

Introduction to Botany. Lecture 14

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Outline

1 Photosynthesis

- Light stage: electron transport, synthesis of ATP and NADPH
- Special cases of photosynthesis

2 Roots and root systems

- Root morphology
- Anatomy and development of roots

Outline

1 Photosynthesis

- Light stage: electron transport, synthesis of ATP and NADPH
- Special cases of photosynthesis

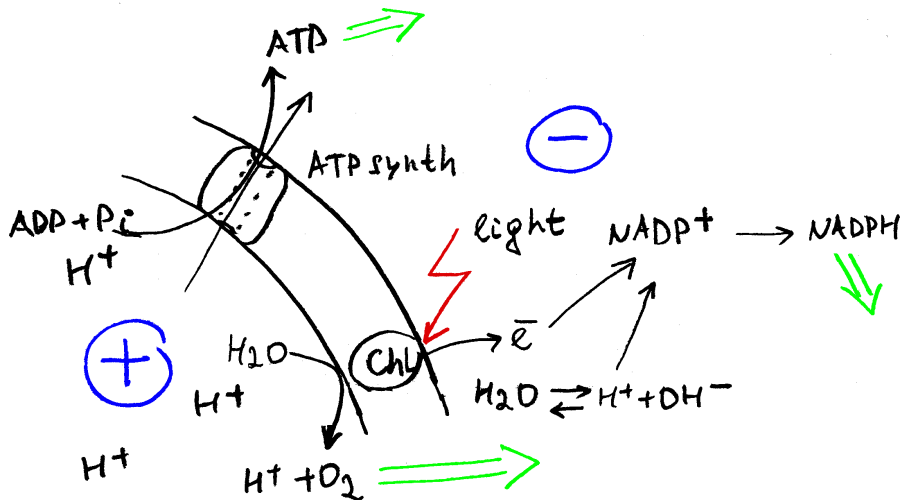
2 Roots and root systems

- Root morphology
- Anatomy and development of roots

Announcements

- **Exam 2:** One more lecture about root, one about water transport, nothing on Wednesday October 6th, exam on October 8th
- **Monday tests:** next Monday test will be pre-exam test, it will contain question similar to Exam 2 questions
- **Monday lab:** two in each team, each team please bring tape-measure, 4 wooden sticks (or long pencils), and white or red thread

Overview of light stage



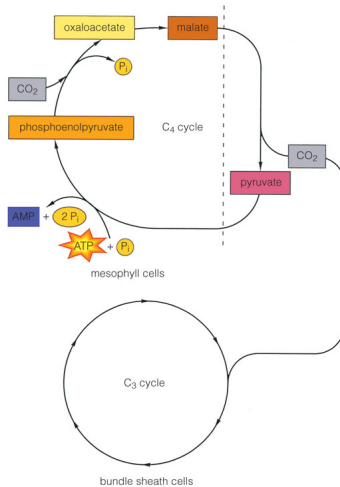
Photorespiration

- $O_2 + C_5$ (ribulose biphosphate) $\xrightarrow{\text{rubisco}}$ 3-phosphoglycerate $\rightarrow CO_2 + PGAL + \text{other molecules}$ (through mitochondria)
- This is a sideway, wasteful process because it costs energy more than Calvin cycle, wastes C_5 and also produces toxic ammonia
- Rubisco is two-faced enzyme, it catalyzes photorespiration if the concentration of O_2 and/or temperature is high
- Photorespiration is said to be an evolutionary relic

Minimization of photorespiration

- To minimize photorespiration, plants need to increase concentration of CO_2
- $\text{CO}_2 + \text{C}_5$ (PEP, phosphoenolpyruvate) $\xrightarrow{\text{PEP carboxylase}}$ C_4 (different organic acids), this is the temporarily accumulation of carbon dioxide
- $\text{C}_4 \rightarrow \text{pyruvate} + \text{CO}_2$, the release of carbon dioxide will increase its concentration
- $\text{Pyruvate} + \text{ATP} \rightarrow \text{PEP} + \text{AMP} + 2\text{P}_i$, the cycle costs ATP
- Processes above called C_4 cycle, it is an addition to Calvin (C_3) cycle in order to increase concentration of CO_2

C₄ cycle



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C₄ and CAM plants

Two groups of plants have C₄ cycle:

① **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)

② **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-plants (7,300 species, 3%) are especially common among Poales (grasses order, e.g., corn) and Caryophyllales (pink order)

Jade plant



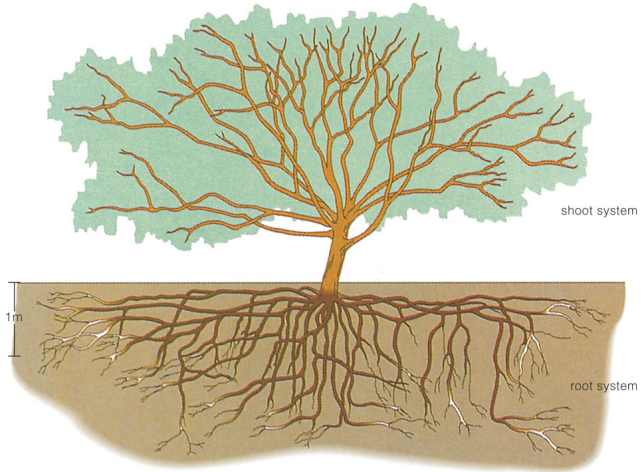
CAM is named after the family Crassulaceae, to which Jade plant (*Crassula ovata*) belongs

Corn



Corn (*Zea mays*) is the C_4 plant, minimizing photorespiration at higher temperatures.

Root system and shoot system



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Definition and functions

- Axial vegetative organ with a function of soil nutrition
- Other functions:
 - 1 Anchor
 - 2 Synthesis
 - 3 Storage
 - 4 Communication
- Features:
 - 1 No leaves
 - 2 Geotropic growth
 - 3 Locates in soil or water

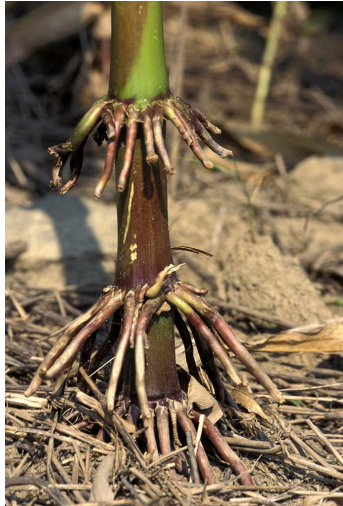
Types of roots

- Primary root: originates from root of seedling
- Secondary (lateral) roots: originate from primary roots
- Adventitious roots: originate from stems

Primary root



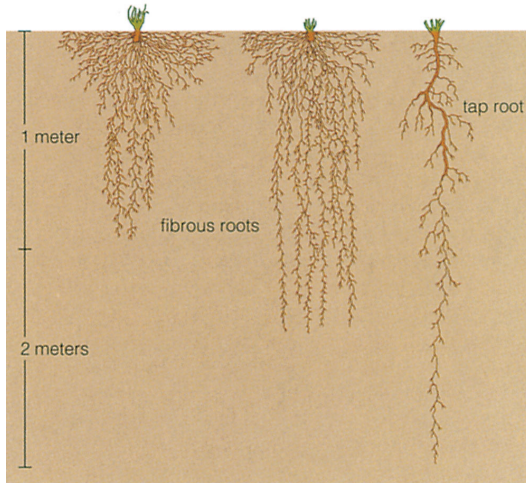
Adventitious root



Root systems

- Tap root system: with well developed primary root (most seed plants)
- Fibrous root system: without clearly visible primary root (monocots, ferns)

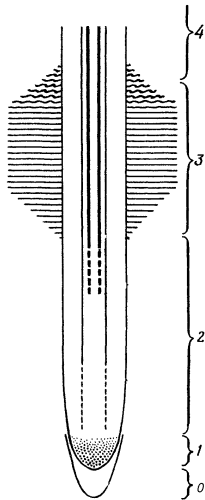
Fibrous and tap root systems



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Root zones

- Root cap
- Root meristem
- Elongation zone
- Absorption zone
- Maturation zone



Summary

- To prevent wasteful **photorespiration**, plants “invented” the addition to photosynthesis, C_4 cycle
- **C_4 cycle** accumulates and then releases carbon dioxide and therefore increases its concentration
- **Root** is an axial vegetative organ with a function of soil nutrition
- **Rhizoderm** and **absorption zone** are the most physiologically important parts of root

For Further Reading



Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.
Plant Biology. 2nd edition.
Thomson Brooks/Cole, 2006.
10, 7.1–7.3.