

C4 Photosynthesis

HORT 3000

C4 Photosynthetic Cycle

- Also called Hatch Slack pathway
- Monocots
- Two distinct photosynthetic tissues
 - Mesophyll
 - Bundle sheath cells
- Carboxylation step is different
 - Acceptor molecule
 - Carboxylation enzyme
 - Carbon source

Some Names and Abbreviations

- Phosphoenol pyruvate = PEP
 - HCO_3^- acceptor molecule
 - 3-carbon sugar
- Phosphoenol pyruvate carboxylase = PEPcase
 - Carboxylation enzyme
- Oxaloacetate = OAA
 - 4-carbon sugar
 - Product of carboxylation reaction

Some Names and Abbreviations

- Malate, Aspartate
 - 4-carbon sugars
- Carboxylation – addition of CO_2 to a molecule
- Decarboxylation – removal of CO_2 from a molecule

C4 Photosynthetic Cycle

First Two Steps of C4 Cycle

- $\text{HCO}_3^- + \text{PEP} > \text{OAA}$
 - Carboxylation step
 - Catalyzed by PEPcase

- OAA reduced by NADH to malate or aspartate (reduction step)

C4 Photosynthetic Cycle

Next Steps in C4 Cycle

- Malate/aspartate moves out of mesophyll into bundle sheath cells
- Decarboxylation in bundle sheath cells makes CO₂ available for fixation via PCR cycle
- Resulting 3-carbon sugar (from decarboxylation) moves back to mesophyll and is used to regenerate acceptor molecule
- Regeneration step requires 2 ATP

Similarities Between PCR and C4 Cycles

- Carboxylation steps energetically favorable
- NADPH / NADH required to remove product of carboxylation reaction through reduction
- ATP required for regeneration
 - 2ATP in C4, 1ATP in PCR

Differences.....

- C4 cycle itself doesn't result in any net carbon fixation
 - C4 plants still must use PCR cycle to fix carbon.
- C4 cycle includes decarboxylation step
- C4 cycle uses two different photosynthetic tissues
- PCR cycle occurs in
 - Bundle sheath cells – monocots
 - Mesophyll - dicots

Kranz Leaf Anatomy

- Only one type of mesophyll
- Vascular bundles closer together therefore more of them
- Bundle sheath cells surround vascular bundles, contain high concentration of chloroplasts
 - Fix CO₂ provided by C4 cycle

Kranz Leaf Anatomy

- Short diffusion path for CO₂ from stomata to initial carboxylation site (mesophyll)
- No mesophyll more than 2-3 cells from b.s. cells
- PCR occurs closer to vascular bundles
 - Photoassimilates quickly exported

Kranz Leaf Anatomy

Dicot vs. Monocot Leaf Anatomy

C4 Photosynthesis

- C4 Cycle concentrates CO₂ in bundle sheath cell at site of PCR Cycle.
- CO₂ assimilation is 2-3x's faster in monocots than in dicots
- PEP-carboxylase is not inhibited by high O₂, so less photorespiration in monocots than in dicots

Some Exceptions

- C3 grasses
 - Some cool season grasses
- C4 dicots
 - Some succulents

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