Introduction to Botany. Lecture 7

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Outline

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Results of Exam 1: statistic summary

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Summary:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
  29.00   38.00   50.00   53.08   63.50   84.00       1
Grades:
  F   D   C   B max
 45  52  60  68  75
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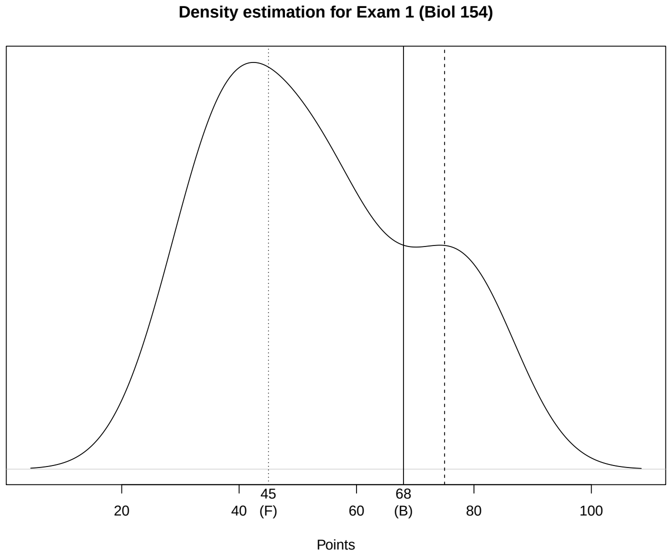
Results of Exam 1: the curve



7. pH is a
    A. **Negative logarithm (degree of ten) of the concentration of protons**
    B. Negative logarithm (degree of ten) of the concentration of hydroxyl ions
    C. Negative logarithm (degree of ten) of the concentration of electrons
19. Which set of three components can make a nucleotide?
    A. Sugar, amino acid and carbon cycle with nitrogen
    B. **Phosphoric acid, sugar and carbon cycle with nitrogen**
    C. Lipid, sugar and carbon cycle with nitrogen

Previous final question: the answer

Which photosystem is responsible for every product of the light stage?

At the end	Photosystem ...
H_2O (result of pump) and $\mathbf{O_2}$	...
Chlorophylls	...
ATP	...
NADPH	...

Previous final question: the answer

Which photosystem is responsible for every product of the light stage?

At the end	Photosystem ...
H_2O (result of pump) and $\mathbf{O_2}$	II
Chlorophylls	II and I
ATP	II
NADPH	I

Photosynthesis

Special case of photosynthesis: C_4 pathway

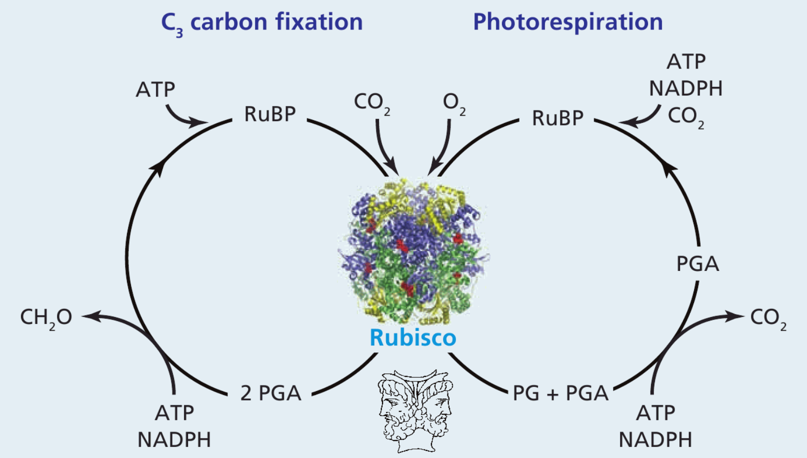
Photorespiration

Rubisco is two-faced enzyme, it catalyzes **photorespiration** if the concentration of O_2 and/or temperature is high:

O_2 + C_5 (ribulose biphosphate) $\xrightarrow{\textit{Rubisco}}$ 3-phosphoglycerate (PGA) + phosphoglycolate (PGAL) $\longrightarrow$ glycolate

- To return glycolate into the Calvin cycle, cell must use peroxisomes, mitochondria and spend ATP
- Photorespiration wastes C_5 and ATP
- Photorespiration is said to be an evolutionary relic from times when atmosphere contained little oxygen

Two-faced Rubisco



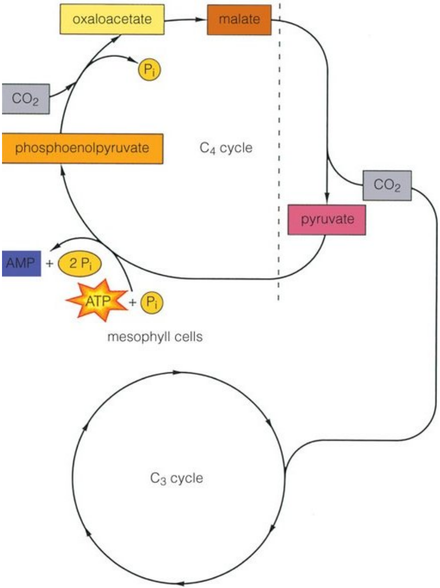
Minimization of photorespiration

To minimize photorespiration, plants need to increase concentration of CO_2. This is how they do it:

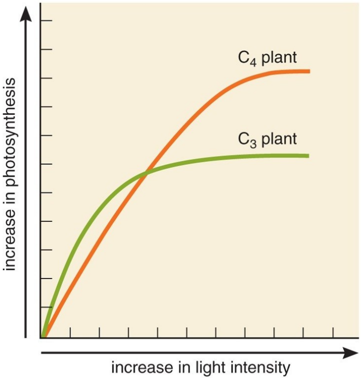
1. $CO_2 + C_5$ (PEP, phosphoenolpyruvate) $\xrightarrow{\text{PEP carboxylase}} C_4$ (different organic acids): this is the temporarily accumulation of carbon dioxide
2. $C_4 \longrightarrow$ pyruvate + CO_2: release of carbon dioxide will increase its concentration
3. Pyruvate + ATP $\longrightarrow$ PEP + AMP + $2P_i$: PEP recovery costs ATP

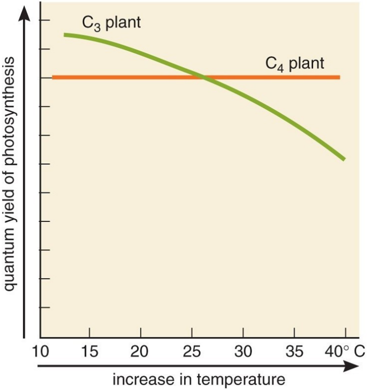
Processes above called C_4 pathway, it is an addition to Calvin (C_3) cycle in order to increase concentration of CO_2

C_4 pathway at-a-glance



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



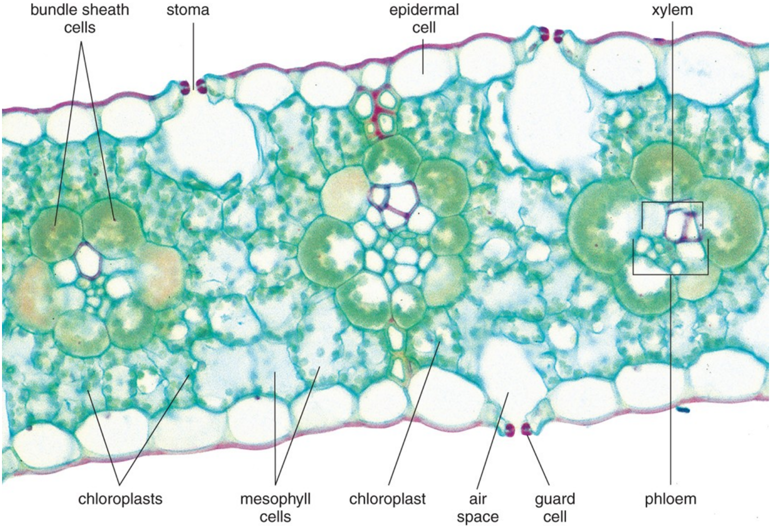


C_4-pathway plants waste ATP to recover PEP but outperform strict C_3 plants when concentration of oxygen is high

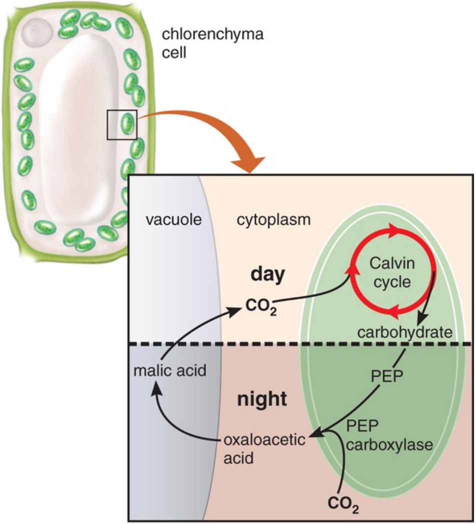
C_4 and CAM plants both use C_4 pathway

- **CAM-plants** which drive C_4 cycle at nights:
  - This is a **temporal** separation between accumulation of CO_2 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)
- **C_4-plants** which drive C_4 in mesophyll cells and C_3 in bundle sheath cells:
  - This is a **spatial** separation between accumulation of CO_2 and photosynthesis: C_4 pathway is located in "normal" mesophyll cells whereas the Calvin cycle is separated to **bundle sheath cells.**
  - C_4-plants (7,300 species, 3%) are especially common among Poales (grasses order, e.g., corn) and Caryophyllales (pink order)

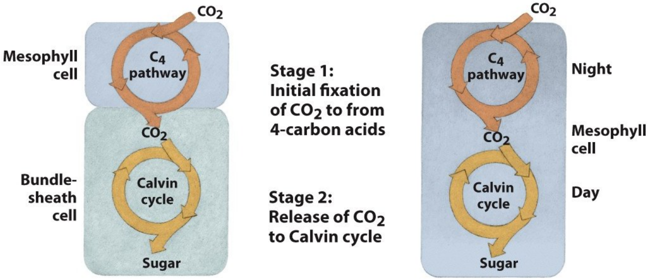
Leaf of C_4 plant: spatial separation of C_3 and C_4 pathways



CAM plants separate C_3 and C_4 pathways in time



CAM plants and C_4 plants



Jade plant

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

Corn

Corn (*Zea mays*) is the C_4 plant which minimizes photorespiration at higher temperatures

Final question (2 points)

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Photorespiration increases when concentration of oxygen grows. Why is photorespitation so intensive at high temperatures?

Summary

- To prevent wasteful **photorespiration**, plants “invented” the addition to photosynthesis, C_4-pathway
- C_4 and CAM plants accumulate and then release carbon dioxide and therefore increase its concentration

For Further Reading

A. Shipunov.
Introduction to Botany [Electronic resource].
2010—onwards.
Mode of access:
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.
Chapter 10.