# The Calvin cycle uses ATP and NADPH to convert $CO_2$ to sugar: *a closer look*

- The Calvin cycle regenerates its starting material after molecules enter and leave the cycle.
    - $CO_2$ enters the cycle and leaves as sugar.
- The cycle uses the energy of ATP and the reducing power of electrons carried by NADPH *that came from the light reactions* to make the sugar.
- The actual sugar product of the Calvin cycle is not glucose, but a three-carbon sugar, **glyceraldehyde-3-phosphate** (**G3P**).
- Each turn of the Calvin cycle fixes ***one*** carbon.
- ***For the net synthesis of one G3P molecule, the cycle must take place three times, fixing three molecules of $CO_2$.***
- To make one glucose molecule would require ***six cycles*** and the fixation of six $CO_2$ molecules.
- The Calvin cycle has three phases:
    - Phase I: Carbon Fixation
    - Phase II: Reduction
    - Phase III: Regeneration of CO2 acceptor (RuBP)

## Phase I: Carbon Fixation

- In the carbon fixation phase, each $CO_2$ molecule is attached to a five-carbon sugar, ribulose bisphosphate (RuBP).
    - This is catalyzed by RuBP carboxylase or **rubisco**.
    - The six-carbon intermediate splits in half to form two molecules of 3-phosphoglycerate per $CO_2$.

## Phase II: Reduction

- During reduction, each 3-phosphoglycerate receives another phosphate group from ATP to form 1,3 bisphosphoglycerate.
- A pair of electrons from NADPH reduces each 1,3 bisphosphoglycerate to G3P.
  - The electrons reduce a carboxyl group to a carbonyl group.
- If our goal was to produce one G3P net, we would start with 3 $CO_2$ (3C) and three RuBP (15C).
- After fixation and reduction we would have six molecules of G3P (18C).
  - One of the six G3P (3C) is a net gain of carbohydrate.
    - This molecule can exit the cycle to be used by the plant cell.
  - ***The other five (15C) must remain in the cycle to regenerate three RuBP.***

## Phase III: Regeneration of RuBP

- In the last phase, regeneration of the $CO_2$ acceptor (RuBP), the five remaining G3P molecules are rearranged to form 3 RuBP molecules.
- To do this, the cycle must spend three more molecules of ATP (one per RuBP) to complete the cycle and prepare for the next.
- For the net synthesis of one G3P molecule, the Calvin recycle consumes ***nine ATP and six NAPDH.***
  - It “costs” three ATP and two NADPH per CO2.
- The G3P from the Calvin cycle is the starting material for metabolic pathways that synthesize other organic compounds, including glucose and other carbohydrates.