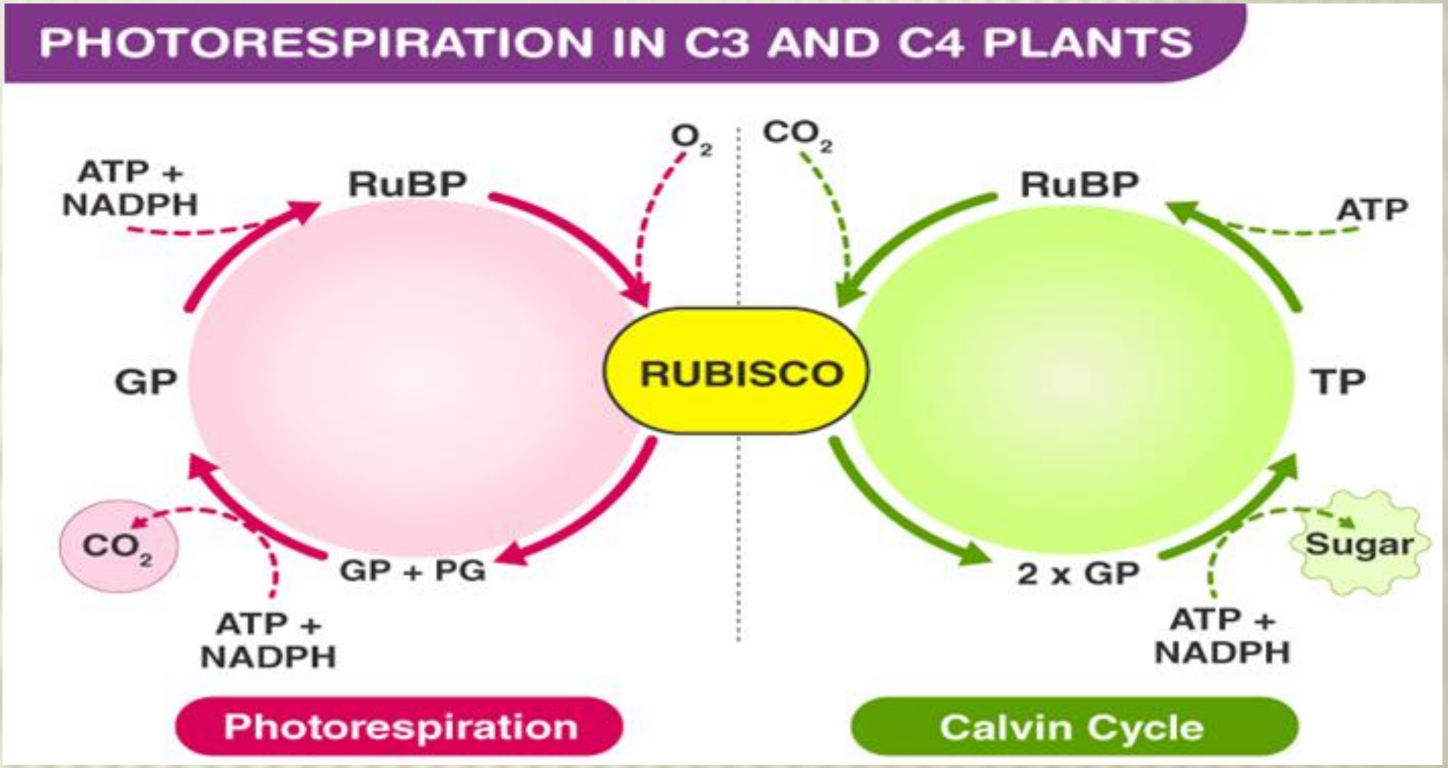
Bhagalpur National College, Bhagalpur

(A Constituent unit of Tilka Manjhi Bhagalpur University, Bhagalpur)

Photorespiration, C4 cycle, CAM cycle (B.Sc.-III)



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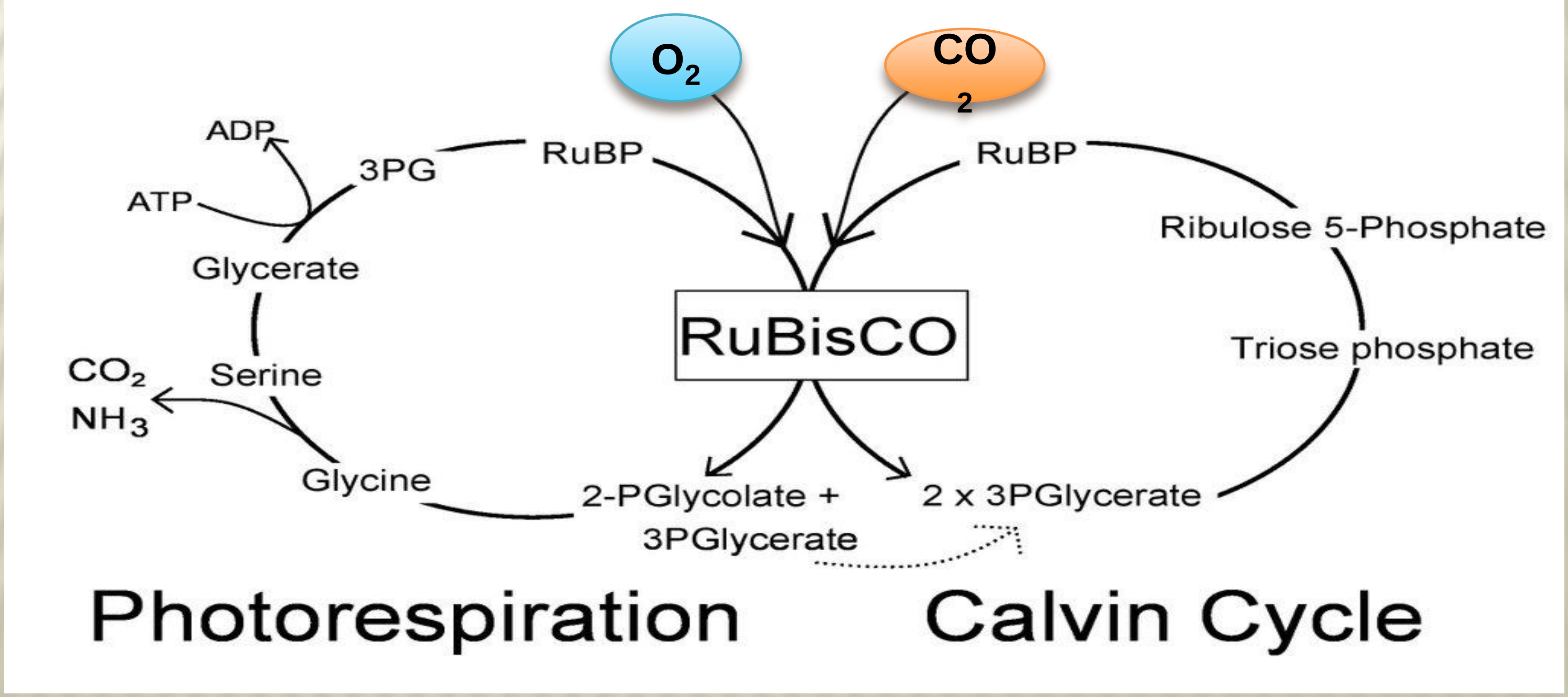
Photorespiration

- Photorespiration occurs when the CO_2 levels inside a leaf become low. This happens on hot dry days .
- On hot dry days the plant is forced to close its stomata to prevent excess water loss.
- The plant continues fix CO_2 when its stomata are closed, the CO_2 will get used up and the O2 ratio in the leaf will increase relative to CO_2 concentrations.
- When the CO_2 levels inside the leaf drop to around 50 ppm, Rubisco starts to combine O_2 with RuBP instead of CO_2.

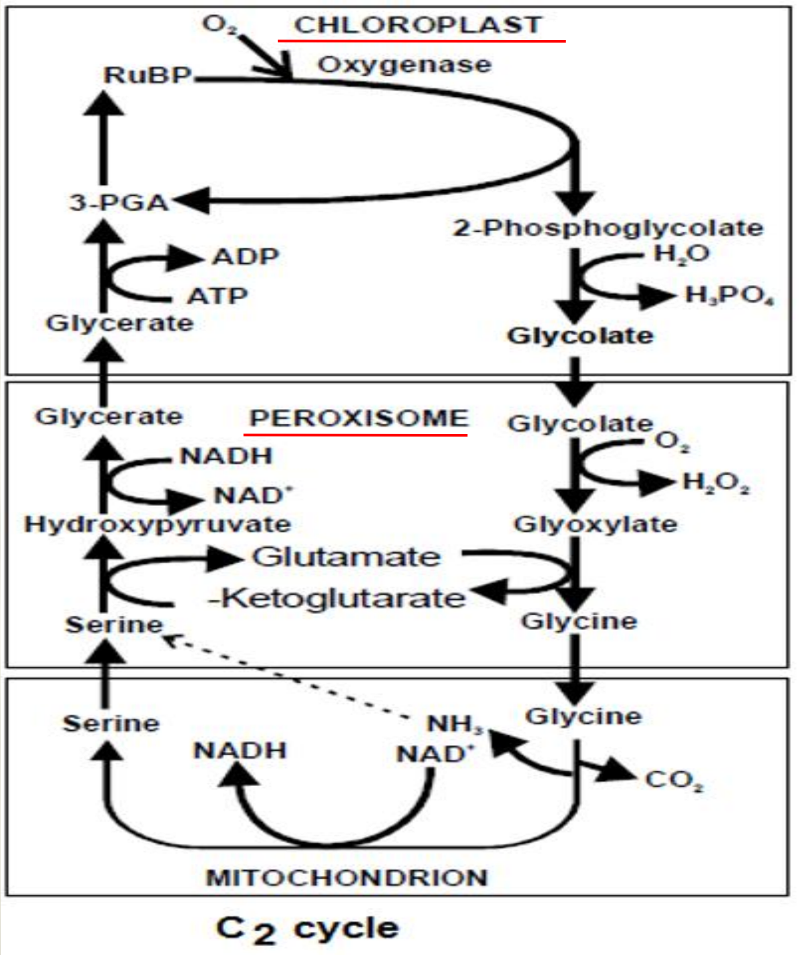


▪ The net result of this is that instead of producing 2 (3C) PGA molecules, only one molecule of PGA is produced and a toxic 2C molecule called **phosphoglycolate** is produced.

▪ The plant must get rid of the phosphoglycolate since it is highly toxic.

▪ It converts the molecule to glycolic acid which is transported to the peroxisome and there converted to **glycine.**

▪ This glycine is further transported to mitochondria where it deaminated to produce **serine**.



- The serine is then used to make other organic molecules.

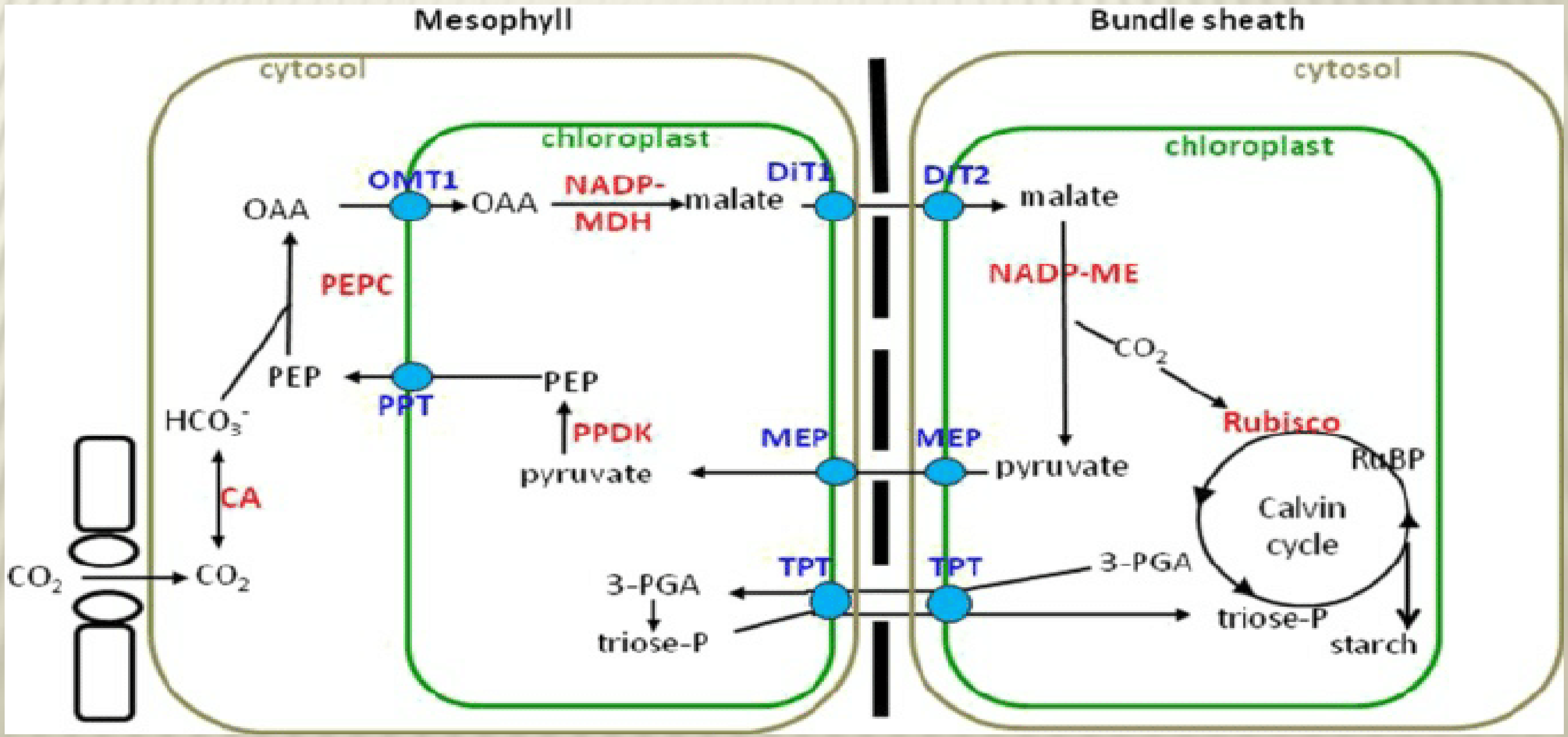
- All these conversions cost the plant energy and results in the net loss of CO2 from the plant.

- To prevent this process, two specialized biochemical additions have been evolved in the plant world: **C_4** and **CAM metabolism.**

C_4 Pathway

- The C_4 pathway is designed to efficiently fix CO_2 at low concentrations and plants that use this pathway are known as C_4 plants.

- These plants fix CO_2 into a four carbon compound (C_4) called **oxaloacetate (OAA)**. This occurs in cells called mesophyll cells.



Overall C_4 Pathway

- CO_2 is fixed to a three-carbon compound called phosphoenolpyruvate (**PEP**) to produce the four-carbon compound **oxaloacetate** (OAA). This step occursin cells called **mesophyll cells**.

- The enzyme catalyzing this reaction, PEP carboxylase (**PEPC**), fixes CO_2 very efficiently so the C_4 plants don't need to have their stomata open as much.

- The oxaloacetate is then converted to another four-carbon compound called **malate** in a step requiring the reducing power of NADPH.

- The malate then exits the mesophyll cells and enters the chloroplasts of specialized cells called **bundle sheath cells**.

- Here the four-carbon malate is decarboxylated to produce CO_2, a three-carbon compound called **pyruvate**, and **NADPH**.

- The CO_2 combines with ribulose bisphosphate (**RuBP**) and goes through the Calvin cycle.

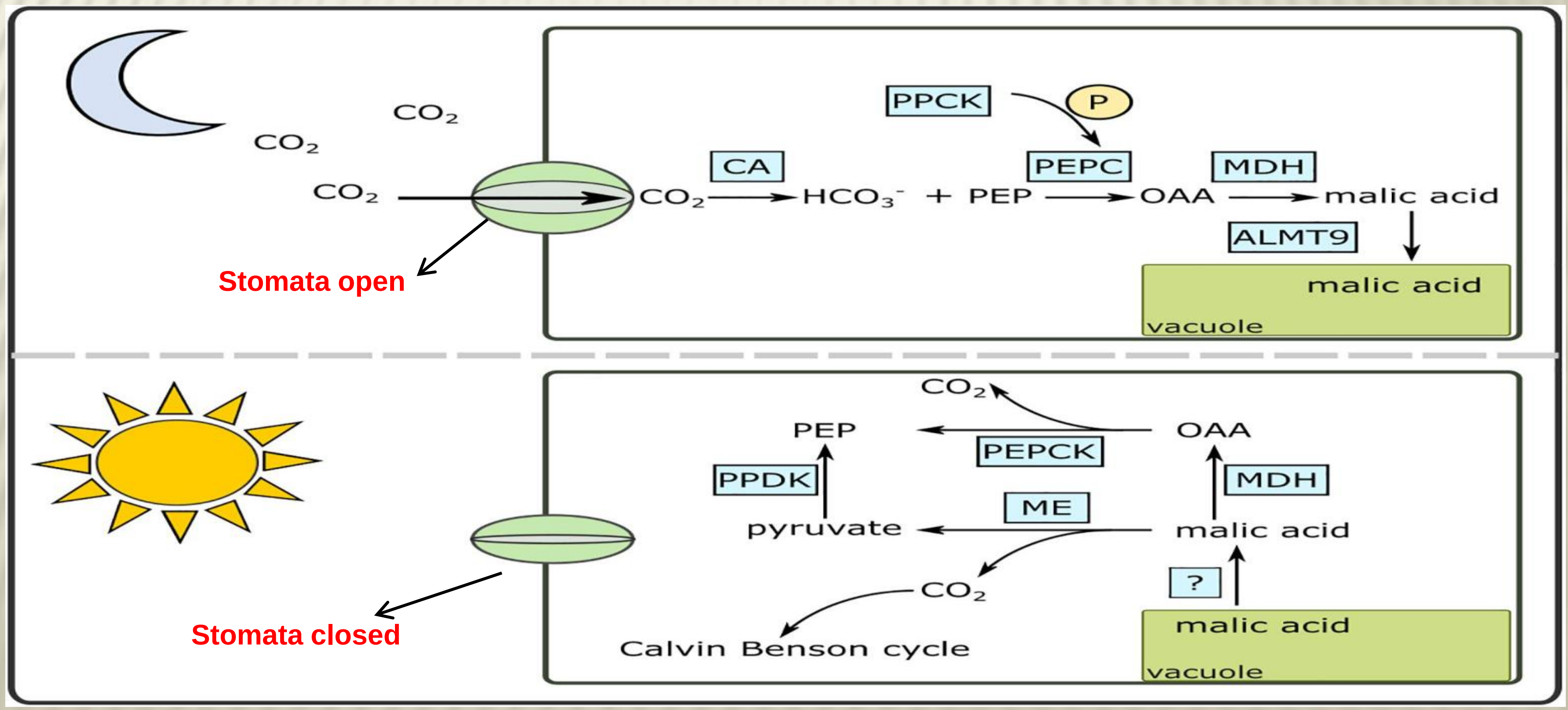
- The pyruvate re-enters the mesophyll cells, reacts with ATP, and is converted back to phosphoenolpyruvate (**PEP**), the starting compound of the C_4 cycle.

CAM Pathway

➢ CAM plants live in very dry condition and, unlike other plants, open their stomata to fix CO_2 only at night (**Acidification**).

➢ Like C_4 plants, they use PEP carboxylase (**PEPC**) to fix CO_2, forming **oxaloacetate**.

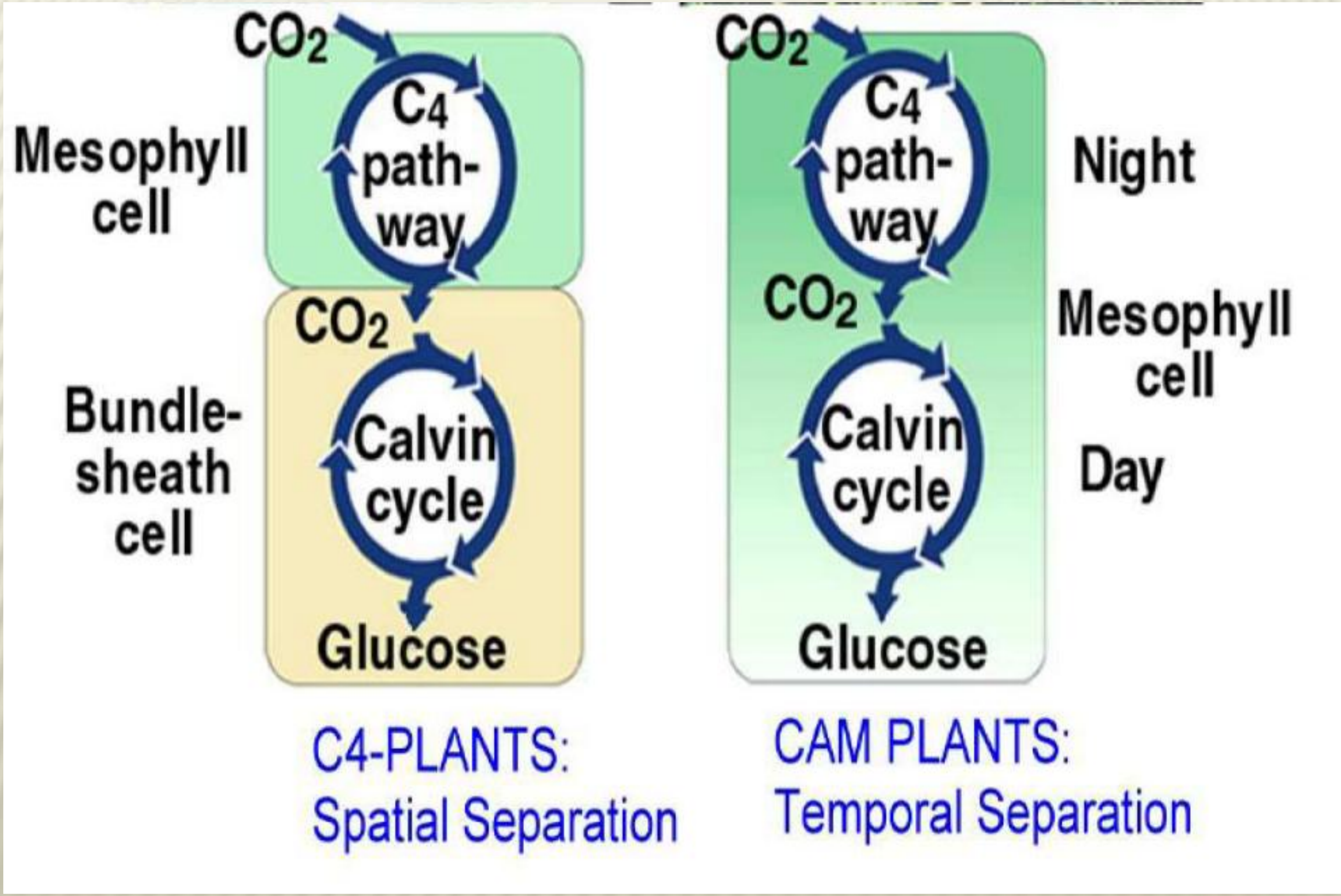
➢ The oxaloacetate is converted to **malate** which is stored in cell vacuoles. During the day when the stomata are closed, CO_2 is removed from the stored malate and enters the Calvin cycle.



Differences between calvin (C_3) and C_4

C_3	C_4
Temp 15-25° C	Temp 30-35° C
Absence of malate	Presence of malate
One carboxylation reaction	2 carboxylation reactions
CO_2 is the substrate	HCO_3 is the substrate
Usual leaf structures	Closed stomata to reduce water loss and concentrating CO_2 in the bundle sheet cells
	Additional ATP is required

Difference between C4 plants and CAM plants



Comparison between C3, C4, and CAM

	C3	C4	CAM
product	G3P Day &night	Malate Day &night	Malate Night only
Anatomy	No bundle sheet cell	Bundle sheet cell	No bundle sheet cell
No of stomata	2000-31000	10000-16000	100-800
Photorespirati on	Up to 40%	Not detectable	Not detectable
Species	Wheat, rice, potato	Sugar cane	Pineapple, vanilla, cacti

Factors affecting photorespiration

O_2: CO_2 Ratio

- If cells have low O_2 but Higher CO_2, normal photosynthesis i.e. Calvin Cycle dominates.
- C_4 plants have little photorespiration because they carry the CO_2 to the bundle sheath cells and can build up high CO_2.
- Calvin Cycle reactions always favored over photorespiration.
- If cells have higher O_2 and lower CO_2, photorespiration dominates.

Temperature

- Photorespiration increases with temperature.

THANK YOU