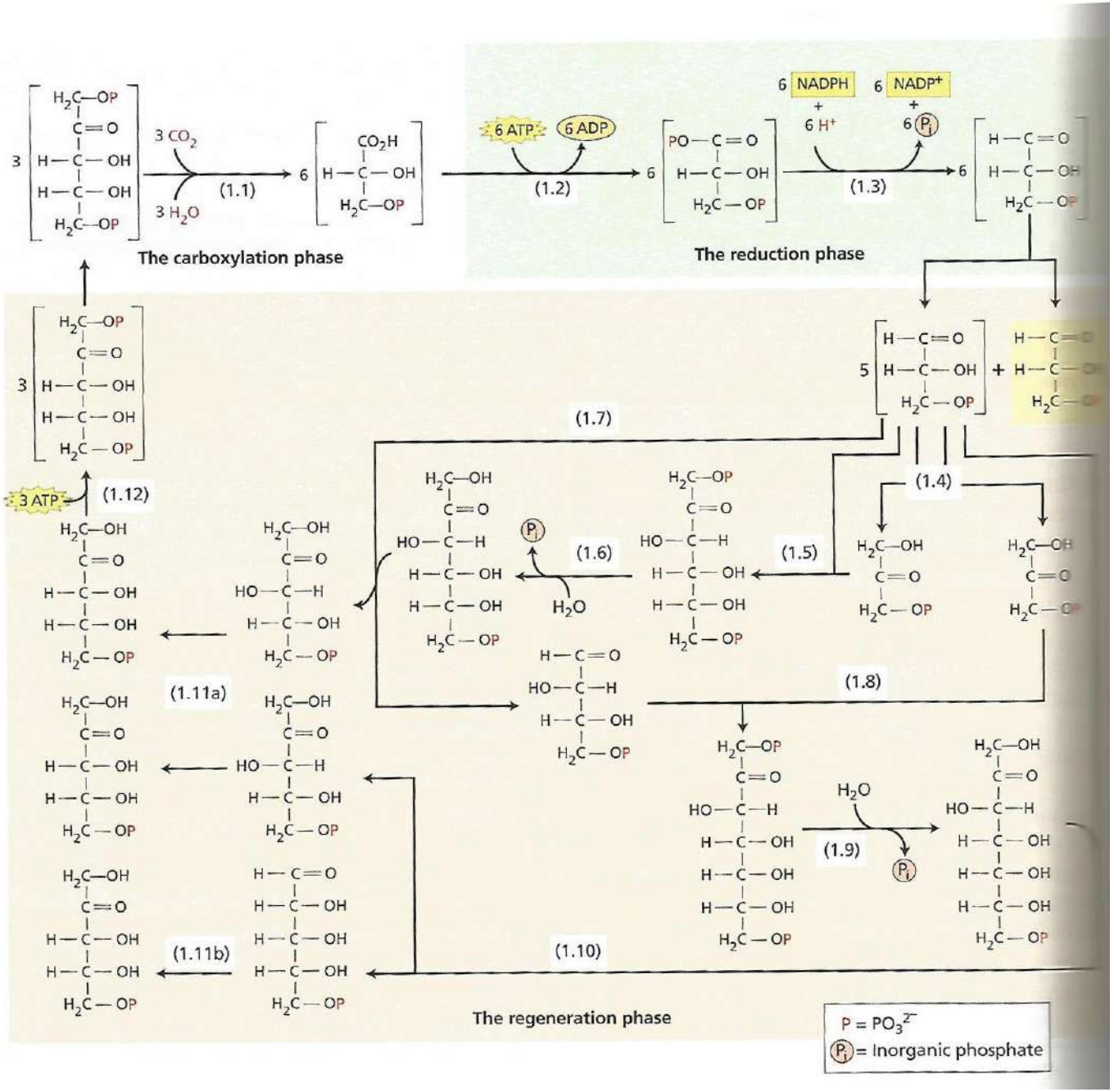

C2 C3 C4 & CAM
Variations on the
theme of photosynthesis


C3 Photosynthesis

C3 Photosynthesis

- Light reactions generate high energy molecules to run the dark reactions (Calvin cycle)
- The first step of the Calvin cycle is the fixation of carbon by RUBISCO using carbon dioxide and ribulose 1,5 bisphosphate as substrates

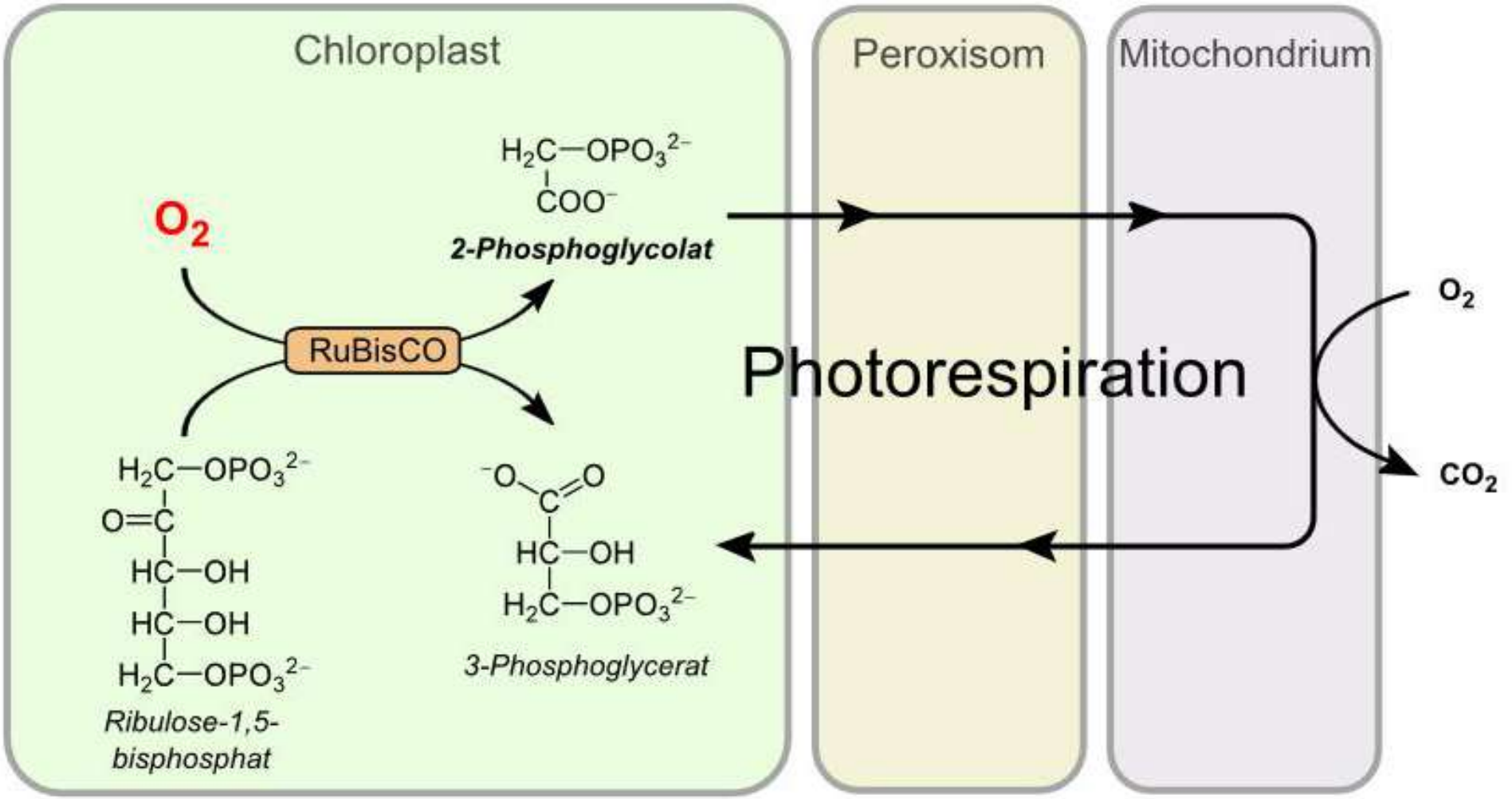
The Calvin cycle, in which 3-phosphoglycerate is formed and goes on to form sucrose for export or starch. Some is also used for recycling into ribulose 1,5 bisphosphate. RUBISCO is the key enzyme involved in carbon fixation. All pathway slides from Taiz & Zeiger – Plant Physiology and Development 6th ed.



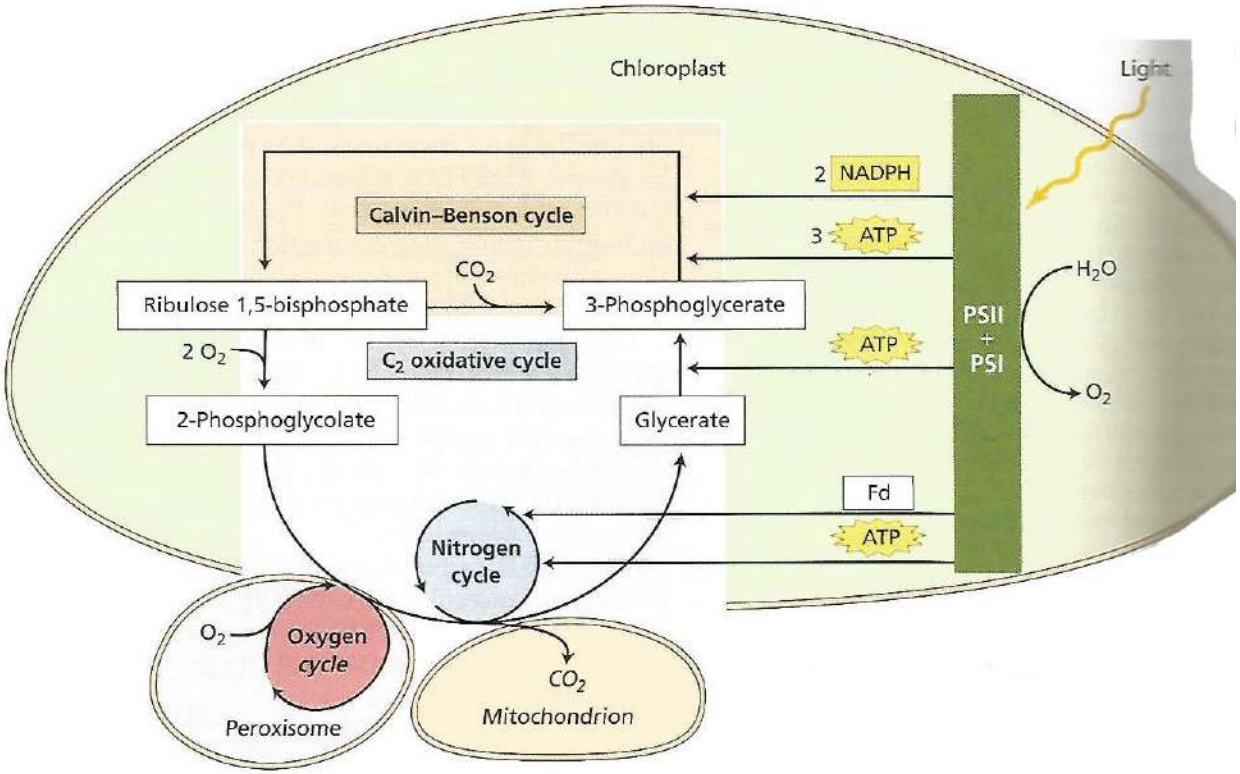
C2 Photosynthesis

- RUBISCO is an ancient enzyme, and evolved when oxygenation was insignificant
- With oxygenic photosynthesis and higher O2 levels in the atmosphere, oxygenation by RUBISCO became significant

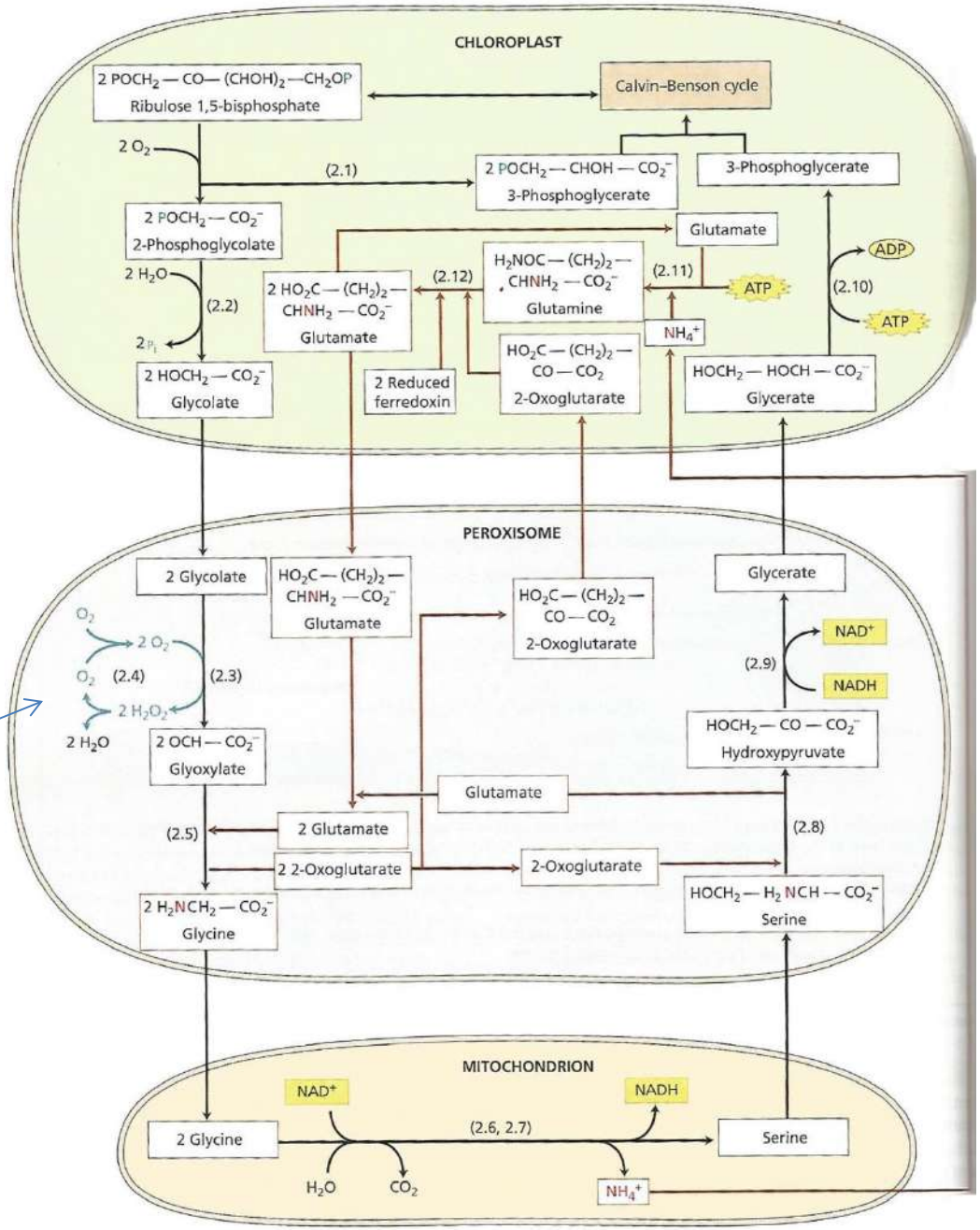
Problem is→ 2-Phosphoglycolate is toxic to plants, it inhibits distinct reactions in the Calvin Cycle. It also represents a significant loss of energy to the plant and is therefore at some cost returned to the Calvin cycle.



It takes energy to return 2-phosphoglycolate to the Calvin cycle



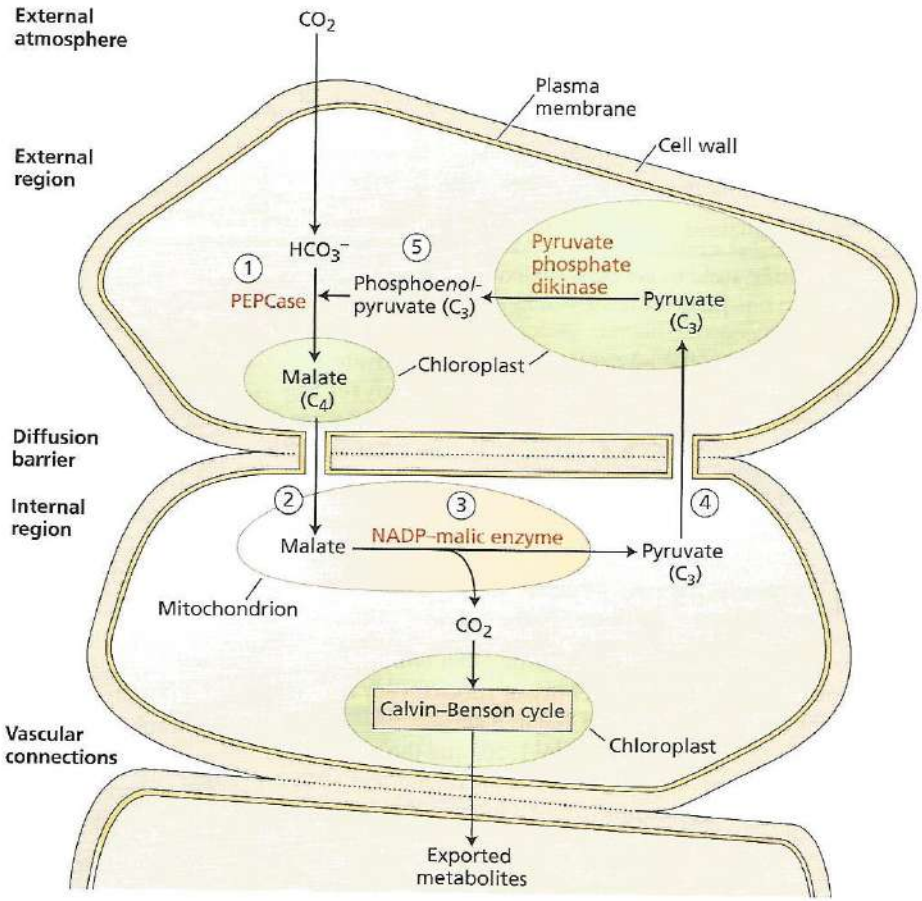
Glycolate oxidase



The C4 and CAM pathways evolved to reduce the impact of oxidation by RUBISCO (photorespiration)

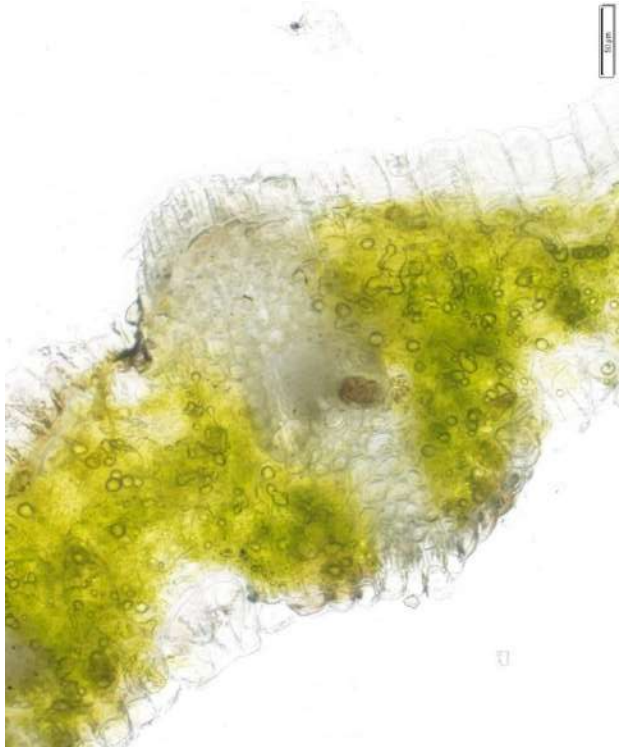
- The C4 photosynthetic pathway concentrates CO2 in the vascular bundle sheath cells of leaves to significantly reduce competition with O2 for the active site on RUBISCO
- The CAM photosynthetic pathway further separates absorption of CO2 in time from its incorporation in the Calvin cycle
- C4 & CAM are more efficient than C3 at yielding energy above about 85 degrees F–Rubisco favors oxygenation the higher the temp because the concentration of CO2 in leaf tissue is less the higher the temp

C4 Photosynthesis

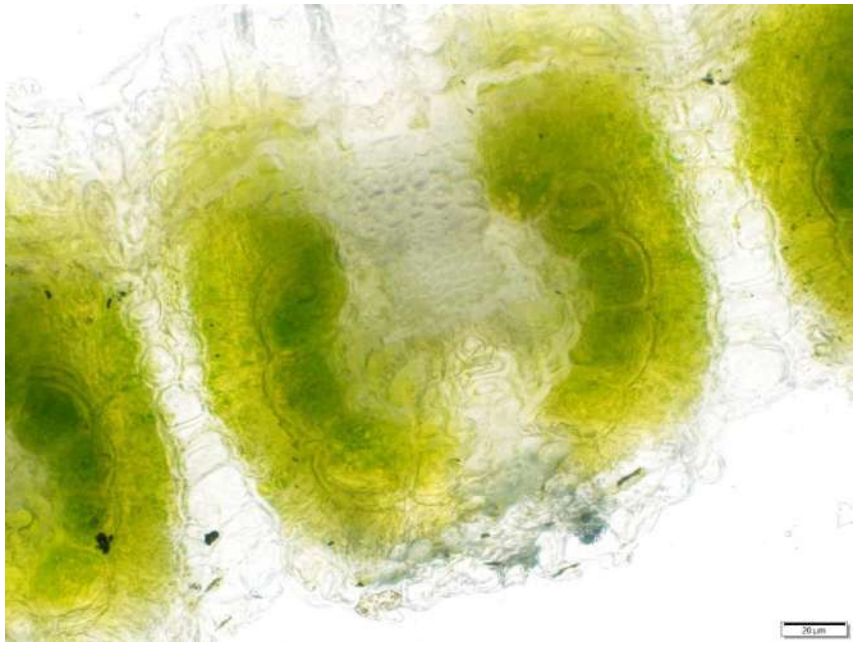


C3 & C4 Photosynthesis– Kranz Anatomy

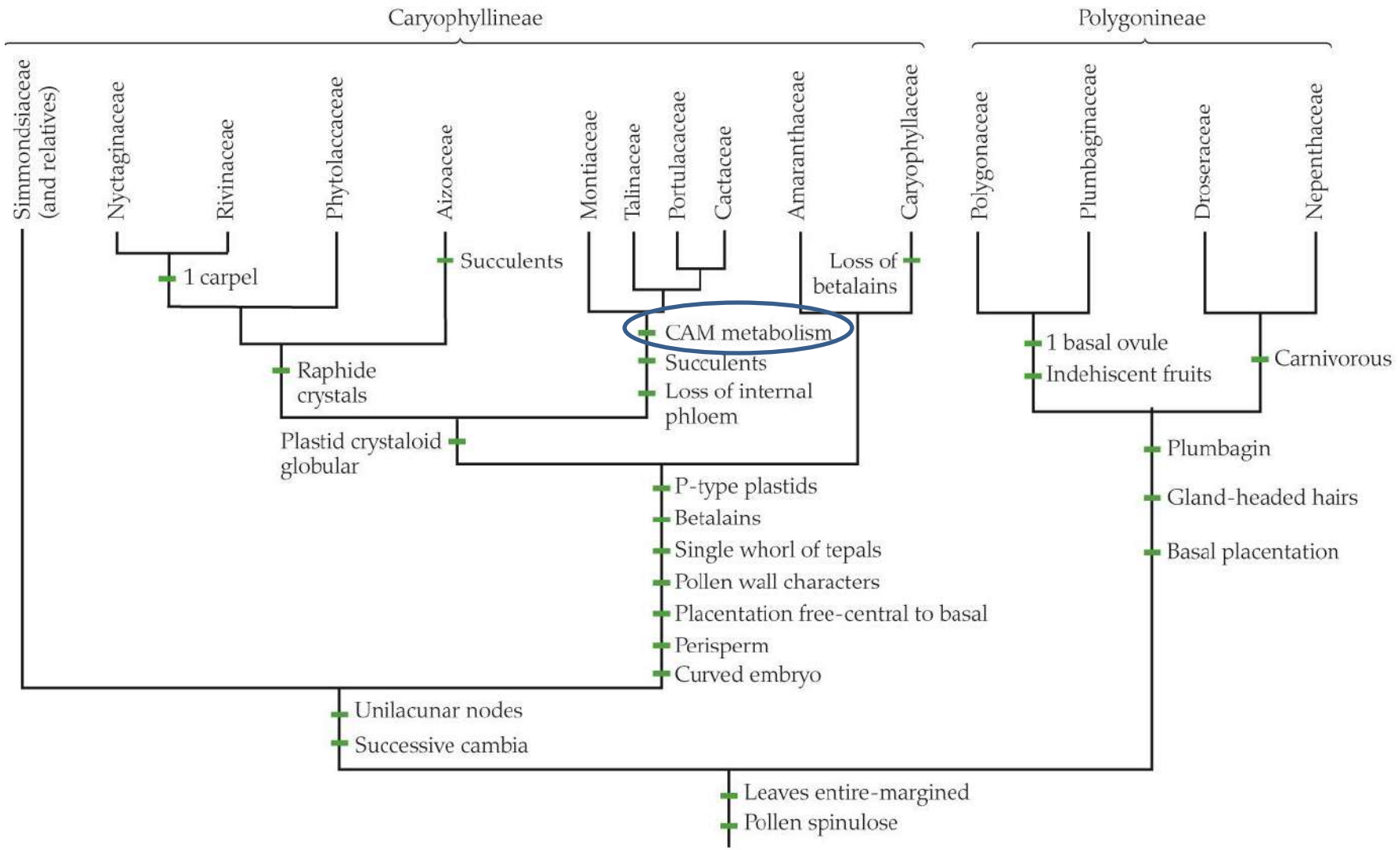
C3– *Bromus catharticus*



C4– *Aristida purpurea*



At 86° F C4 becomes more efficient than C3 due to photorespiration. The starch rich chloroplasts of the Kranz anatomy lack grana, the site of the light reactions. They differ from the chloroplasts of the outer bundle sheath (dimorphic chloroplasts).

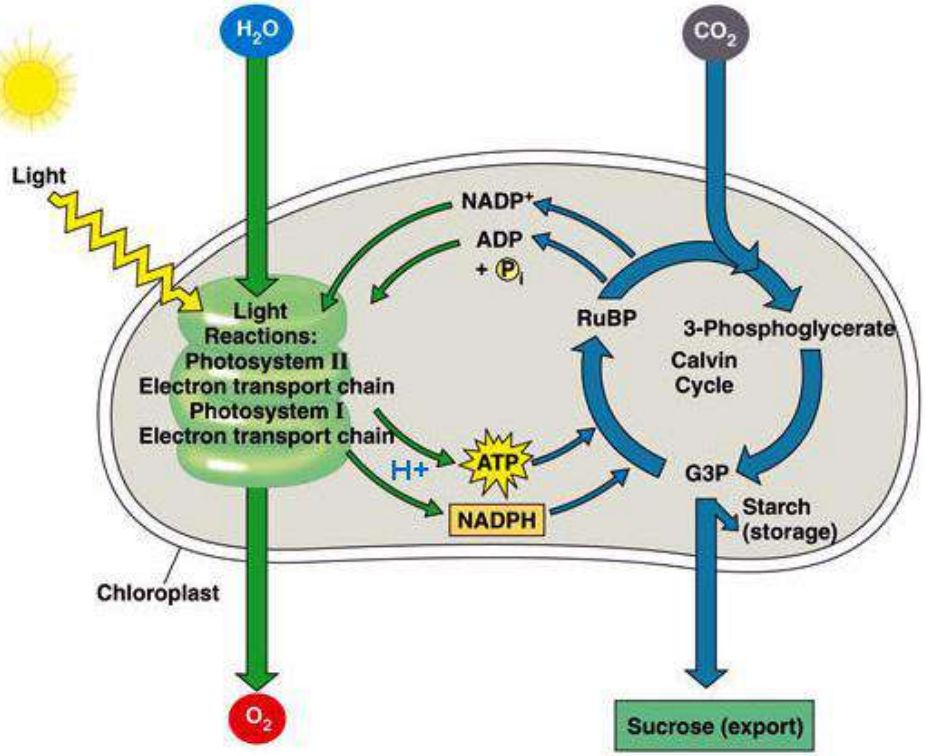


PLANT SYSTEMATICS 4e, Figure 8.97

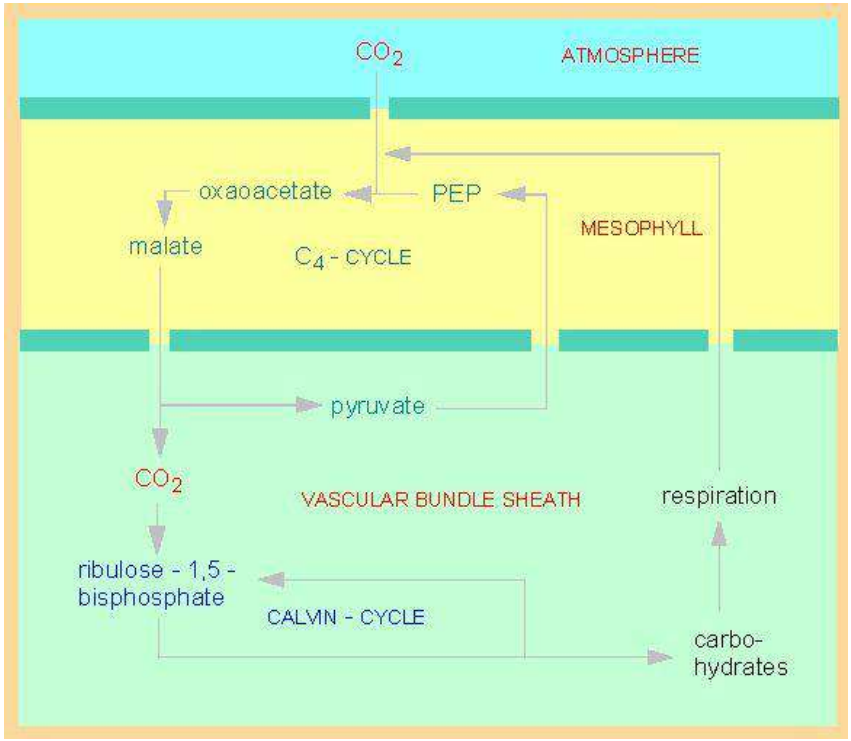
Caryophyllales

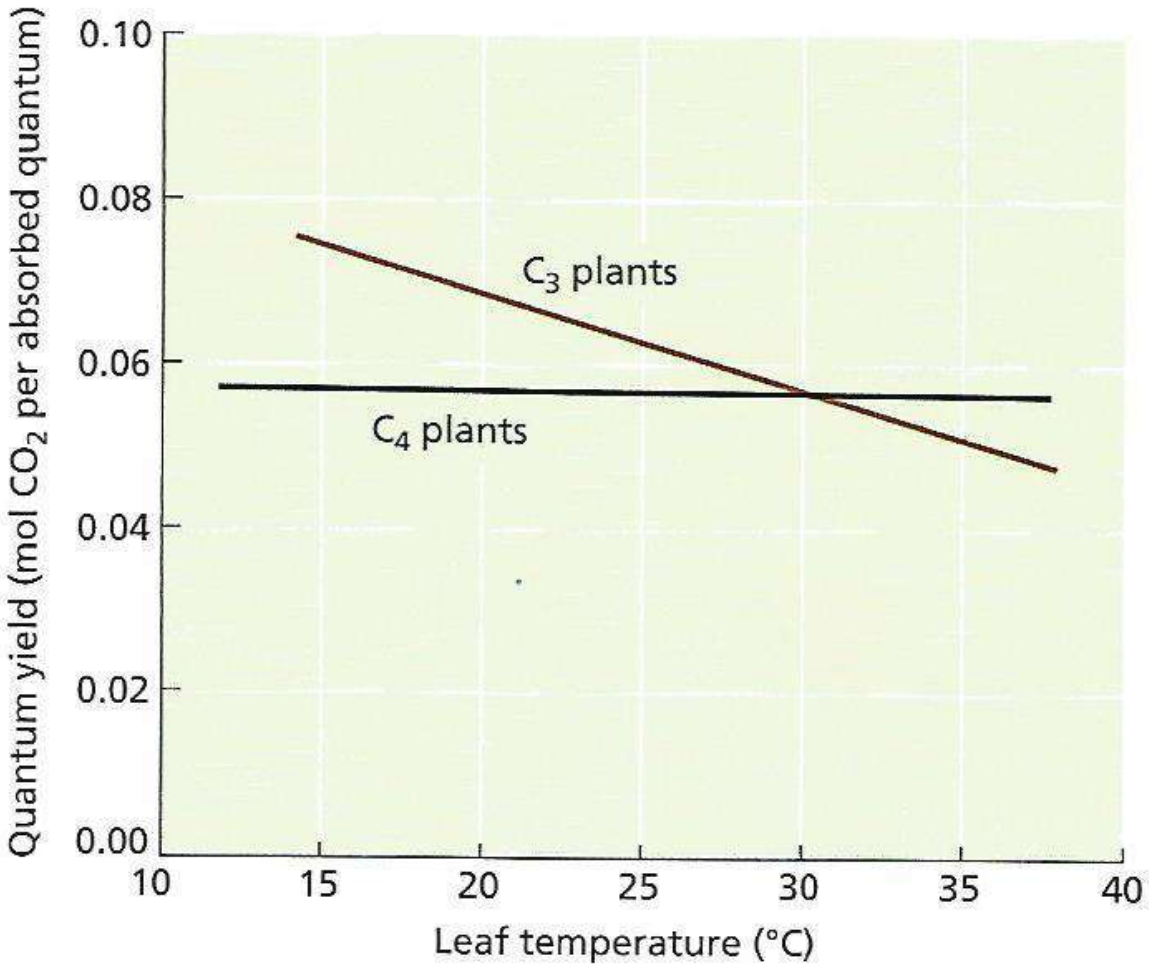
Some Grasses use the C3 photosynthetic pathway (cool season grasses) and some use the C4 pathway (warm season grasses)

C3 pathway



C4 pathway

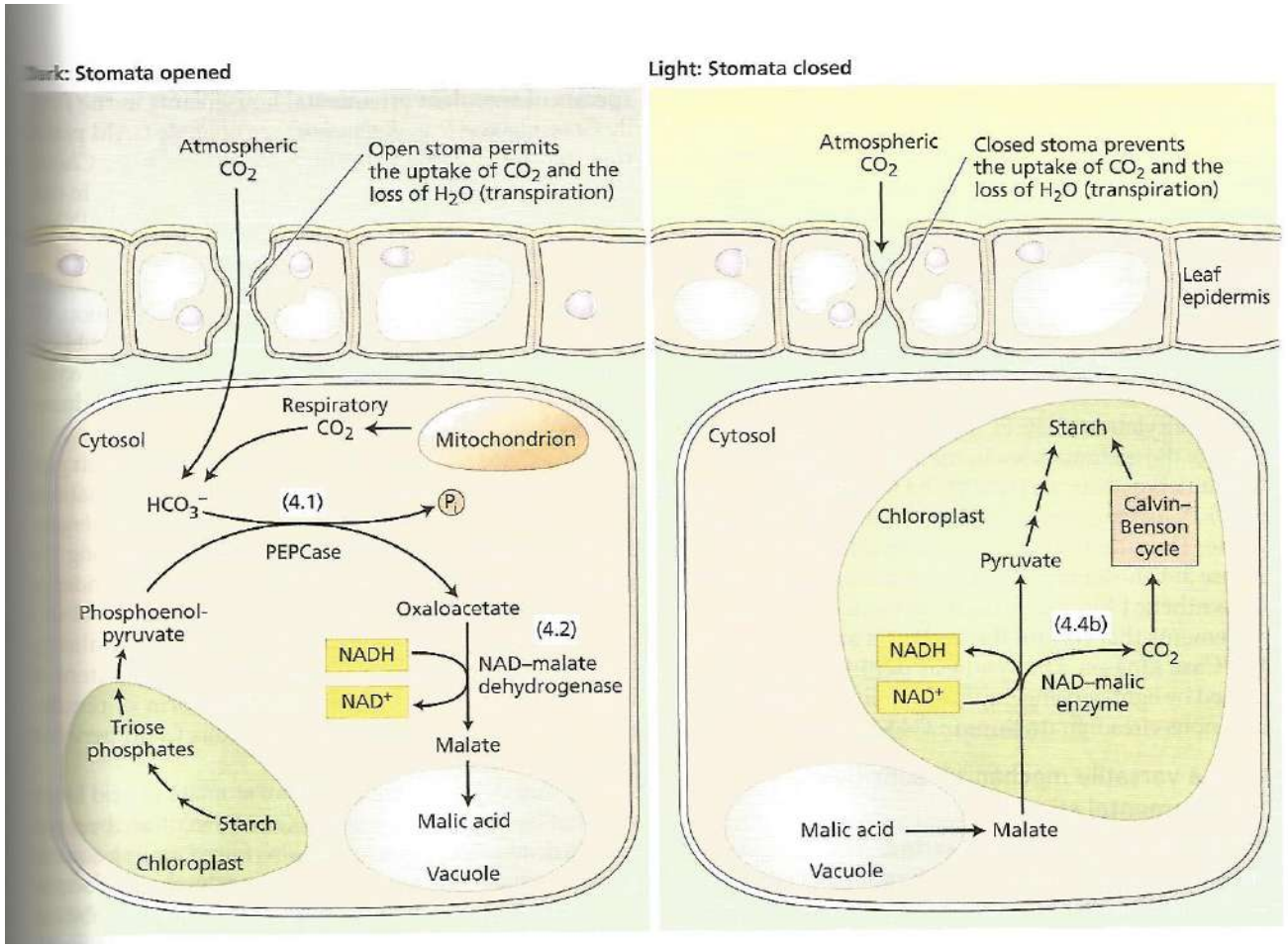



Quantum yield (mol CO_2 per absorbed quantum)
0.10
0.08
0.06
0.04
0.02
0.00
C_3 plants
C_4 plants
10
15
20
25
30
35
40
Leaf temperature (°C)


wiseGEEK

CAM (Crassulacean Acid Metabolism) Photosynthesis

CAM Photosynthesis



CAM Photosynthesis

In addition to being more efficient like C4 at higher temperatures, CAM conserves water by allowing stomata to be closed during the heat of the day

“Since every CO2 molecule has to be fixed twice, first by 4-carbon organic acid and second by RuBisCO, the C4 pathway uses more energy than the C3 pathway. The C3 pathway requires 18 molecules of ATP for the synthesis of one molecule of glucose, whereas the C4 pathway requires 30 molecules of ATP. This energy debt is more than paid for by avoiding losing more than half of photosynthetic carbon in photorespiration as occurs in some tropical plants, making it an adaptive mechanism for minimizing the loss.”

--quoted from that ubiquitous source, Wikipedia