

Introduction to Botany

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Lecture 10

Outline

1 Questions and answers

- Quiz

2 Photosynthesis

- Special case of photosynthesis: C_4 pathway
- C_4 and CAM plants

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- Quiz

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Questions and answers

Quiz

Final question (2 points)

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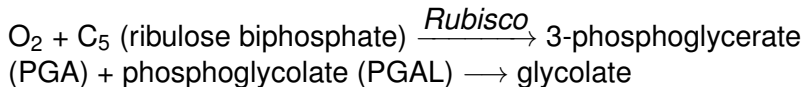
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Photosynthesis

Special case of photosynthesis: C₄ pathway

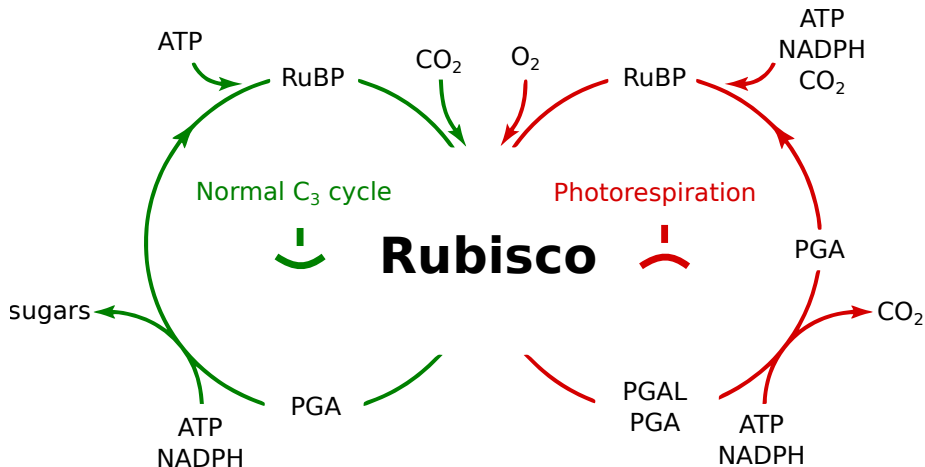
Photorespiration

Rubisco is two-faced enzyme, it catalyzes **photorespiration** if the concentration of O₂ and/or temperature is high:



- To return glycolate into the Calvin cycle, cell must use peroxisomes, mitochondria and spend ATP
- Photorespiration wastes C₅ and ATP
- Photorespiration is said to be an evolutionary relic from times when atmosphere contained little oxygen

Two-faced Rubisco



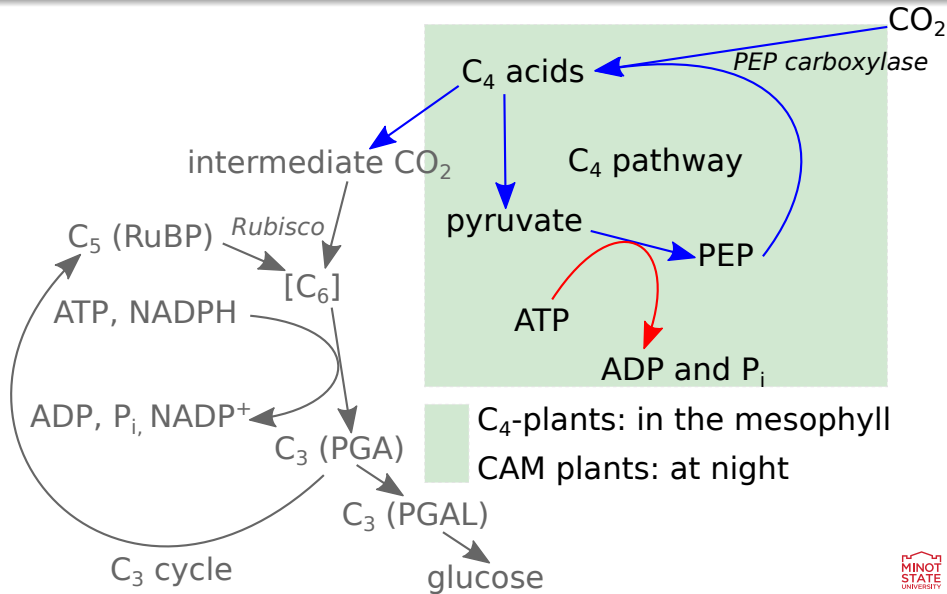
Minimization of photorespiration

To minimize photorespiration, plants need to increase concentration of CO₂. This is how they do it:

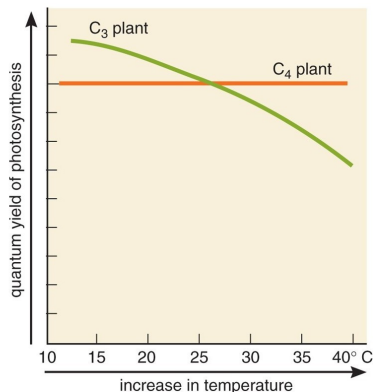
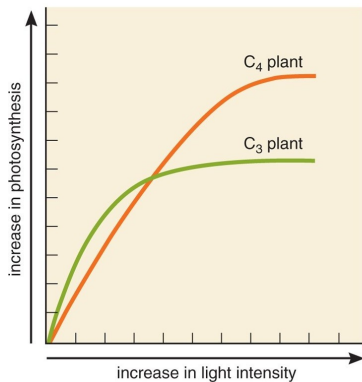
- Ⓐ $\text{CO}_2 + \text{C}_5 \text{ (PEP, phosphoenolpyruvate)} \xrightarrow{\text{PEP carboxylase}} \text{C}_4$
(different organic acids): this is the temporarily accumulation of carbon dioxide
- Ⓑ $\text{C}_4 \longrightarrow \text{pyruvate} + \text{CO}_2$: release of carbon dioxide will increase its concentration
- Ⓒ $\text{Pyruvate} + \text{ATP} \longrightarrow \text{PEP} + \text{ADP} + \text{P}_i$: PEP recovery costs ATP!
(but **less** than photorespiration)

Processes above called C₄ pathway, it is an addition to Calvin (C₃) cycle in order to increase concentration of CO₂

C₄ pathway at-a-glance



C_4 -pathway plants feel better at high temperature and light intensity



C_4 -pathway plants waste ATP to recover PEP but outperform strict C_3 plants when concentration of oxygen is high

Photosynthesis

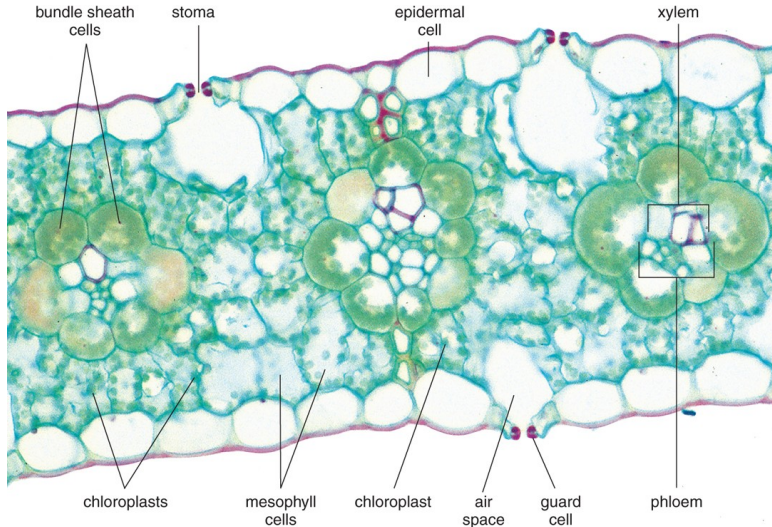
C₄ and CAM plants

C₄ and CAM plants both use C₄ pathway

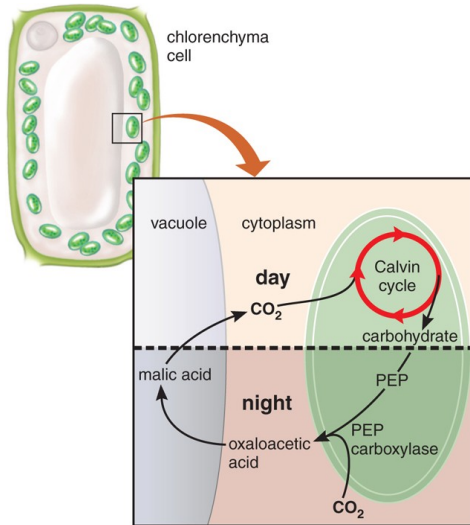
- **CAM-plants** which drive C₄ cycle at nights:
 - This is a **temporal** separation between accumulation of CO₂ and photosynthesis)
 - CAM-plants (17,000 species, 7% of plant biodiversity) are mostly succulents from different orders and families (e.g., cacti—Cactaceae from Caryophyllales), other examples are bromeliads like pineapple.
- **C₄-plants** which drive C₄ in mesophyll cells and C₃ in bundle sheath cells:
 - This is a **spatial** separation between accumulation of CO₂ and photosynthesis: C₄ pathway is located in “normal” mesophyll cells whereas the Calvin cycle is separated to **bundle sheath cells**.
 - C₄-plants (7,300 species, 3%) are especially common among Poales (grasses order, e.g., corn, millet, sorghum) and Caryophyllales (pink order)

There are plants which combine C₄ and CAM (*Portulacaria*) and even C₃ and CAM (*Clusia*).

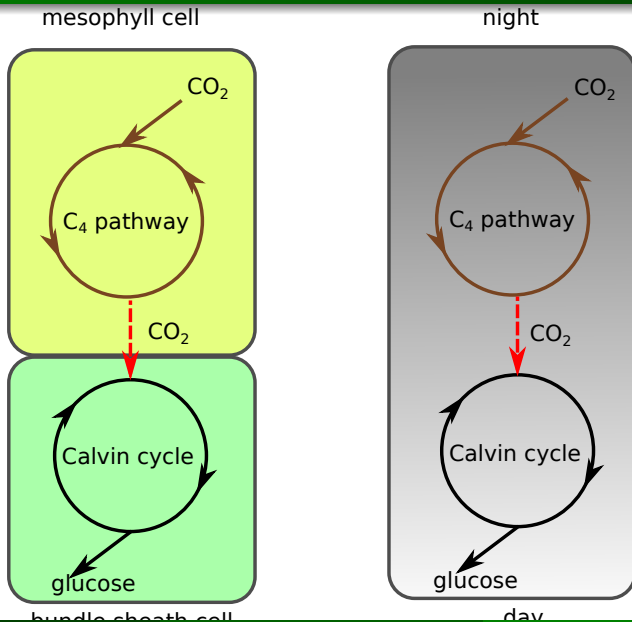
Leaf of C₄ plant: spatial separation of C₃ and C₄ pathways



CAM plants separate C₃ and C₄ pathways in time



CAM plants and C₄ plants



Jade plant



CAM is named after the family Crassulaceae,
Jade plant (*Crassula ovata*) family

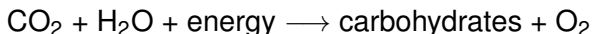
Corn



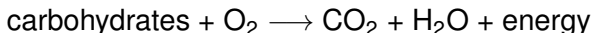
Corn (*Zea mays*) is the C₄ plant which minimizes photorespiration at higher temperatures

True respiration

- The common misconception about plants is that their only energy-related metabolic process is photosynthesis:



- However, as most eukaryotes, plants have mitochondria in cells and use *aerobic* (oxygen-related) respiration to obtain energy:



- Typically, plants spend much less oxygen in respiration than they make in photosynthesis. However, at nights plants do exactly the same as animals, and make only carbon dioxide!

Final question (2 points)

Final question (2 points)

...

Summary

- **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
- **Enzymatic stage** of photosynthesis results in synthesis of organic molecules
- C₄ and CAM plants accumulate and then release carbon dioxide and therefore increase its concentration

For Further Reading



A. Shipunov.

Introduction to Botany [Electronic resource].

Mode of access:

http://ashipunov.info/shipunov/school/biol_154