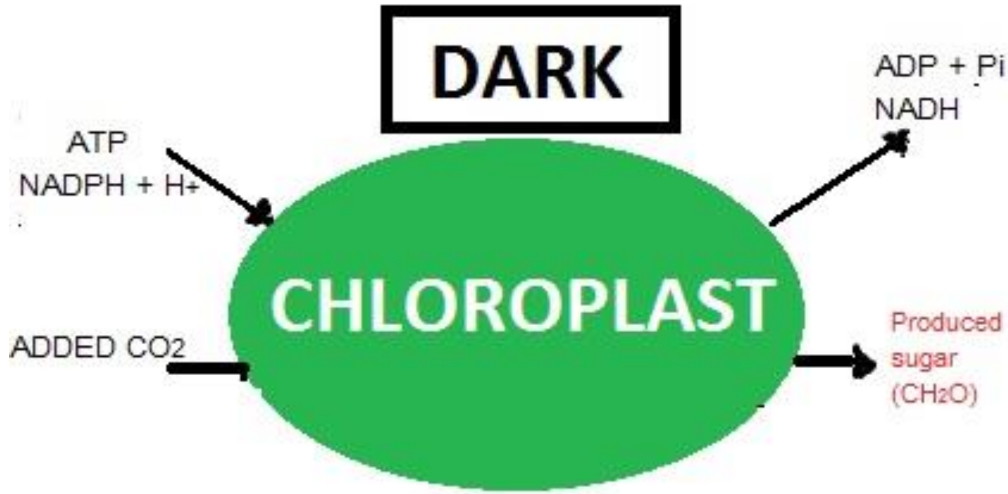
PHOTOSYNTHESIS
(DARK REACTION/ CALVIN CYCLE)

For B.Sc. Part II (Subs) Group C (Plant Physiology)



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Lecture No.06

Dark reaction/ Calvin cycle)

Stroma reactions were long thought to be independent of light and, as a consequence, were referred to as the dark reactions. However, because these stroma-localized reactions depend on the products of the photochemical processes, and are also directly regulated by light, they are more properly referred to as the carbon reactions of photosynthesis.

- ✓ First stable compound of Calving cycle is 3C-PGA (Phosphoglceric acid) thus Calvin cycle is called as C3 - cycle.
- ✓Rubbisco (Ribulose bis-phosphate carboxylase-oxygenase) is main enzyme in C3 - cycle, which is present in stroma
- ✓ CO2 - acceptor in Calvin cycle is RuBp. This carboylation reaction is catalysed by Rubisco.
- ✓C3, C4, C5, C6 and C7 monosaccharides are intermediates of calving Cycle.

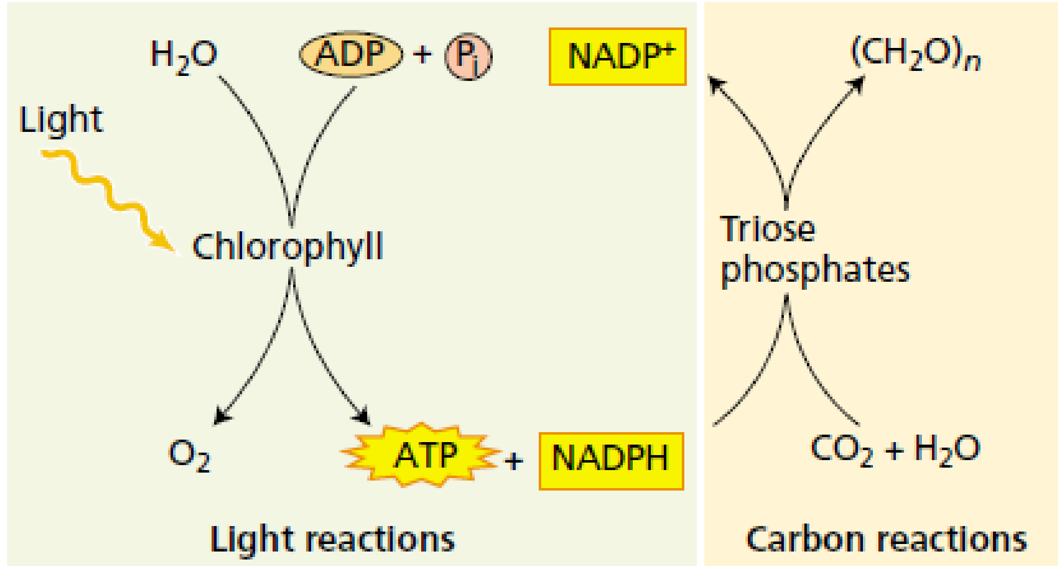

Figure: Light and carbon reactions of photosynthesis.

- All photosynthetic eukaryotes, from the most primitive alga to the most advanced angiosperm, reduce CO2 to carbohydrate via the same basic mechanism: the photosynthetic carbon reduction cycle **.**
- In the Calvin cycle, CO2 and water from the environment are enzymatically combined with a five-carbon acceptor molecule to generate two molecules of a three-carbon intermediate.

- This intermediate (3-phosphoglycerate) is reduced to carbohydrate by use of the ATP and NADPH generated photochemically.
- The cycle is completed by regeneration of the five-carbon acceptor (ribulose-1,5-bisphosphate [RuBP])

The Calvin cycle proceeds in three stages

1. Carboxylation of the CO_2 acceptor ribulose-1,5-bisphosphate, forming two molecules of 3-phosphoglycerate, the first stable intermediate of the Calvin cycle

2. Reduction of 3-phosphoglycerate, forming gyceraldehyde- 3-phosphate, a carbohydrate

3. Regeneration of the CO_2 acceptor ribulose-1,5-bisphosphate from glyceraldehyde-3-phosphate

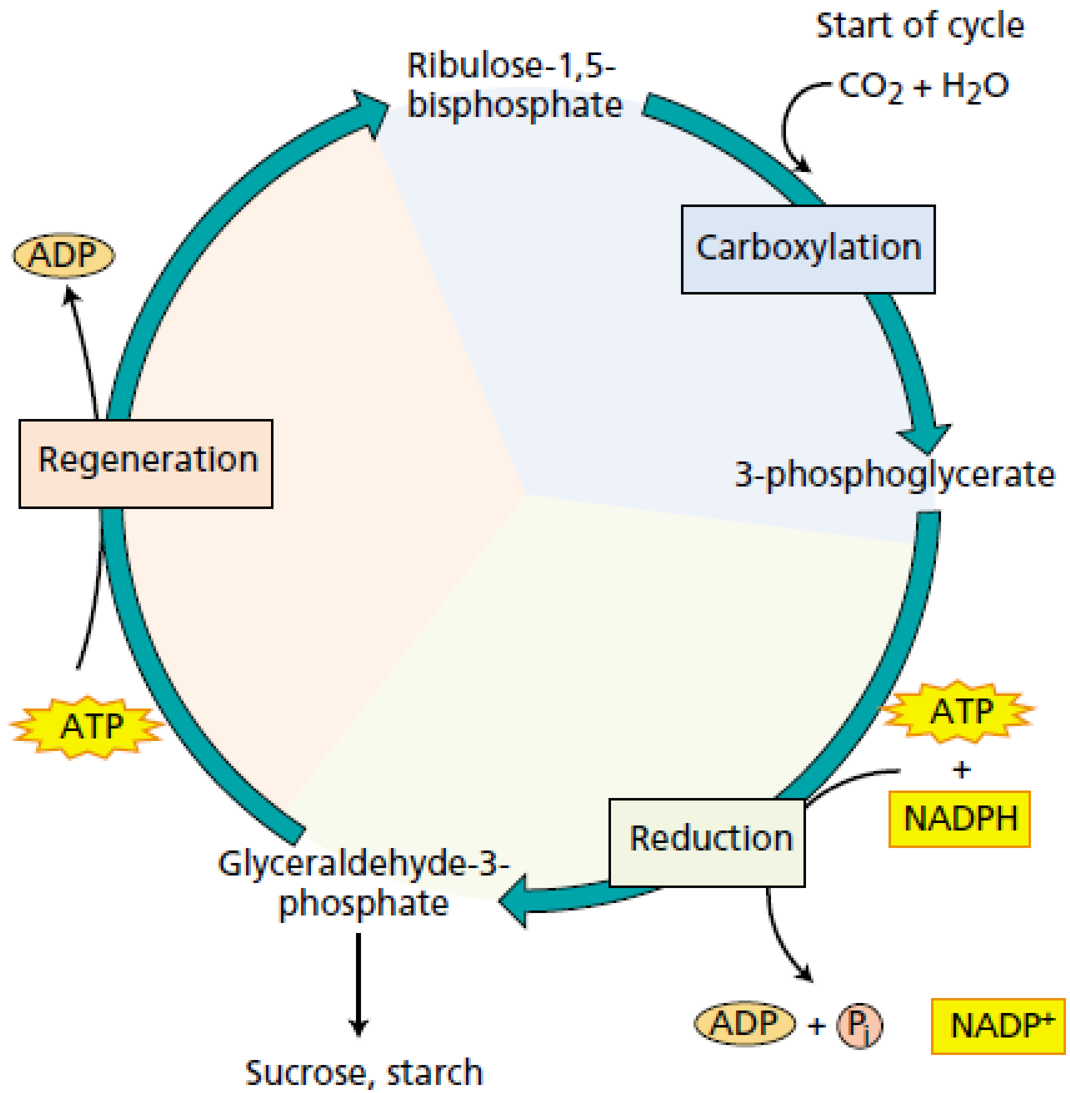

Figure: Overview of Calvin cycle

Enzyme	Reaction
1. Ribulose-1,5-bisphosphate carboxylase/oxygenase	6 Ribulose-1,5-bisphosphate + 6 CO_2 + 6 H_2O → 12 (3-phosphoglycerate) + 12 H^+
2. 3-Phosphoglycerate kinase	12 (3-Phosphoglycerate) + 12 ATP → 12 (1,3-bisphosphoglycerate) + 12 ADP
3. NADP:glyceraldehyde-3-phosphate dehydrogenase	12 (1,3-Bisphosphoglycerate) + 12 NADPH + 12 H^+ → 12 glyceraldehye-3-phosphate + 12 $NADP^+$ + 12 P_i
4. Triose phosphate isomerase	5 Glyceraldehyde-3-phosphate → 5 dihydroxyacetone-3-phosphate
5. Aldolase	3 Glyceraldehyde-3-phosphate + 3 dihydroxyacetone-3-phosphate → 3 fructose-1,6-bisphosphate
6. Fructose-1,6-bisphosphatase	3 Fructose-1,6-bisphosphate + 3 H_2O → 3 fructose-6-phosphate + 3 P_i
7. Transketolase	2 Fructose-6-phosphate + 2 glyceraldehyde-3-phosphate → 2 erythrose-4-phosphate + 2 xylulose-5-phosphate
8. Aldolase	2 Erythrose-4-phosphate + 2 dihydroxyacetone-3-phosphate → 2 sedoheptulose-1,7-bisphosphate
9. Sedoheptulose-1,7,bisphosphatase	2 Sedoheptulose-1,7-bisphosphate + 2 H_2O → 2 sedoheptulose-7-phosphate + 2 P_i
10. Transketolase	2 Sedoheptulose-7-phosphate + 2 glyceraldehyde-3-phosphate → 2 ribose-5-phosphate + 2 xylulose-5-phosphate
11a. Ribulose-5-phosphate epimerase	4 Xylulose-5-phosphate → 4 ribulose-5-phosphate
11b. Ribose-5-phosphate isomerase	2 Ribose-5-phosphate → 2 ribulose-5-phosphate
12. Ribulose-5-phosphate kinase	6 Ribulose-5-phosphate + 6 ATP → 6 ribulose-1,5-bisphosphate + 6 ADP + 6 H^+
Net: 6 CO_2 + 11 H_2O + 12 NADPH + 18 ATP → Fructose-6-phosphate + 12 $NADP^+$ + 6 H^+ + 18 ADP + 17 P_i	

Note: P_i stands for inorganic phosphate.

Table: Reactions of the Calvin cycle

Regulation of the Calvin cycle

- The high energy efficiency of the Calvin cycle indicates that some form of regulation ensures that all intermediates in the cycle are present at adequate concentrations and that the cycle is turned off when it is not needed in the dark.
- In general, variation in the concentration or in the specific activity of enzymes modulates catalytic rates, thereby adjusting the level of metabolites in the cycle.
- Changes in gene expression and protein biosynthesis regulate enzyme concentration.
- Posttranslational modification of proteins contributes to the regulation of enzyme activity.
- At the genetic level the amount of each enzyme present in the chloroplast stroma is regulated by mechanisms that control expression of the nuclear and chloroplast genomes
- Short-term regulation of the Calvin cycle is achieved by several mechanisms that optimize the concentration of intermediates

Reference: Plant Physiology, by Lincoln Taiz and Eduardo Zeiger

Thank You !!