# Plant cell, Photosynthesis, and Ecological biology

## 405 Biochem

**By**

**Prof. Entsar Saad**

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# Stages of Photosynthesis

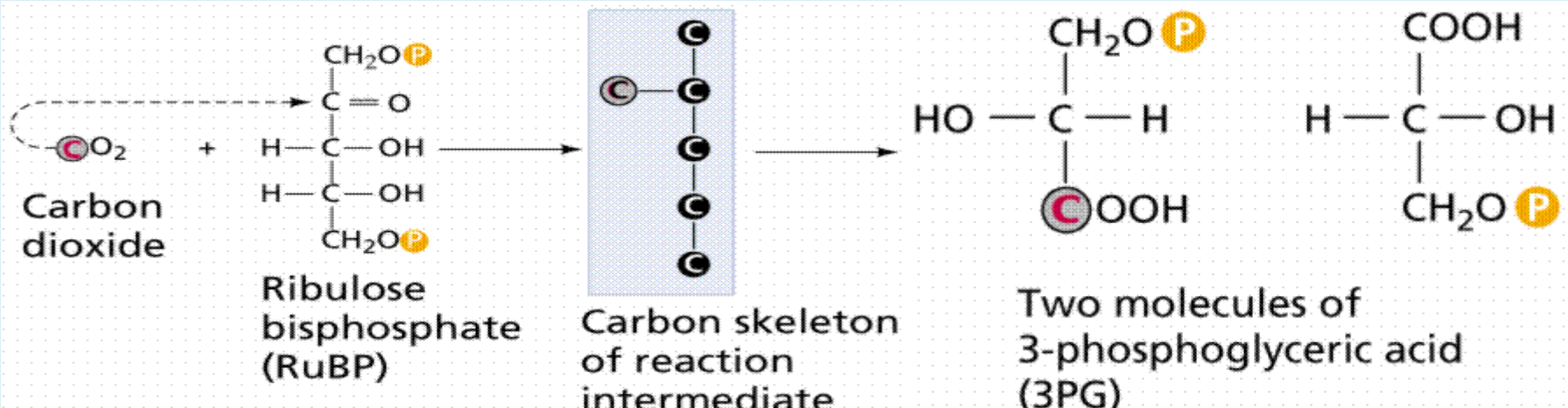
## ➢(2)The dark reactions (Calvin cycle)

➢ The Calvin cycle consists of four major steps:

**1. Carbon dioxide enters the plant. It combines with RuBP (ribulose biphosphate), a five carbon sugar molecule.**

• RuBP carboxylase (**RuBisCO**), catalyzes the Carbon dioxide fixation reaction. RuBP carboxylase enzyme makes up about 25% of the total protein on the chloroplast. Also RuBP carboxylase enzyme is the most abundant protein on earth

• The resulting product from this fixation process is an unstable six-carbon sugar molecule that easily splits into 2 molecules of phosphoglyceric acid or 3-phosphoglycerate or 3-phosphoglyceric acid (PGA), a three-carbon molecule so **Calvin cycle sometimes called the $C_3$ pathway.**



# Stages of Photosynthesis

## ➢(2)The dark reactions (Calvin cycle) (Calvin Benison Cycle)

**2. PGAL or G3P (phosphoglyceraldehyde or glyceraldehyde-3-phosphate) is formed from 1 PGA molecule combining with a phosphate group supplied by ATP (from the light reaction); and another PGA molecule reacting with hydrogen from a molecule of NADPH+ (also from the light reaction)**

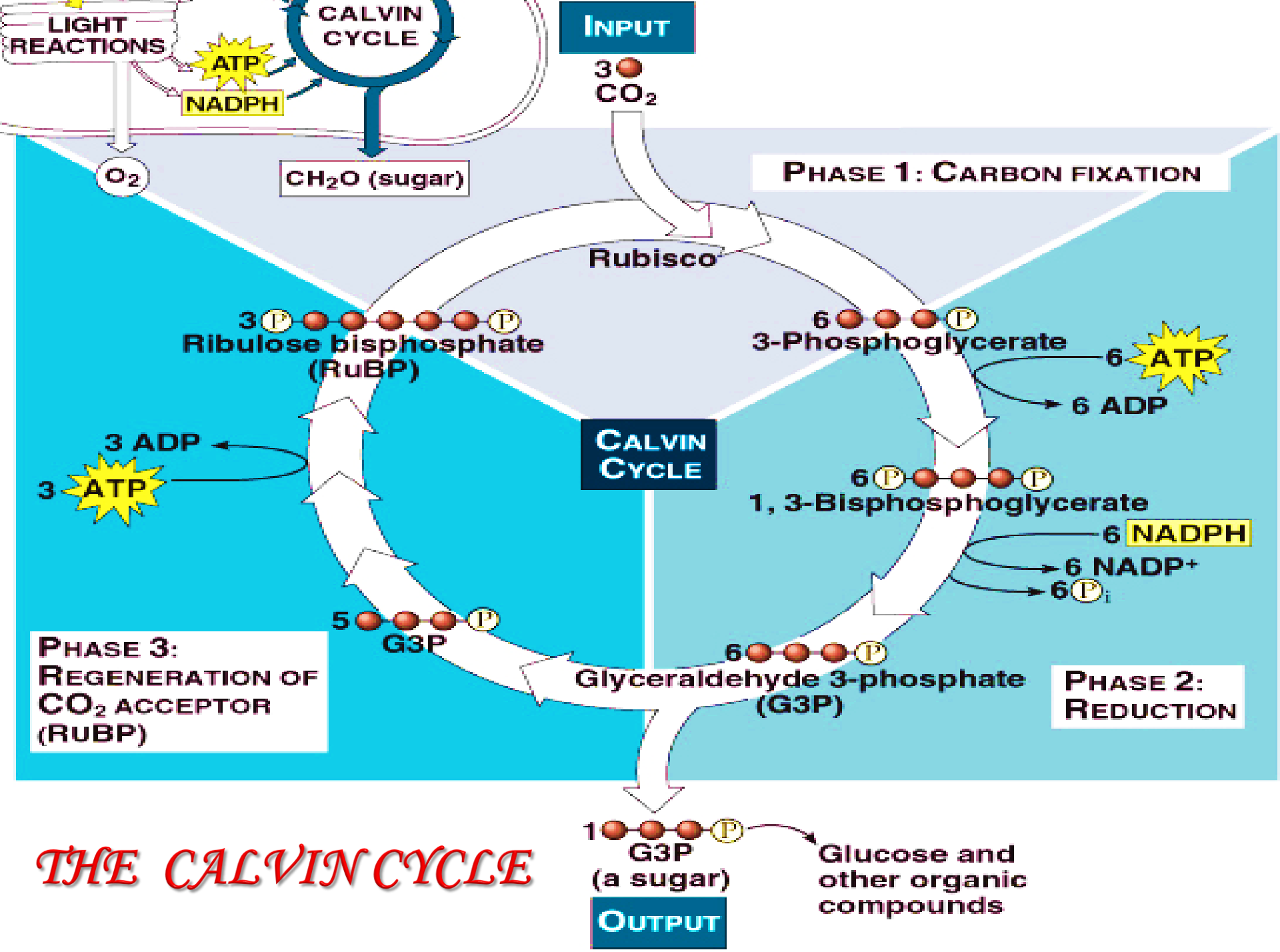
**3. Glucose is formed from two PGAL molecules,**

**4. Most of the PGAL is used to regenerate more RuBP, using the energy supplied by ATP.** The RuBP produced is reused in another cycle of $CO_2$ fixation.

- Also PGAL is converted to other products such as fructose, sucrose, maltose, and starch

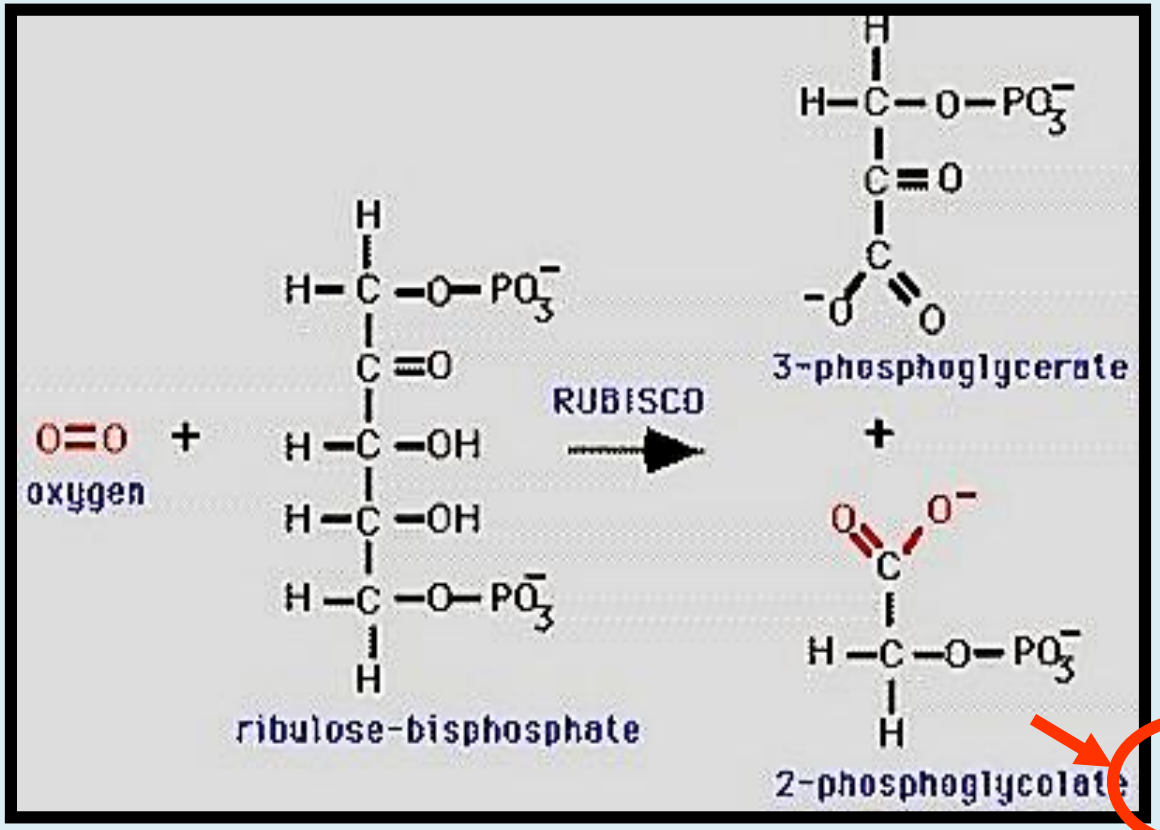
# THE CALVIN CYCLE

- The Calvin cycle, like the citric acid cycle, regenerates its starting material after molecules enter and leave the cycle
- The cycle builds sugar from smaller molecules by using ATP and the reducing power of electrons carried by NADPH. ATP provides the energy, while NADPH provides the electrons required to fix the $CO_2$ into carbohydrates.
- In most plants ($C_3$ plants), initial fixation of $CO_2$, via rubisco, forms a three-carbon compound (3-phosphoglycerate)
- In photorespiration, rubisco adds $O_2$ instead of $CO_2$ in the Calvin cycle, producing a two-carbon compound
- Photorespiration consumes $O_2$ and organic fuel and releases $CO_2$ without producing ATP or sugar




# THE CALVIN CYCLE

# Rubisco Enzyme

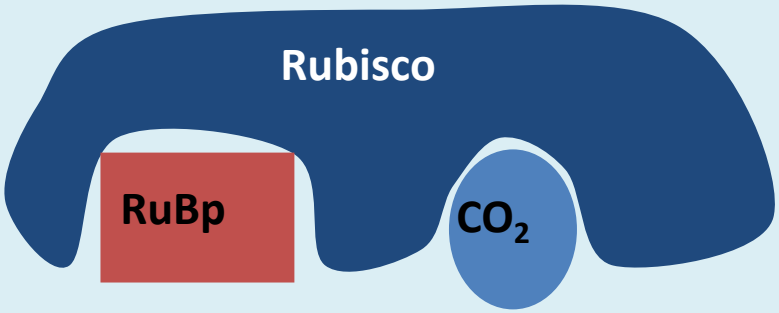


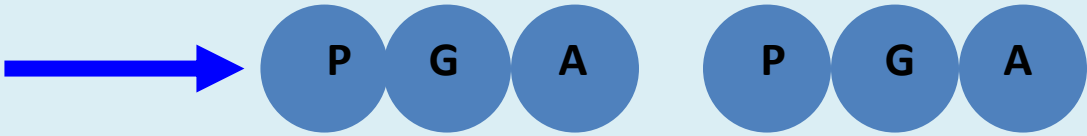

In photorespiration

**C3 photosynthesis produces a three-carbon compound via the Calvin cycle**

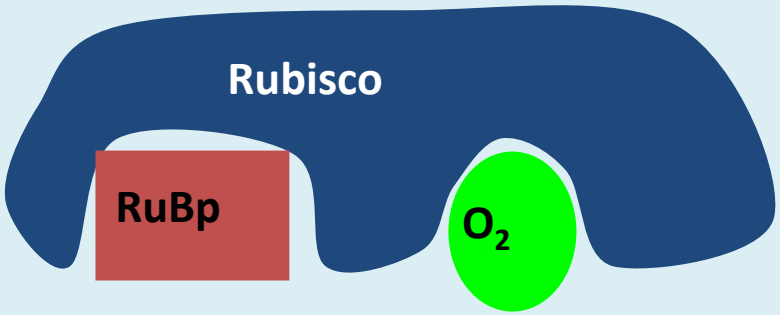
$CO_2$ + RuBP $\xrightarrow{\text{rubisco}}$ 2 molecules of 3-phosphoglycerate (PGA)

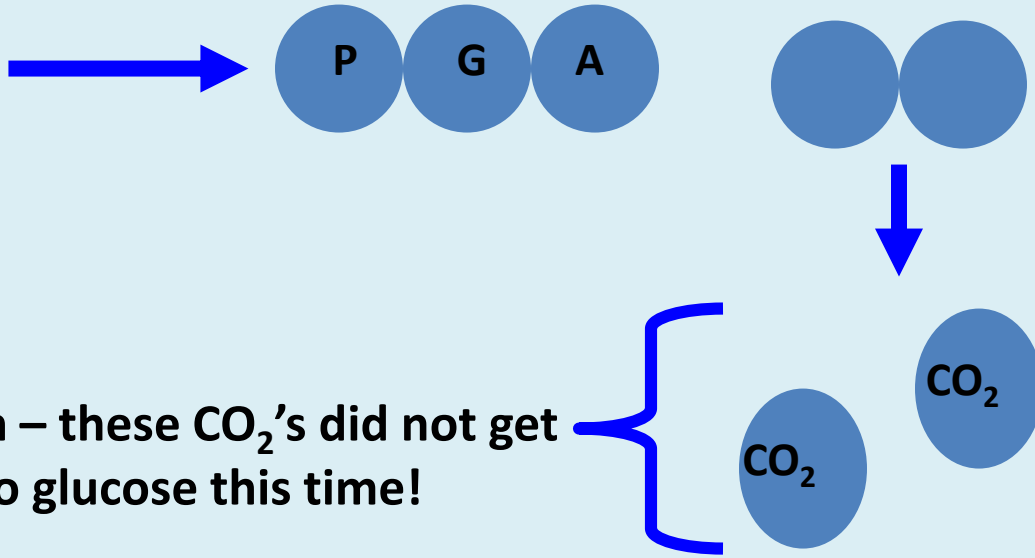
In photosynthesis **of C3 plants**




**Later becomes glucose!**




**Photorespiration – these $CO_2$'s did not get incorporated into glucose this time!**

# ALTERNATES OF CALVIN CYCLE

## (Adaptions for hot/arid conditions)

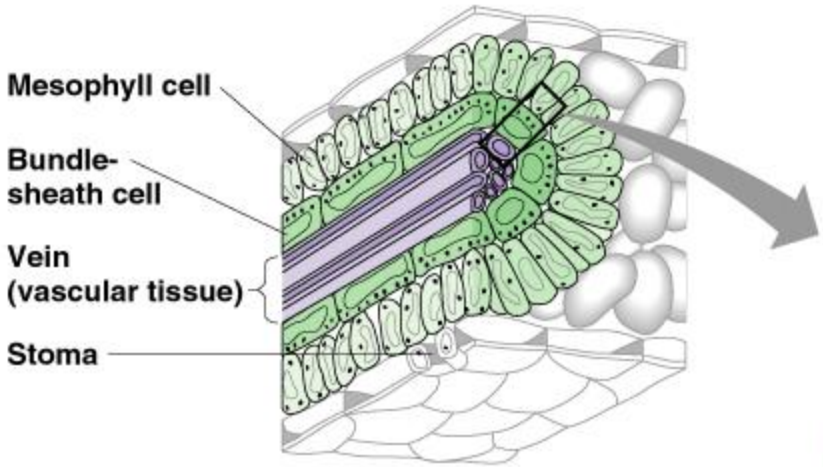
1. **$C_4$ pathway –**

**C4** photosynthesis makes an intermediate four-carbon compound that splits into a three-carbon compound for the Calvin cycle.

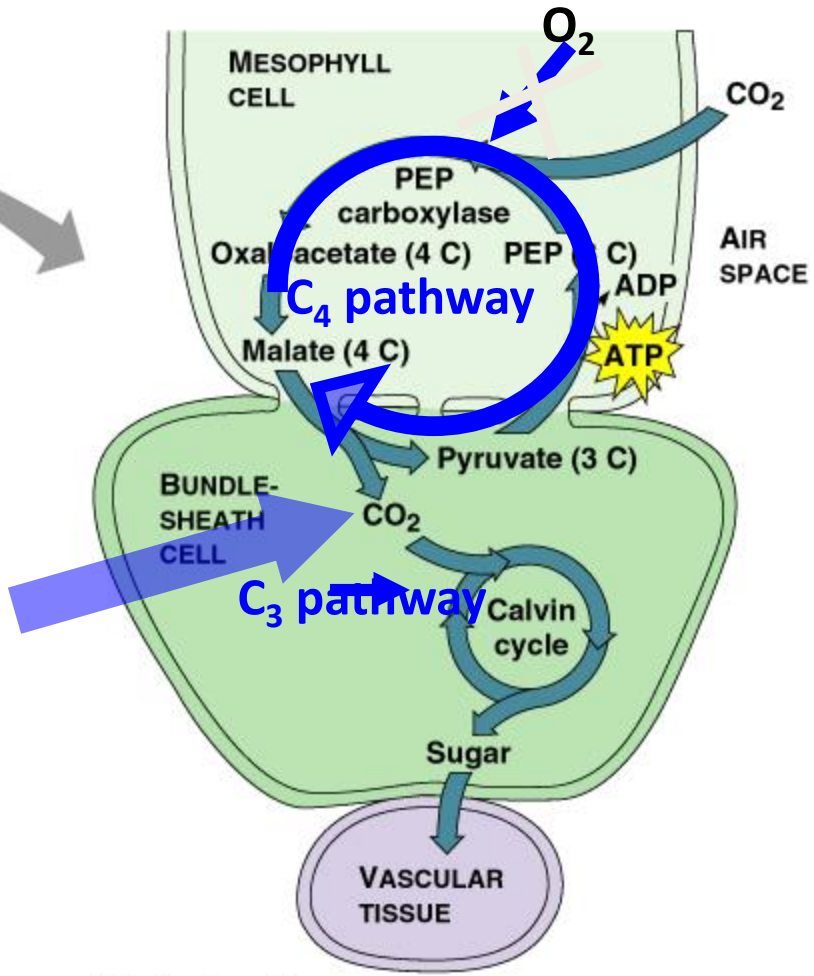
**Evolved in hot, dry climate**

- **Form 4-carbon compounds**
- **Partially close stomata**
- **E.g. for $C_4$ plants Corn, sugar cane**

# Leaf anatomy of plants adapted for hot/arid conditions (**$C_4$ plants**)…




(a) $C_4$ leaf anatomy




(b) The $C_4$ pathway

**Separate $CO_2$ fixation and sugar making into two different cells**

**PEP is phosphoenolpuruvate**