

Introduction to Botany. Lecture 7

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Outline

1 Questions and answers

2 Photosynthesis

- Special case of photosynthesis: C_4 pathway



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1 Questions and answers

2 Photosynthesis

- Special case of photosynthesis: C_4 pathway



Results of Exam 1: statistic summary

Summary:

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
45.00	52.00	65.00	67.59	81.00	94.00	7

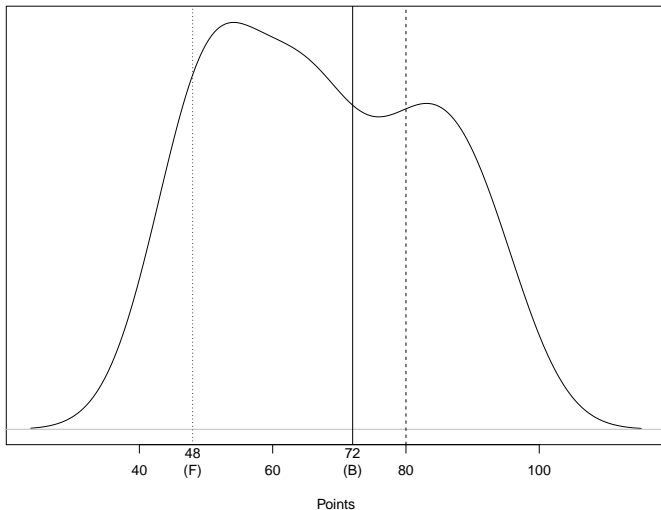
Grades:

F	D	C	B	max
48	56	64	72	80



Results of Exam 1: the curve

Density estimation for Exam 1 (Biol 154)



22. Two isotopes of same element:

- ① **Have the same number of protons and electrons but different number of neutrons**
- ② Have the same number of protons and neutrons but different number of electrons
- ③ Have the same number of neutrons and electrons but different number of protons

36. Botany is a “slice” science, whereas _ is a “layer” science:

- ① Zoology
- ② Entomology
- ③ **Cytology**

46. Which of the following statements is NOT true?

- ① Carnivorous plants are autotrophs
- ② **Carnivorous plants are organotrophs**
- ③ Carnivorous plants are phototrophs



Previous final question: the answer

What is wrong in this picture?

Before photosynthesis	After photosynthesis
H_2O NADP^+ CO_2	O_2 NADPH $\text{C}_6\text{H}_{12}\text{O}_6$ (or other organic molecules)



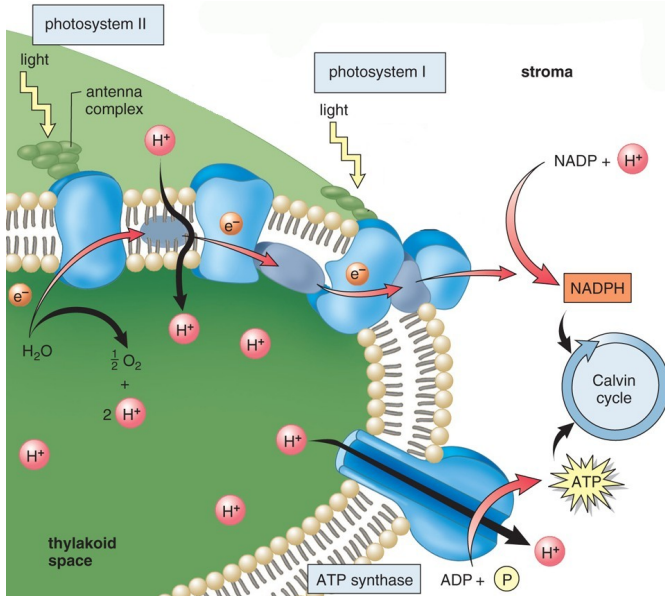
Previous final question: the answer

What is wrong in this picture?

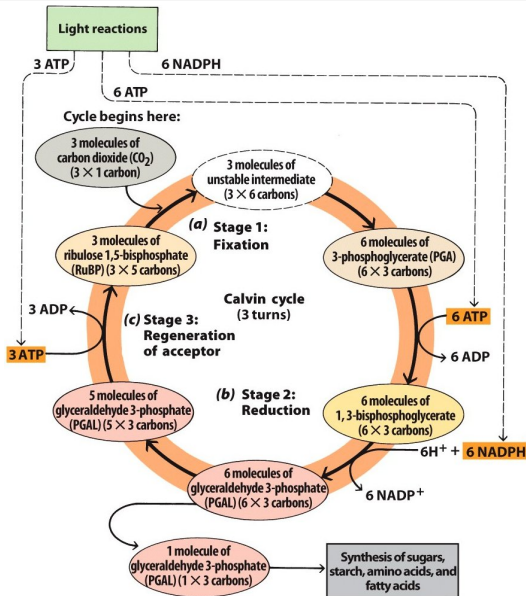
Before photosynthesis	After photosynthesis
H_2O NADP^+ CO_2	O_2 , H_2O NADPH NADP^+ $\text{C}_6\text{H}_{12}\text{O}_6$ (or other organic molecules)



Light stage



Enzymatic stage



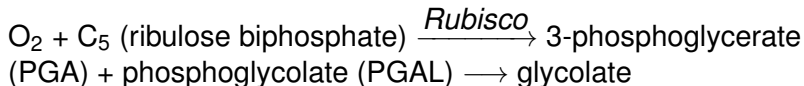
Photosynthesis

Special case of photosynthesis: C₄ pathway



Photorespiration

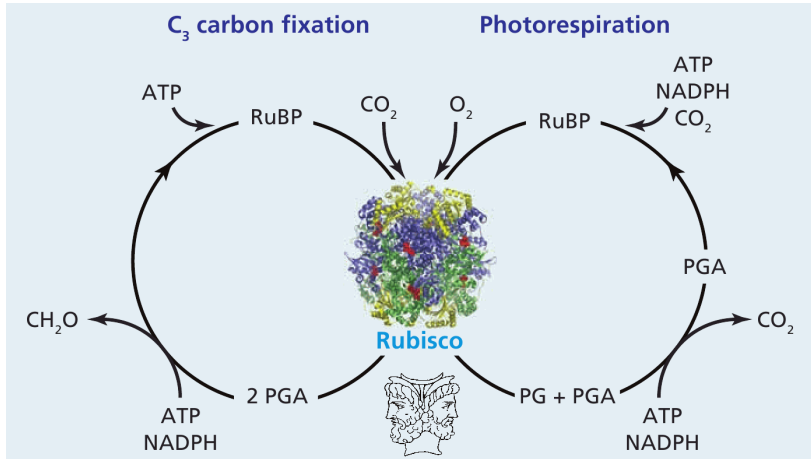
Rubisco is two-faced enzyme, it catalyzes **photorespiration** if the concentration of O₂ and/or temperature is high:



- 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

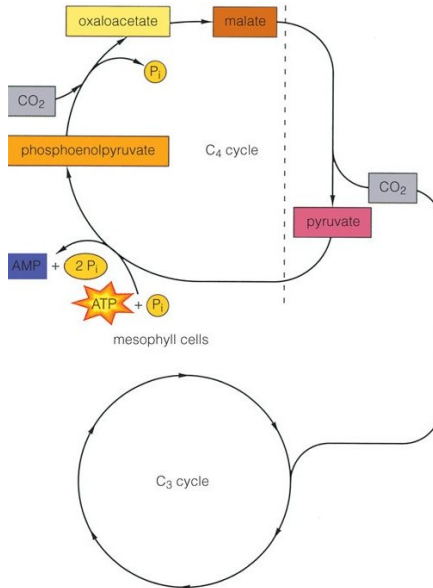
To minimize photorespiration, plants need to increase concentration of CO₂. This is how they do it:

- 1 CO₂ + C₅ (PEP, phosphoenolpyruvate) $\xrightarrow{\text{PEP carboxylase}}$ C₄
(different organic acids): this is the temporarily accumulation of carbon dioxide
- 2 C₄ \longrightarrow pyruvate + CO₂: release of carbon dioxide will increase its concentration
- 3 Pyruvate + ATP \longrightarrow PEP + AMP + 2P_i: PEP recovery costs ATP

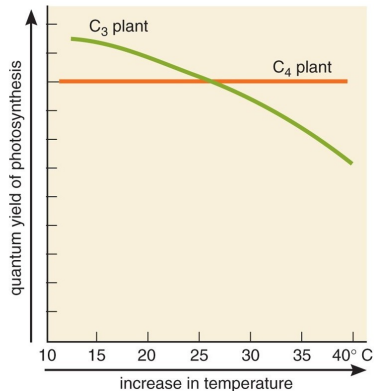
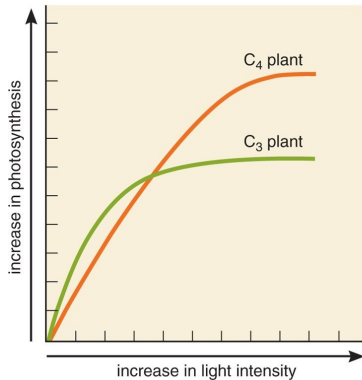
Processes above called C₄ pathway, it is an addition to Calvin (C₃) cycle in order to increase concentration of CO₂



C₄ pathway at-a-glance



C₄-pathway plants feel better at high temperature and light intensity



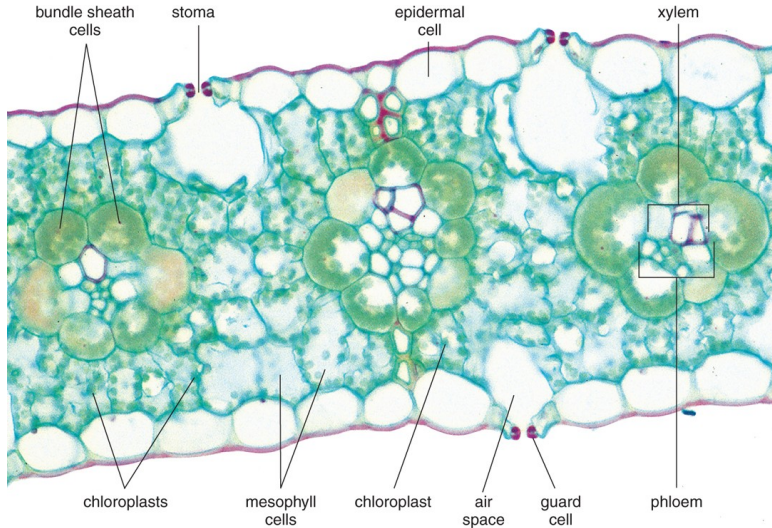
C₄-pathway plants waste ATP to recover PEP but outperform strict C₃ plants when concentration of oxygen is high

C_4 and CAM plants both use C_4 pathway

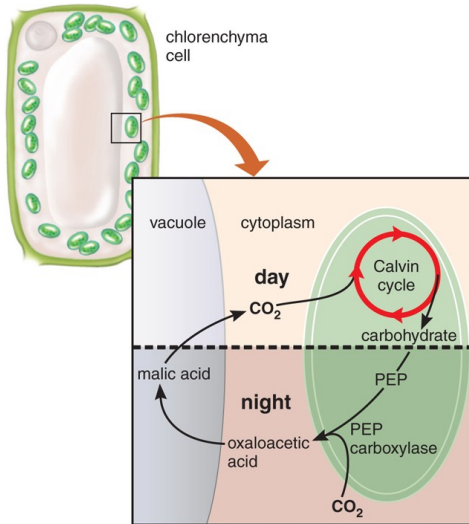
- **CAM-plants** which drive C_4 cycle at nights:
 - This is a **temporal** separation between accumulation of CO_2 and photosynthesis)
 - CAM-plants (17,000 species, 7% of plant biodiversity) are mostly succulents from different orders and families (e.g., cacti—Cactaceae from Caryophyllales)
- **C_4 -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)



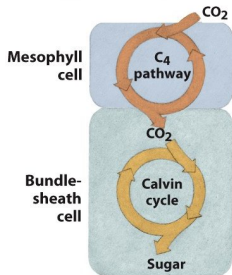
Leaf of C_4 plant: spatial separation of C_3 and C_4 pathways



CAM plants separate C_3 and C_4 pathways in time

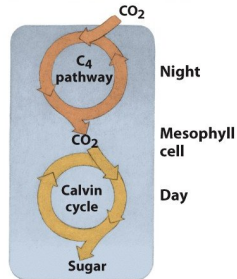


CAM plants and C_4 plants



Stage 1:
Initial fixation
of CO_2 to form
4-carbon acids

Stage 2:
Release of CO_2
to Calvin cycle



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)



Final question (2 points)

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



Summary

- To prevent wasteful **photorespiration**, plants “invented” the addition to photosynthesis, C₄-pathway
- 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].

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.

