Aim: What happens during the Calvin cycle?

Light-independent reactions occur *all the time*. The plant uses these reactions to create organic compounds from carbon dioxide.

History of the discovery of the "dark reactions"

- Hydrogen (from water) + carbon dioxide → glucose
- Low energy reactants produce high energy products. Highly endergonic.
- Energy for the dark reactions, called ***carbon fixation***, is provided by ATP and the reducing power of electrons carried by NADPH . Enzymes catalyze each step of this process.

History of the discovery of the "dark reactions"

1940: Ruben Kamen (University of California at Berkley) learned how to use radioactive carbon-14 and began to use it to study plant biology.

1946 – Melvin Calvin (University of California at Berkley) began his studies of carbon fixation by using algae and radioactive carbon^{14} dioxide. He skillfully stopped the process by killing the algae at varying times and analyzed the intermediates that were produced.

1961 – Melvin Calvin wins the Nobel prize for the carbon fixation cycle that bears his name.

Summary of the Calvin cycle

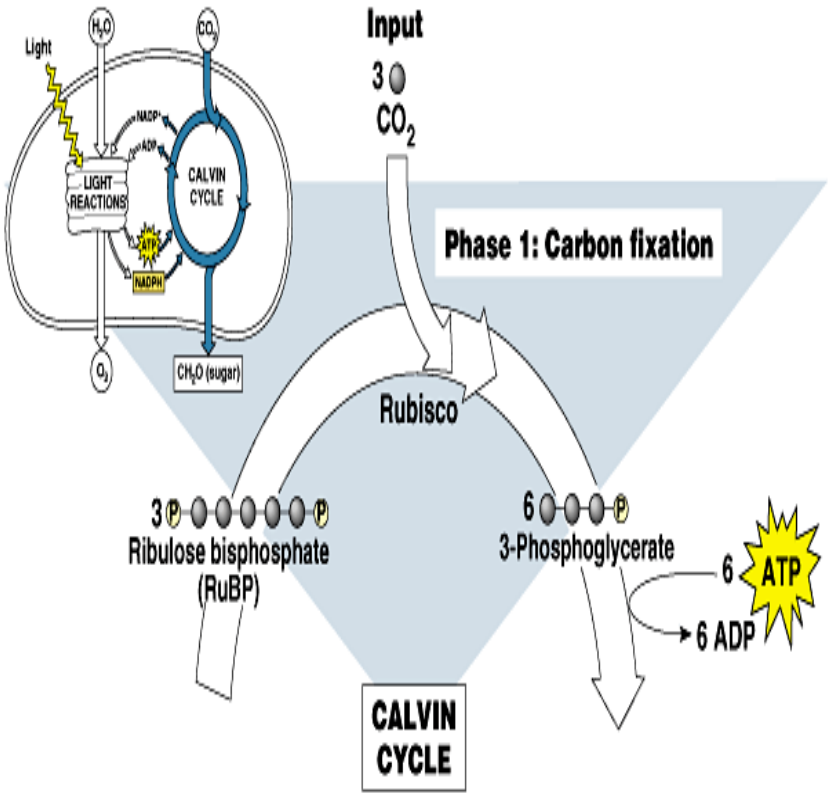
- Each turn of the Calvin cycle fixes one carbon.
- The actual sugar product of the Calvin cycle is not glucose, but a three-carbon sugar, **glyceraldehyde-3-phosphate** (**G3P**), also known as PGAL.
- For the net synthesis of one PGAL molecule, the cycle must take place three times, fixing three molecules of CO_2.
- To make one glucose molecule would require six cycles and the fixation of six CO_2 molecules.

Summary of the Calvin cycle

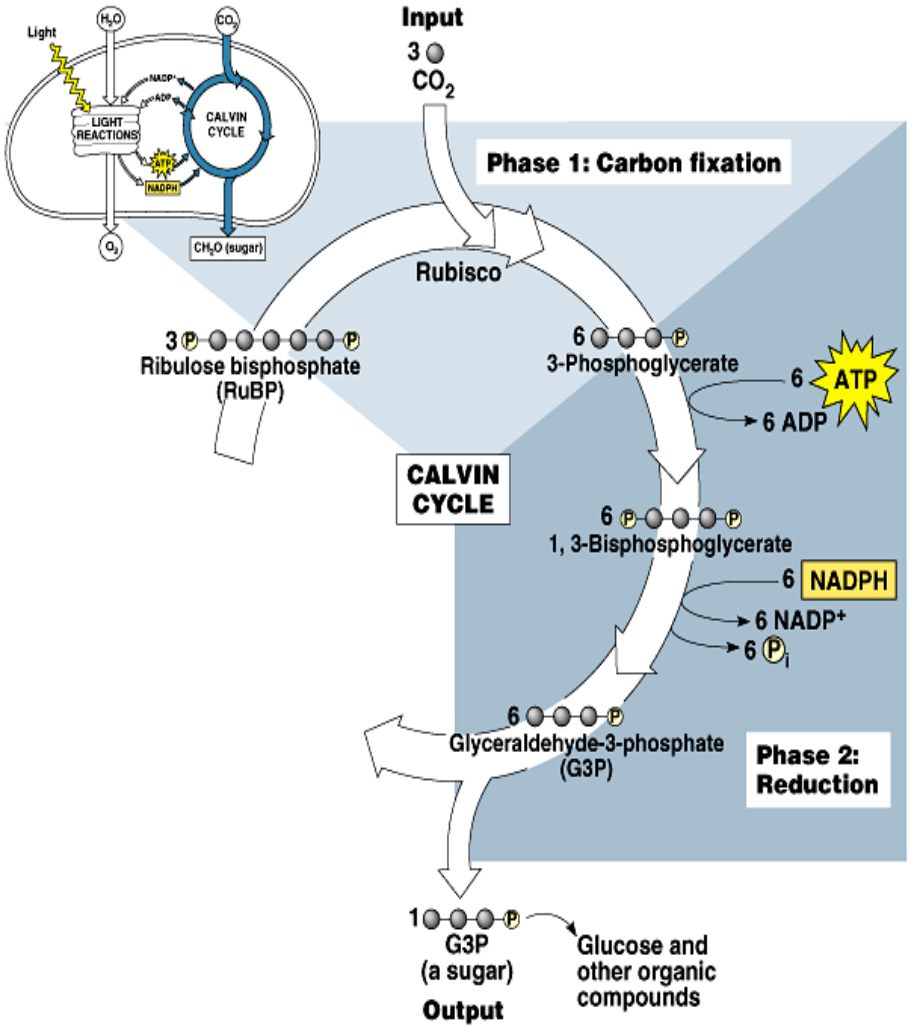
- Glucose is only one product of photosynthesis. Some plants use the Calvin cycle to synthesize lipids and proteins from PGAL and other intermediates.
- Plants store carbohydrates as starch to avoid the high osmotic concentration dissolved glucose would create in the cells.

Details of the Calvin cycle (I)

- The Calvin cycle has three phases.
- 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.



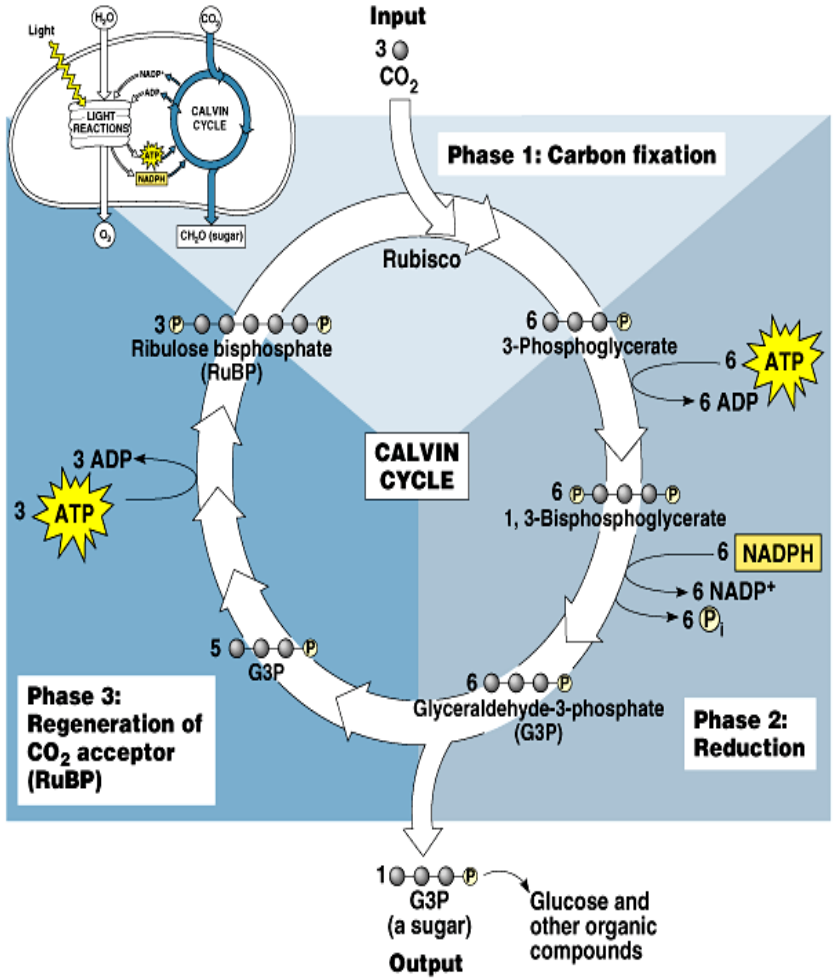
Details of the Calvin cycle (II)

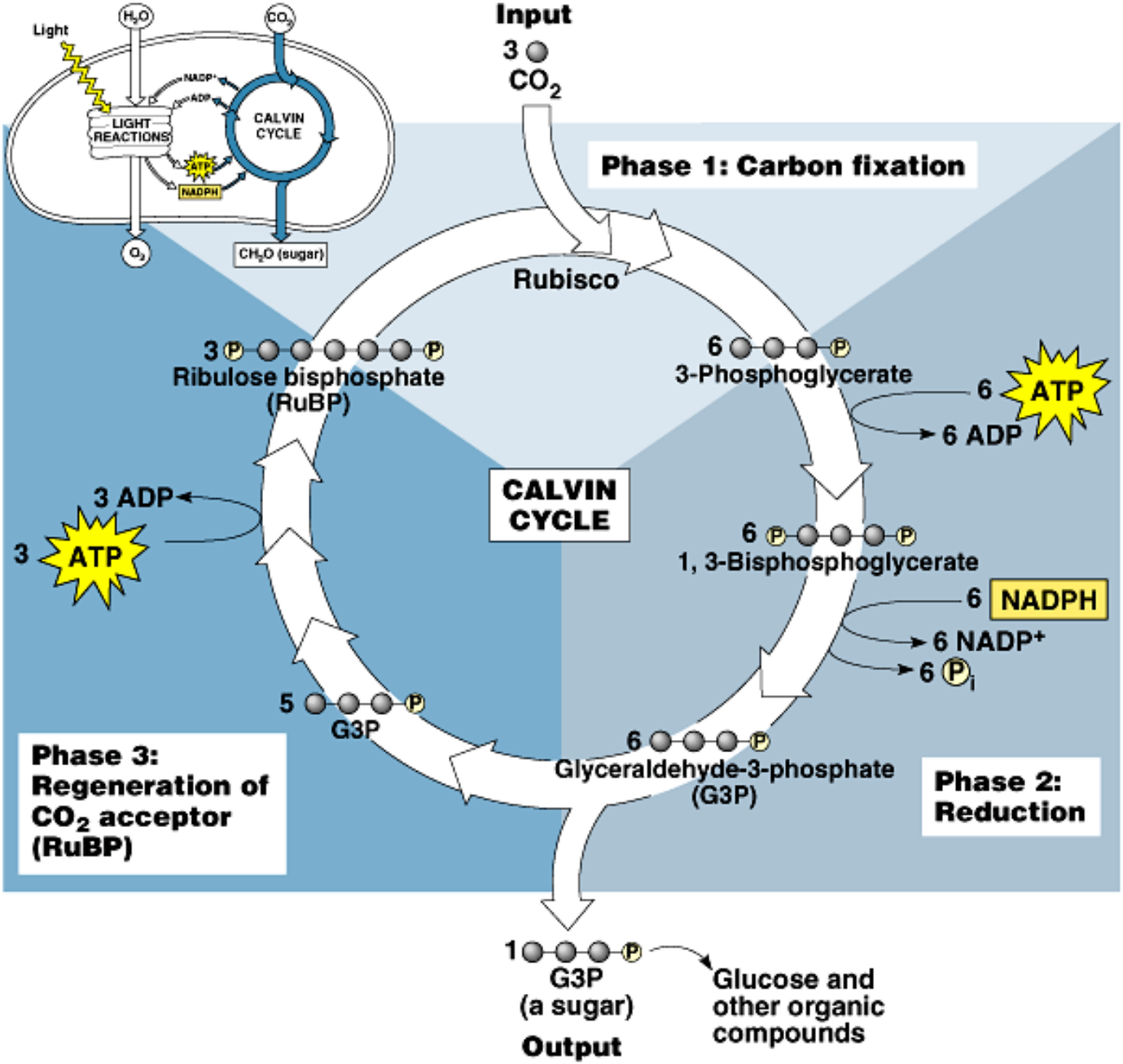


- During reduction, each 3-phosphoglycerate receives another phosphate group from ATP to form 1,3 bisphosphoglycerate.
- A pair of electrons from NADPH reduces each 1,3 bisphosphoglycerate to G3P (PGAL).

Details of the Calvin cycle (III)

- In the last phase, regeneration of the CO_2 acceptor (RuBP), these five 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.




Light
H_2O
CO_2
NADP+
ADP
LIGHT REACTIONS
CALVIN CYCLE
ATP
NADPH
O_2
CH_2O (sugar)
Input
3 CO_2
Phase 1: Carbon fixation
Rubisco
3 Ribulose bisphosphate (RuBP)
6 3-Phosphoglycerate
6 ATP
6 ADP
CALVIN CYCLE
3 ADP
3 ATP
6 1, 3-Bisphosphoglycerate
6 NADPH
6 NADP+
6 P_i
5 G3P
6 Glyceraldehyde-3-phosphate (G3P)
Phase 3: Regeneration of CO_2 acceptor (RuBP)
Phase 2: Reduction
1 G3P (a sugar)
Output
Glucose and other organic compounds