

Plant biochemistry

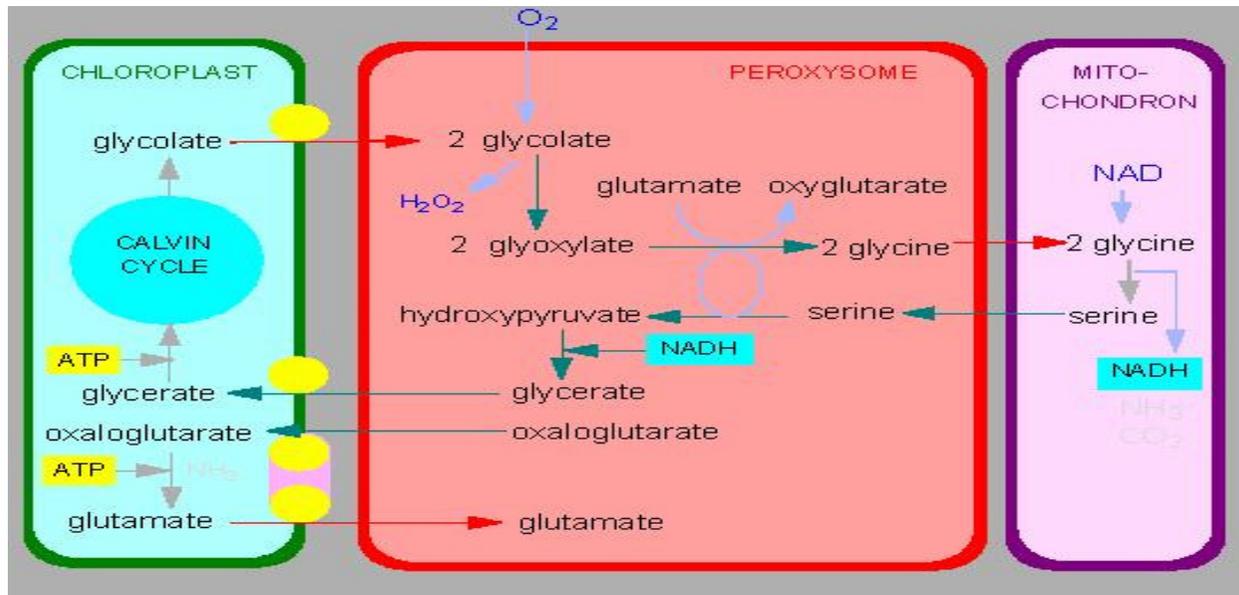
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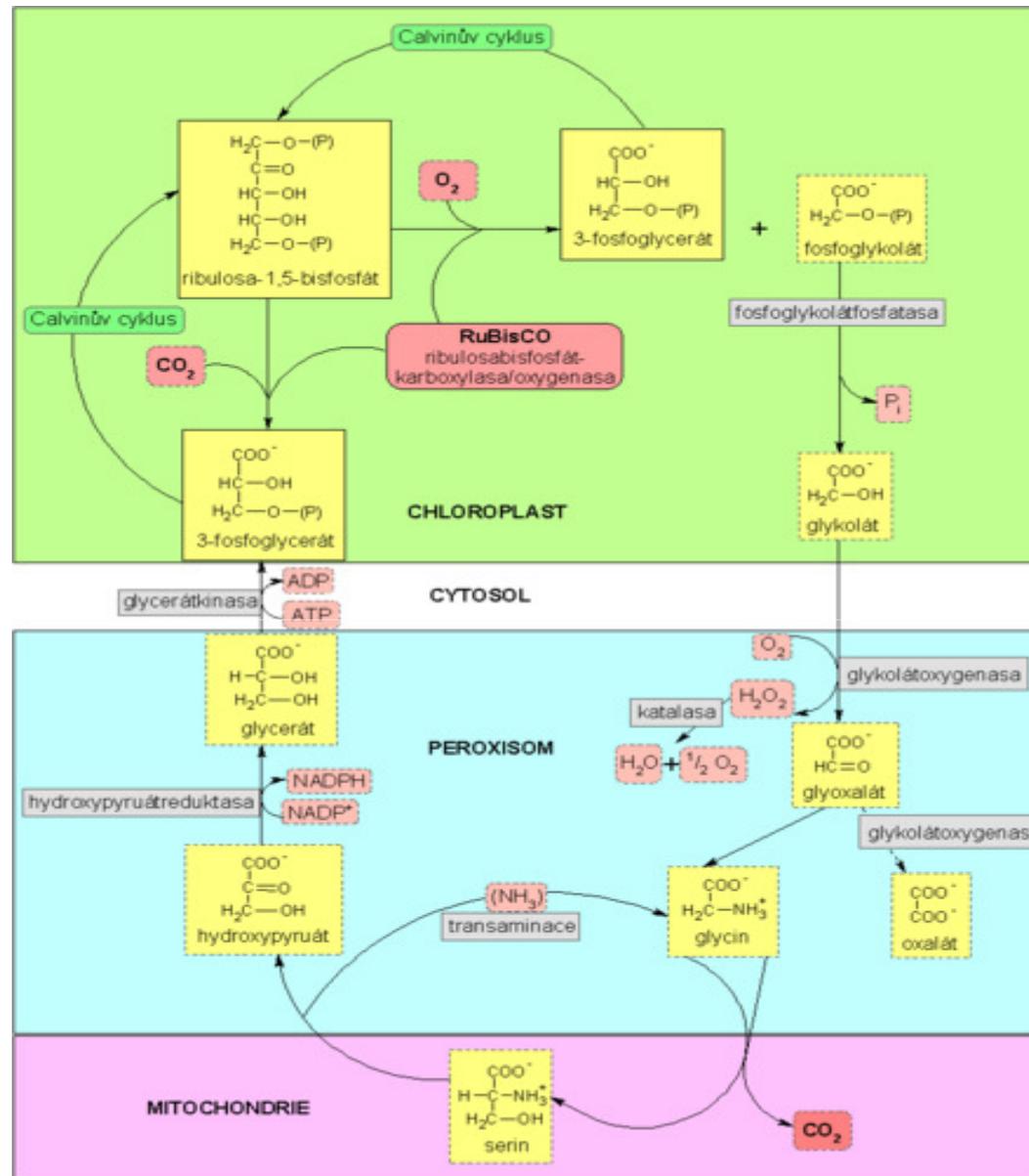
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Photorespiration

- The enzyme (Rubisco) has an **oxygenase** activity which increase more rapidly with Temperature than does its carboxylase activity.
- (Rubisco) ribulose 1.5 diphosphate carboxylase , is not specific for CO_2 as a substrate.
- **O_2 Competes with CO_2 at the active site**, and rubisco catalyzes the condensation of O_2 with ribulose 1,5 diphosphate to form one molecule of (3 phosphoglycerate) and one of phosphoglycolate.





- This reaction is carried out at the same active site of carboxylation so both reactions **compete** with each other .
- This is the **1st step in photorespiration** in which 2 molecules of phosphoglycolate is converted to one molecule of serine (which has 3 carbons) and a molecule of CO₂.
- However , under **normal** conditions the rate of the **carboxylase activity is 4 times** higher than the oxygenase activity.

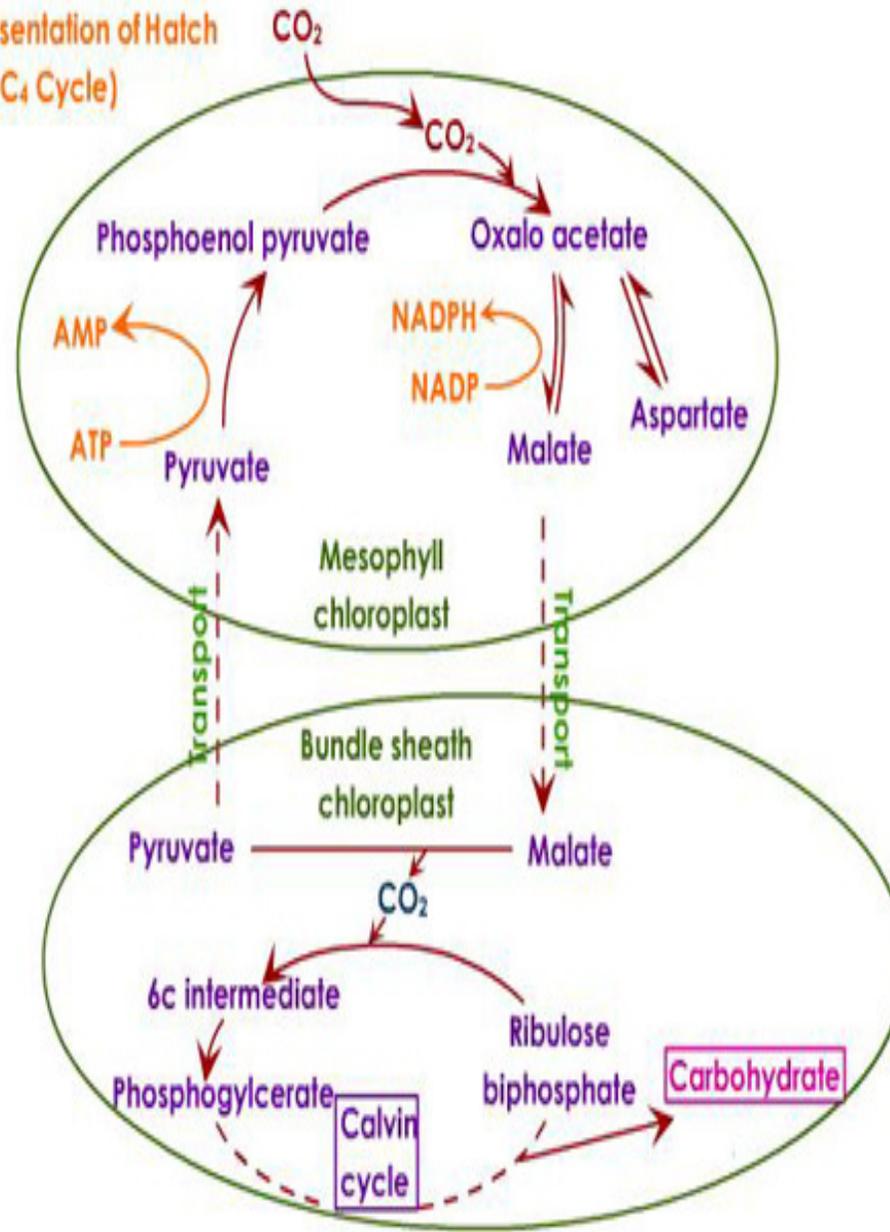
- ✓ Photorespiration consumes O₂ but unlike mitochondrial respiration, it does not conserve energy (**no energy production**, it is wasteful pathway).
- ✓ photorespiration **a catabolic process**, occurring only in the light in which O₂ is consumed and Co₂ is evolved.
- ✓ what the function of photorespiration remains obscure. It appears to be a totally wasteful process and yet it may be that future research will show that it has a use full role.

- ❖ one of the suggestions about the role of photorespiration is that it constitutes a **complex terminal oxidase system** for consuming excess ATP and NADPH which may have been generated in the light phase of photosynthesis .
- ❖ the fact that plants which are totally free of photorespiration have not so far been found, certainly suggests that it is useful process.

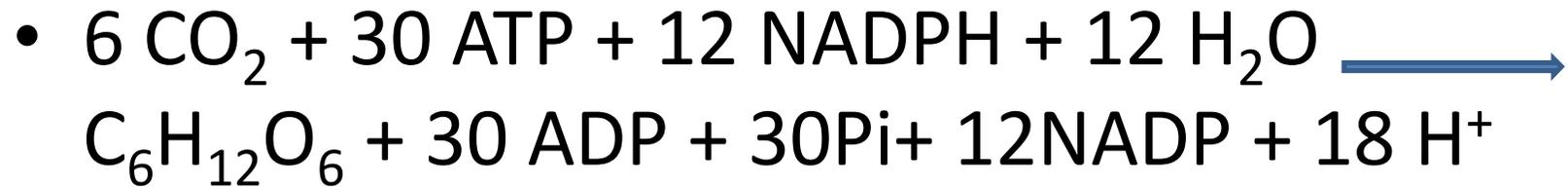
C₄ Pathway

- ❑ **Tropical plants** avoid very high rates of wasteful photorespiration by achieving a high local conc. Of CO₂ at the site of Calvin cycle in their photosynthetic cells .
- ❑ The C₄ Pathway is **used to transport Co₂** .[C₄ Plants prevent photorespiration, as it does not produce any energy] .
- ❑ C₄ Pathway starts in the **mesophyll cell** to transport CO₂ Via C₄ Compounds (dicarboxylic acid, malate) to the bundle – sheath cell .

The schematic representation of Hatch and Slack pathway (C₄ Cycle)



- When the C4 Pathway and Calvin cycle operate together then **the net reaction** is :



Plant :

- Ex .Corn (maize) and sugar cane .
- C4 which grow in high light intensity and temp, have several important characteristics :
 1. high photosynthetic rate .
 2. high growth rate .
 3. low photorespiration rate
 4. low rates of water loss.
 5. a unusual leaf structures which are :

a unusual leaf structures which are :

- i. **air space extending** from the atmosphere to a very high proportion of photosynthetic cells, allowing efficient CO₂ intake .
- ii. mesophyll cells **loosely arranged** in spirals around the layers of bundle – sheath cells .
- iii. the presence of **many plasmodesmata** between mesophyll cells and bundle – sheath cells .
- iv. stomata **have higher resistance** to CO₂ diffusion than C₃ plants .

- **N.B**

- **C₄** plants serve to **Concentrate CO₂** in the **bundle – Sheath** chloroplast → higher CO₂ Conc .gradient between atmosphere and the mesophyll cell surface because stomata have higher resistance to CO₂ diffusion than C₃ Plant.
- Photorespiration is **very active in C3** Plant but is relatively in significant in C₄ plants,

- ✓ C_3 Plants lose 20-40 % of CO_2 , fixed by photosynthesis, as a result of photorespiration. Such losses in C_4 plants are very small.
- ✓ This would indicate that C_4 plants grow more efficiently than C_3 plants.
- ✓ This is particularly unfortunate in view of the fact that all major agricultural crop species with exception of maize , millet, Sorghum and sugar cane are C_3 plants .

Variations in the mechanisms of the dark phase of photosynthesis

C₃ plants	C₄ plants
1. occurs in plants that need optimum temp for CO ₂ fixation 15- 25 c ⁰ (major agricultural group)	1. occurs in tropical grass e.g maize (corn), millet, sugar cone .Sorghum (plants grow optimally at high light intensity and at day temp of 30-35 c ⁰)
2. absence of dicorboxylic acid	2. presence of dicarboxylic acid (e.g malic acid)
3. one carboxylation reaction	3. two carboxylation reactions - one in mesophyll cell : corbuxylation of PEP - One in bundle – sheath cell: RUDP carboxylation
4. ATP and 2 NADPH are required for fixation of each CO ₂	4. additional 2 ATP are required for conversion of pyruvic acid into PEP in the mesophyll .cells So, 5 ATP +2 NADPH are required for fixation of each CO ₂ c waste full of 2 ATP per CO ₂ fixed

5. CO_2 is the substrate for RUDP Carboxylase	5. HCO_3^- (bicarbonate) is the substrate of PEP carboxylase
6. Usual leaf Structures a. Stomata have low resistance to gaseous flow b. C_3 has much less open structure than in C_4 Leaves	6. Unusual leaf Structures a. stomata have higher resistance to gaseous flow that . * reduce loss of H_2O from plant leaves * Conc CO_2 in the bundle – sheath cell higher CO_2 conc gradient between a atmosphere and mesophyll cell surface b. leaves characterized by having an extensive network of air spaces which allows air to bathe a high proportion of photosynthetic cells
7. photo respiration is very active as a result of photo respiration	7. photorespiration is relatively insignificant
8. C_3 plants lose 20-40 % of carbon fixed by photosynthesis grow less efficiently than C_4 (particularly unfortunate)	8. C_4 plants grow more efficient than C_3