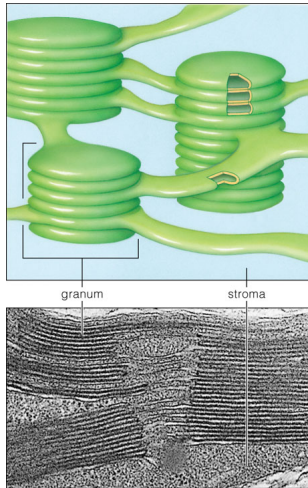
- Even isolated chloroplasts may take light and fixate carbon dioxide
- Photosynthesis is related with membrane system (thylacoids) of chloroplasts, which has two parts:
 - 1 grana
 - 2 stroma lamellum

Stroma



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Tylacoids

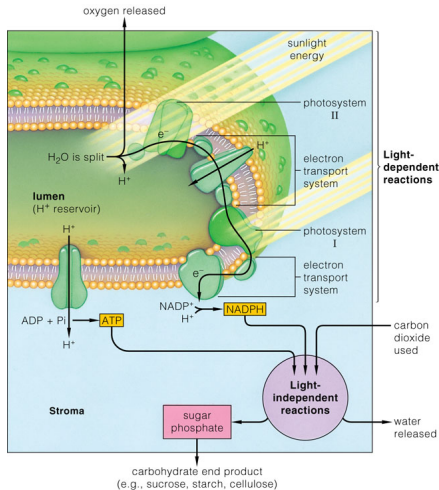


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Division of labor in chloroplast

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

Location of two stages



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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 reactions are concentrated around **thylacoid membrane** whereas enzymatic reactions concentrate in **stroma**

For Further Reading



Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.
Plant Biology. 2nd edition.
Thomson Brooks/Cole, 2006.
10.1–10.4.