The Calvin cycle uses ATP and NADPH to convert CO_2 to sugar:

ATP and NADPH produced by the light reactions are used in the Calvin cycle to reduce carbon dioxide to sugar.

- The Calvin cycle is similar to the Krebs cycle in that the starting material is regenerated by the end of the cycle.
- Carbon enters the Calvin cycle as CO_2 and leaves as sugar.
- ATP is the energy source, while NADPH is the reducing agent that adds high-energy electrons to form sugar.
- The Calvin cycle actually produces a three-carbon sugar *glyceraldehyde 3-phosphate* (G3P).

For the Calvin cycle to synthesize one molecule of sugar (G3P), three molecules of CO_2 Must enter the cycle. The cycle may be divided into three phases:

Phase 1: Carbon Fixation. The Calvin cycle begins when each molecule of CO_2 is attached to a five-carbon sugar, *ribulose bisphosphate (RuBP)*.

- This reaction is catalyzed by the enzyme *RuBP carboxylase (rubisco*) - the most abundant protein on Earth!
- The product of this reaction is an unstable six-carbon intermediate that immediately splits into two molecules of 3-phosphoglycerate.
- For every three CO_2 molecules that enter the Calvin cycle via rubisco, three RuBP molecules are carboxylated forming six molecules of 3-phosphoglycerate.

Phase 2: Reduction. This endergonic reduction phase is a two-step process that couples ATP hydrolysis with the reduction of 3-phosphoglycerate to glyceraldehyde phosphate.

- An enzyme phosphorylates 3-phosphoglycerate by transferring a phosphate group from ATP. This reaction:
    - ➪ produces 1, 3-bisphosphoglycerate.
    - ➪ uses six ATP molecules to produce six molecules of 1,3-bisphosphoglycerate.
    - ➪ primes 1,3-bisphosphoglycerate for the addition of high-energy electrons from NADPH.

• Electrons from NADPH reduce the carboxyl group of 1,3-bisphosphoglycerate to the aldehyde group of glyceraldehyde 3-phosphate (G3P).

- ➪ The product, G3P, stores more potential energy than the initial reactant, 3-phosphoglycerate.
- ➪ G3P is the same three-carbon sugar produced when glycolysis splits glucose.

• For every three CO_2 molecules that enter the Calvin cycle, six G3P molecules are produced, only one of which can be counted as net gain.

- ➪ The cycle begins with three five-carbon RuBP molecules – a total of 15 carbons.
- ➪ The six G3P molecules produced contain 18 carbons, a net gain of three carbons from CO_2.
- ➪ One G3P molecule exits the cycle; the other five are recycled to regenerate three molecules of RuBP.

Phase 3: Regeneration of Starting Material (RuBP). A complex series of reactions rearranges the carbon skeletons of five G3P molecules into three RuBP molecules.

• These reactions require three ATP molecules.
• RuBP is thus regenerated to begin the cycle again.

For the net synthesis of one G3P molecule, the Calvin cycle uses the products of the light reactions:

- ➪ 9 ATP molecules
- ➪ 6 NADPH molecules

G3P produced by the Calvin cycle is the raw material used to synthesize glucose and other carbohydrates.

• The Calvin cycle uses 18 ATP and 12 NADPH molecules to produce one glucose molecule.