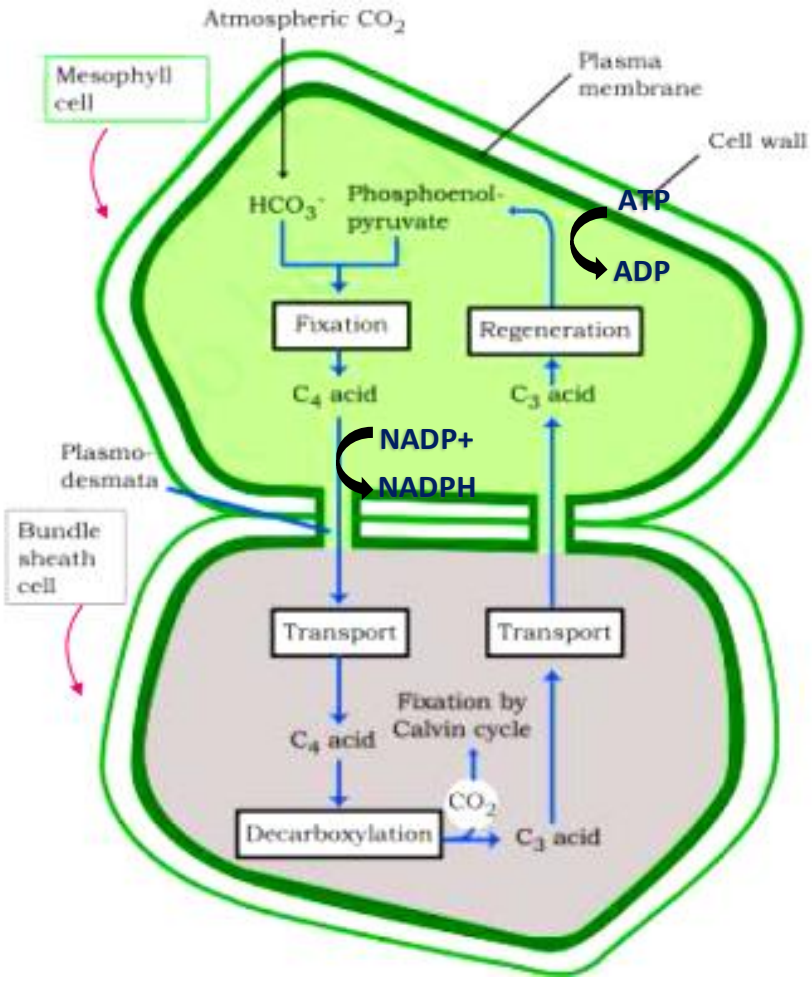
C4 pathway/Hatch Slack Pathway (1965, 1967),

- For plants adapted to dry tropical region like Maize, Sugarcane, Sorghum etc.
- First stable product is 4-carbon compound **Oxaloacetic acid** (AAO).
- C_4 plants have **Kranz Anatomy** (vascular bundles are surrounded by bundle sheath cells arranged in wreath like manner), characterized by large no of chloroplast.
- Bundle Sheath cells have thick wall impervious to gases and absence of intercellular spaces.
- The primary CO_2 acceptor is a 3-carbon molecule **Phosphoenol Pyruvate** present in mesophyll cells and enzyme involved is Phosphoenol Pyruvate carboxylase (**PEPcase**).
- In C4 plants Mesophyll cells lack RuBisCO and it is present in Bundle Sheath where Calvin cycle takes place.

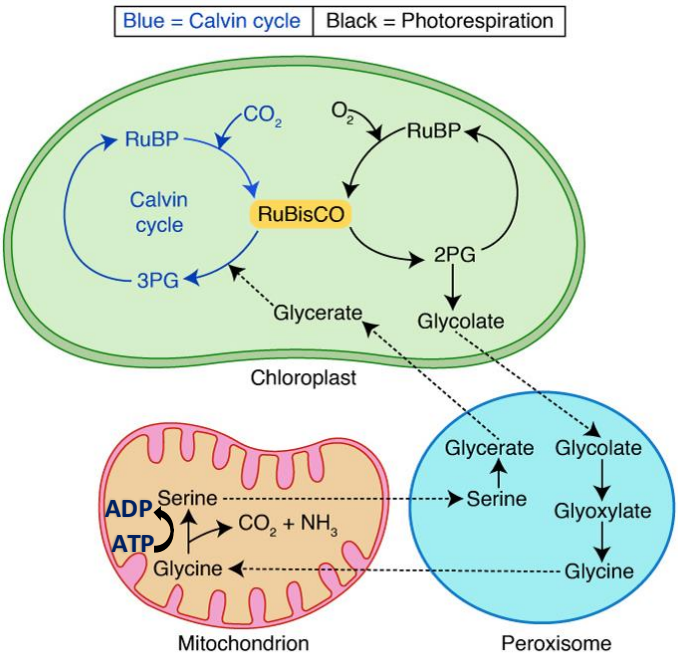


1. **Carboxylation/ CO_2 Fixation:** CO_2 from atmosphere is converted Bicarbonate ions using enzyme carbonic anhydrase and further Bicarbonate ions are converted to **Oxaloacetic acid (OAA)** with the help of Phosphoenol Pyruvate (PEP) in the mesophyll cell using enzyme **PEPcase.**
2. Oxaloacetate reduces to malic acid & aspartic acid (4-C compound) in the presence of malate dehydrogenase enzyme.
3. **Transportation:** The malic acid then transferred to the bundle sheath cell through plasmodesmata.
4. **Decarboxylation:** In bundle sheath cell, malic acid is decarboxylated in the presence of the malic enzyme and releases Carbon dioxide & Pyruvate.
5. Carbon dioxide enters into the Calvin cycle (Chloroplast in Bundle sheath) and pyruvate returns back to the mesophyll cells.
6. Regeneration: In mesophyll cell, pyruvate in the presence of pyruvate phosphate dikinase enzyme converts into phosphoenolpyruvate, and the cycle repeats.

Photorespiration

- Photorespiration decreases the rate of photosynthesis when oxygen concentration is increased from 2-3% to 21%.
- **RuBisCO** (most abundant enzyme) has much greater affinity for CO_2 that O_2 if they are in equal ration.
- In case of low CO2 concentration and high O_2 concentration RuBisCO act as oxygenase.
- In C3 plants in presence of light and higher concentration of Oxygen results in the binding of RuBisCO enzyme with O_2 to form.
- Result in formation of one molecule of PGA (3C) & one molecule of phosphoglycolate (2C).
- In photorespiration no sugar is synthesise rather ATP is used to release CO_2.
- This pathway involves **Chloroplast, Peroxisome and Mitochondria**.

  RuBisCO + $O_2 \rightarrow$ PGA + phosphoglycolate (2C)

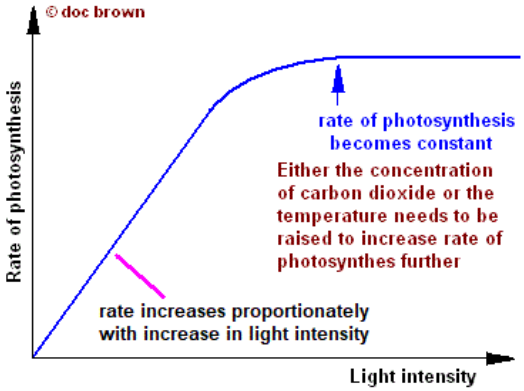


Que: Why Photorespiration does not occur in C4 Plants?

Ans: Because in mesophyll cells CO2 is converted to C4 acid that is transfer to bundle sheath and broke-down there to release CO2 that increases intracellular concentration of CO2 at enzyme site. This ensures that the RuBisCO functions as a carboxylase, thus, minimising the oxygenase activity.

Factors affecting photosynthesis

Internal factors affecting rate of photosynthesis are , size, age and orientation of leaves, mesophyll cells and chloroplasts, internal CO2 concentration and the amount of chlorophyll. It dependent on the genetic predisposition and the growth of the plant.



External factors are:

1. **Light-** as light intensity increases, the rate of photosynthesis also increases until light saturation point.
   Light Saturation occur at 10 percent of full sunlight.
   Increase in light intensity beyond a point causes breakdown of chlorophyll.
2. **Carbon dioxide concentration**– Major limiting factor for photosynthesis.
   With increase in concentration of CO_2 up to 0.05 % CO2 concentration fixation rate increases, beyond this can be damaging.
   In Low light intensity neither C3 nor C4 respond to high CO2 conc.
   In high light intensity both C3& C4 show increase in Photosynthesis.
   Saturation point for C4 plants is 364 μlL^{-1} while for C3 plant is 450 μlL^{-1}.
   Greenhouse crop (require more CO_2 conc) Tomato, bell Peper etc.
3. **Temperature-** it does not influence the rate of photosynthesis directly but at higher temperature enzyme activity is inhibited due to denaturation of enzymes which affect the dark reaction.
   C3 plant have lower optimum temp.
4. **Water**– Water stress can cause closing of stomata, makes leaves wilt and decrease surface area hence decrease metabolic activity.
   Increase in amount of water, does not increase proportionally as after saturation no more water is required during photosynthesis.

Blackman's Law of Limiting Factors states:

If a chemical process is affected by more than one factor, then its rate will be determined by the factor which is **nearest to its minimal value:** it is the factor which directly affects the process if its quantity is changed.

Que: Differentiate between C3 plants and C4 plants.

C3 plants	C4 plants
1. The leaves do not have Kranz anatomy. 2. Photorespiration occurs. 3. RuBP is the first acceptor of CO2. 4. PGA is the first stable product. 5. Plants can not tolerate high temp & high light intensity 6. Mesophyll cells perform complete photosynthesis.	1. The leaves show Kranz anatomy in leaves. 2. Photorespiration does not occur. 3. PEP is the first acceptor of CO2. 4. OAA is the first stable product. 5. Plants can tolerate high temp & high light intensity 6. Mesophyll cells perform only initial fixation rest process is completed in Bundle Sheath.

Que: How many ATP and NADPH are used in C3 & C4 cycle to produce one molecule of glucose.

In C3 Cycle : Total 18 ATP and 12

In C4 Cycle: 30 ATP and 12 NADPH