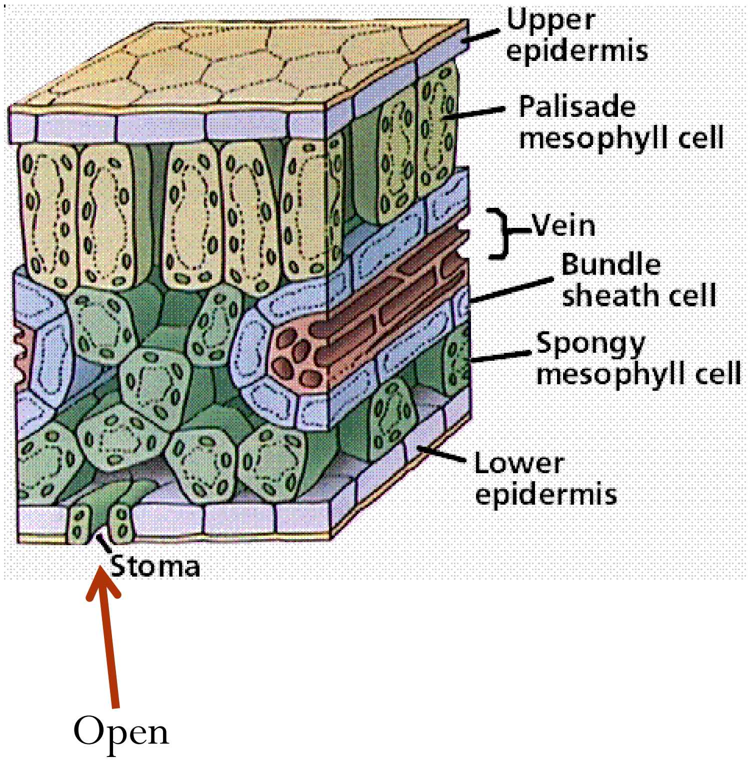
Comparison of C3, C4 and CAM Photosynthesis

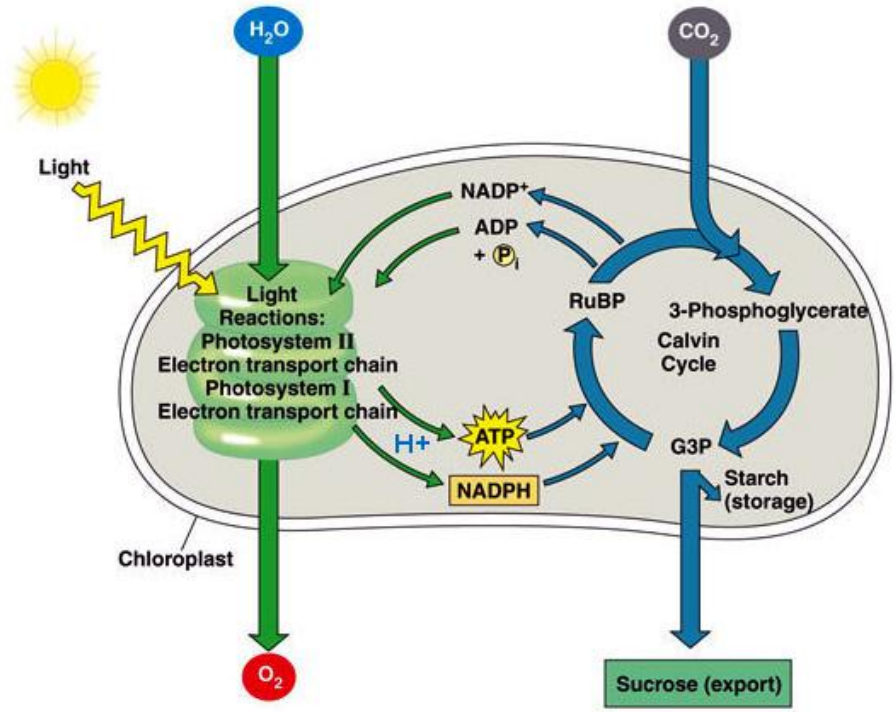
C3

- Photosynthesis is occurring in the mesophyll.
- Stomata are open during the day.
- CO_2 is fixed during the Calvin Cycle.
- CO_2 binds with RuBP using the enzyme RUBISCO.
- 6-C compound formed is unstable and quickly breaks into 3-C compounds.



C3 - Advantages

- More efficient than C4 and CAM plants under cool and moist conditions and under normal light.
- C3 requires fewer enzymes and no specialized plant anatomy.
- MOST plants are C3.



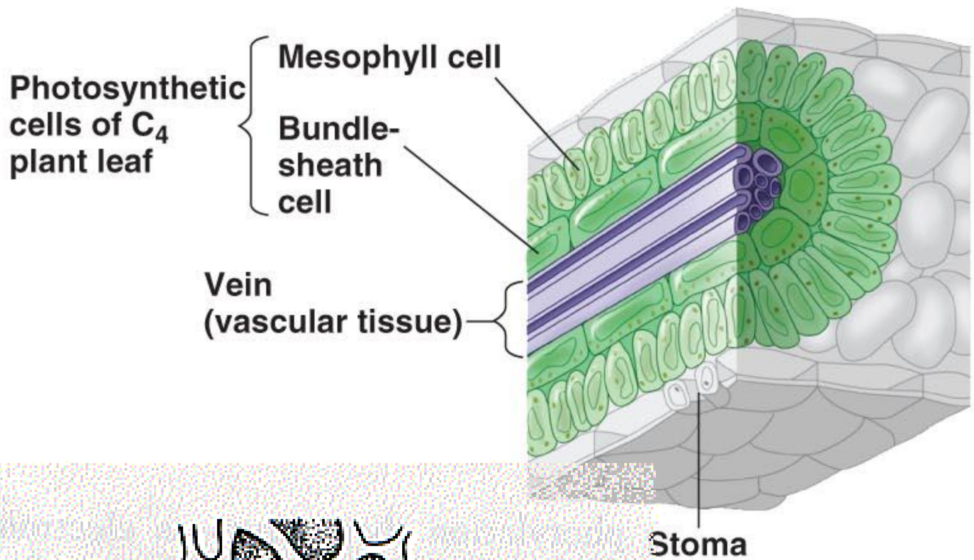
Problem with C3 pathway under high light intensity and high temperatures

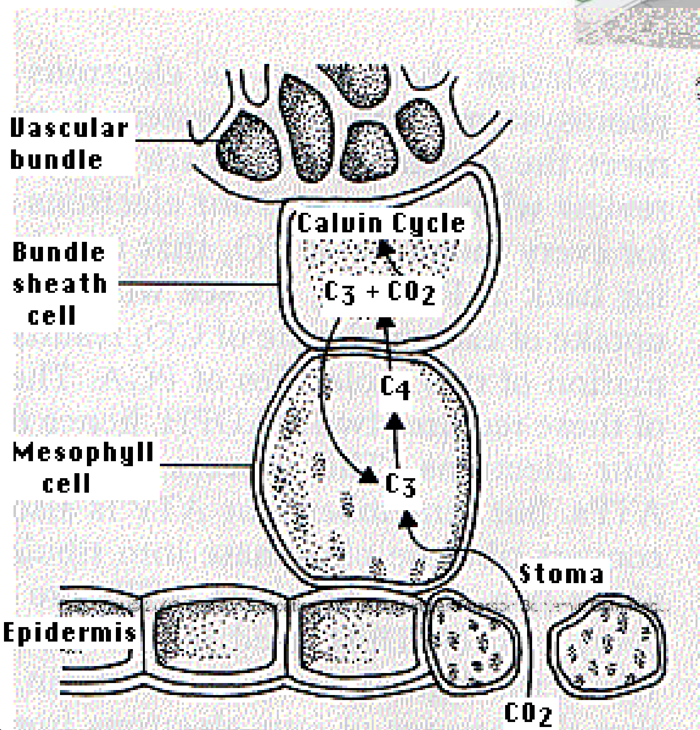
- Oxygen omitted by the light reactions dissolves in the cytosol.
- The higher the temperature (30°C and above) the more oxygen that dissolves in the cytosol.
- RUBISCO can bind to both CO2 and O2.
- High CO2, Low O2 – favors carboxlyase activity (continue in Calvin cycle)
- Low CO2, High O2 – favors oxygenase activity (photosrespiration)
  - Photorespiration undoes the carbon fixation that is occuring in the Calvin cycle and reduces overall plant productivity.

C4 Pathway

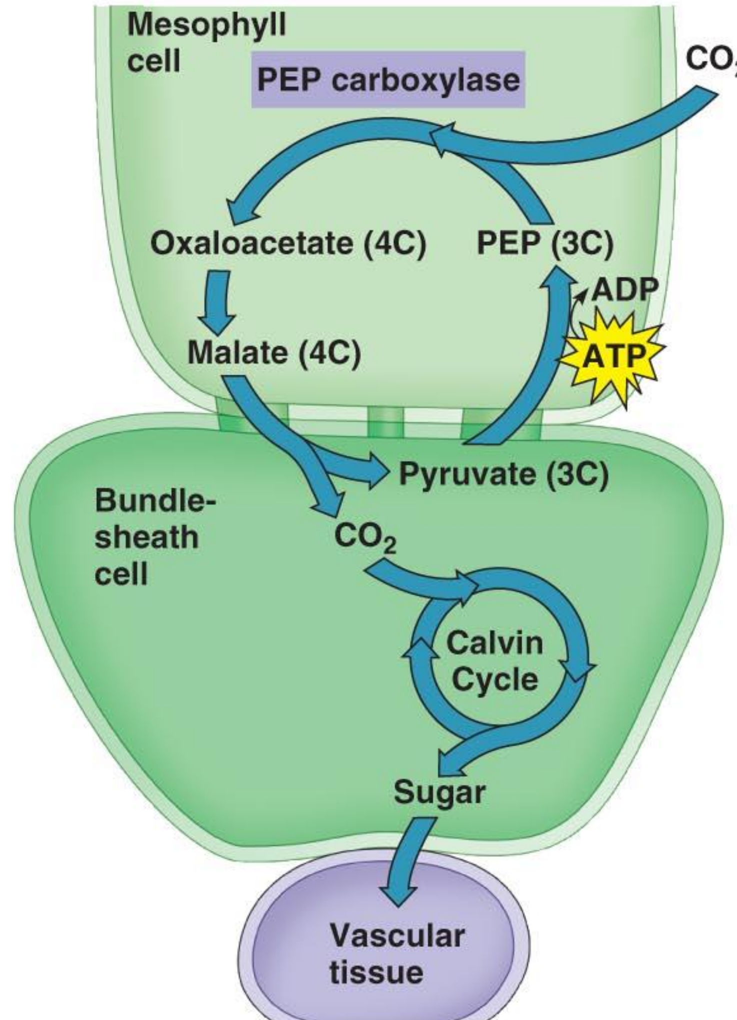
- **C_4 plants have structural changes in their leaf anatomy so:**
  - C_4 and C_3 pathways are separated in different parts of the leaf
  - RUBISCO sequestered where the CO_2 level is high; the O_2 level low.
- **CO_2 enters through the stomata and diffuses into a mesophyll cell**.
  - Being close to the leaf surface, these cells are exposed to high levels of O_2,
  - But have no RUBISCO so cannot start photorespiration (nor the reactions of the Calvin cycle).
- **Instead the CO_2 is inserted into a 3-carbon compound (C_3) called (PEP) forming the 4-carbon compound(C_4).**
- **The 4-C compound is transported into a bundle sheath cell**.
- **Here the 4-carbon compound is broken down into**
  - **carbon dioxide**, which enters the Calvin cycle to form sugars and starch.
  - **pyruvic acid** (**C_3**), which is transported back to a mesophyll cell where it is converted back into **PEP**.
- **These C_4 plants are well adapted to habitats with high daytime temperatures intense sunlight.**

C_4 leaf anatomy



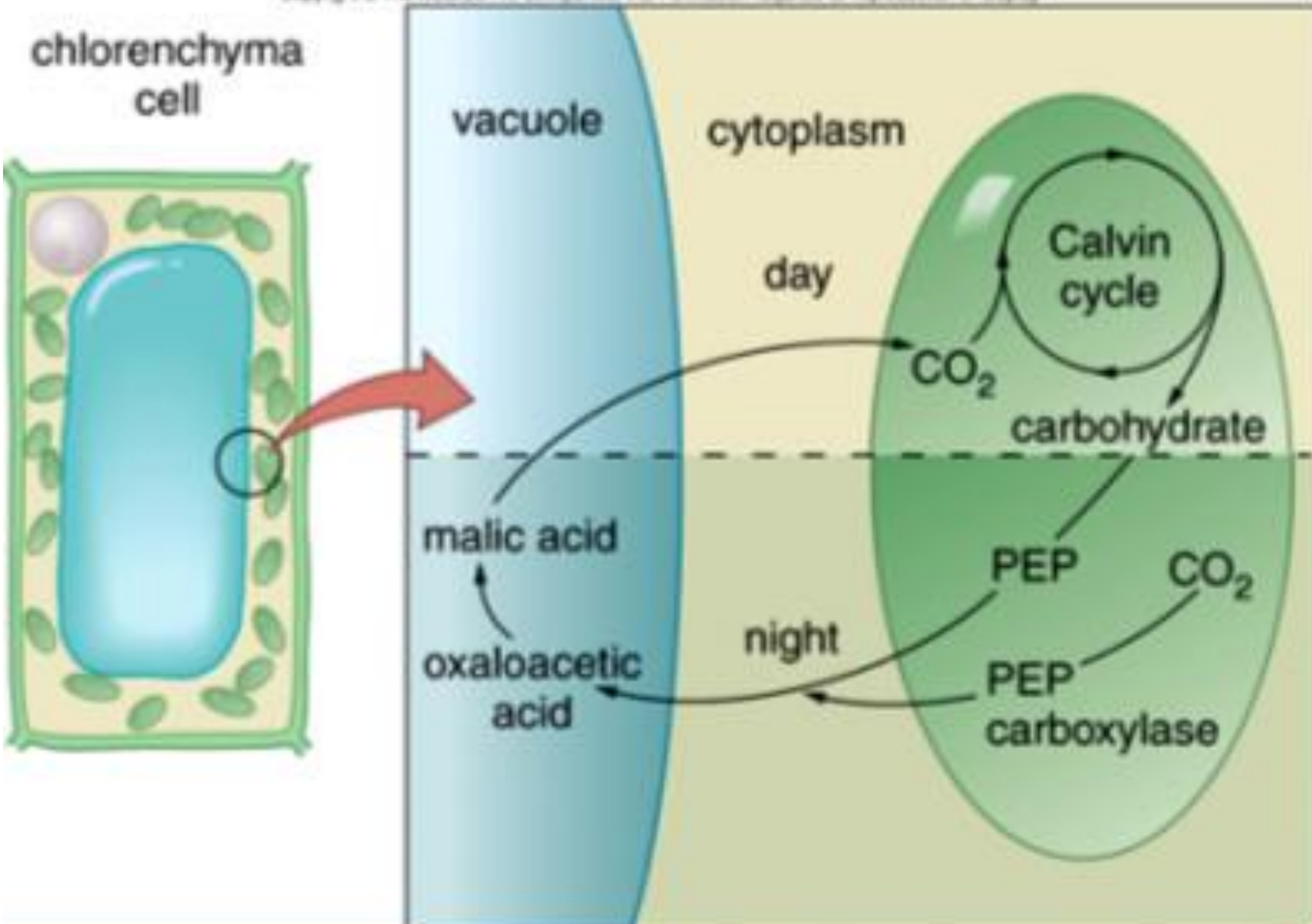


The C_4 pathway



CAM Pathway

- **These are also C_4 plants but instead of segregating the C_4 and C_3 pathways in different parts of the leaf, they separate them in time instead.**
- CAM plants take in CO_2 **at night** through their open stomata (they tend to have reduced numbers of them).
- The CO_2 joins with PEP to form the **4**-carbon oxaloacetic acid.
- This is converted to **4**-carbon **malic acid** that accumulates during the night in the **central vacuole** of the cells.
- In the morning, the stomata close (thus conserving moisture as well as reducing the inward diffusion of oxygen).
- The accumulated malic acid leaves the vacuole and is broken down to release CO_2.
- The CO_2 is taken up into the Calvin (C_3) cycle.
- These adaptations also enable their owners to thrive in conditions of high daytime temperatures , intense sunlight , low soil moisture.


chlorenchyma
cell
vacuole
cytoplasm
day
Calvin
cycle
CO_2
carbohydrate
malic acid
PEP
CO_2
night
oxaloacetic
acid
PEP
carboxylase