M.Sc. Botany
Semester-II (2018-20)
MBOTCC-7: Physiology & Biochemistry

Unit –II
PHOTORESPIRATION

Nitu Bharti
Assistant Professor
Department of Botany

PHOTORESPIRATION

An important property of rubisco is its ability to catalyze both the carboxylation and the oxygenation of RuBP. Oxygenation is the primary reaction in a process known as photorespiration. Because photosynthesis and photorespiration work in diametrically opposite directions, photorespiration results in loss of CO_2 from cells that are simultaneously fixing CO_2 by the Calvin cycle.

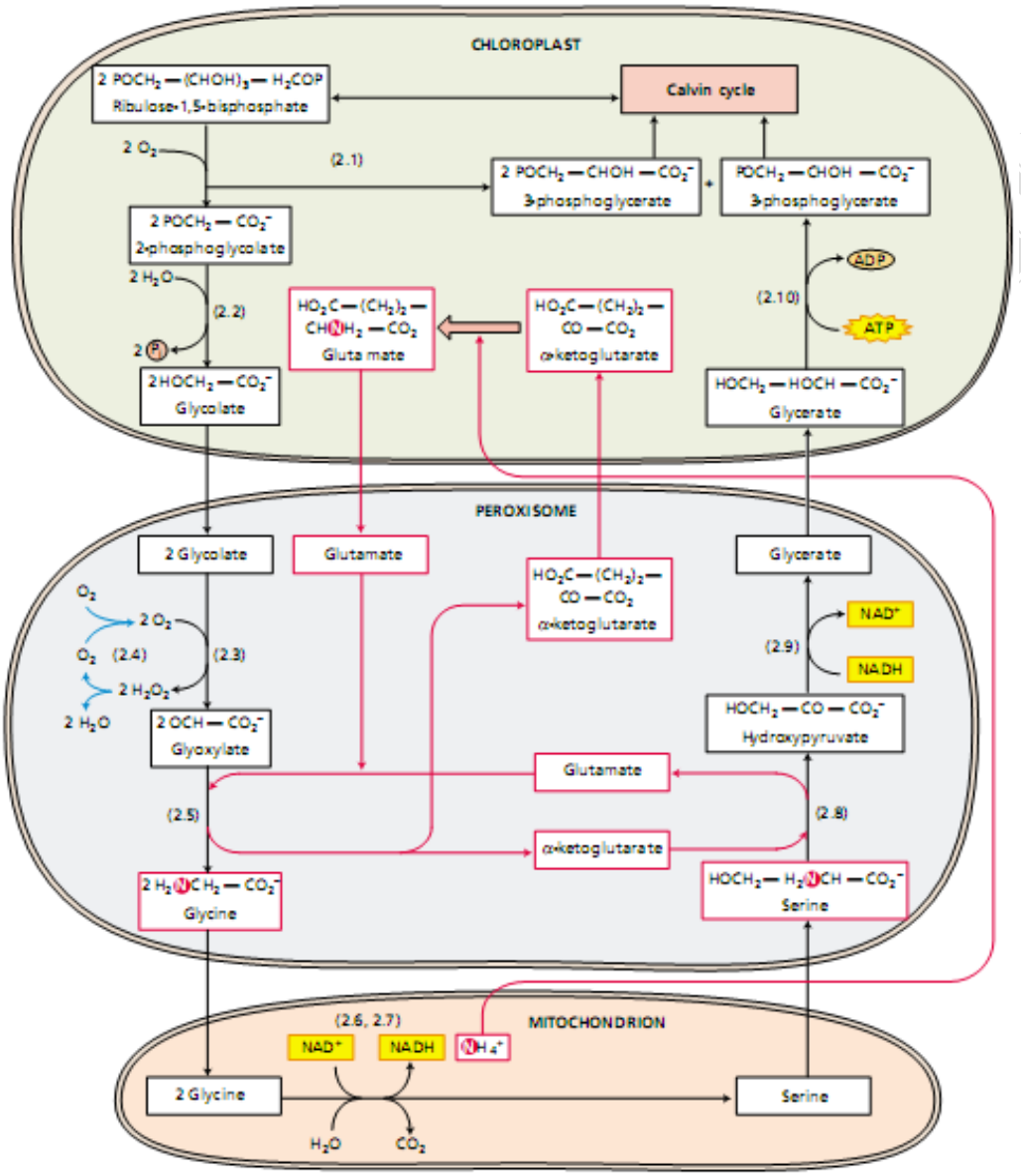

FIGURE: The main reactions of the photorespiratory cycle. Operation of the C2 oxidative photosynthetic cycle involves the cooperative interaction among three organelles: chloroplasts, mitochondria, and peroxisomes.

1. As alternative substrates for rubisco, CO_2 and O_2 compete for reaction with ribulose-1,5-bisphosphate because carboxylation and oxygenation occur within the same active site of the enzyme.
2. Photosynthetic carbon metabolism in the intact leaf reflects the integrated balance between two mutually opposing and interlocking cycles. The Calvin cycle can operate independently, but the

C2 oxidative photosynthetic carbon cycle depends on the Calvin cycle for a supply of ribulose-1,5-bisphosphate. The balance between the two cycles is determined by three factors: the kinetic properties of rubisco, the concentrations of the substrates CO_2 and O_2, and temperature. Photorespiration (oxygenation) increases relative to photosynthesis (carboxylation) as the temperature rises, thus increasing temperatures progressively tilt the balance away from the Calvin cycle and toward the oxidative photosynthetic carbon cycle.

3. In photorespiration, various compounds are circulated in concert through two cycles. In one of the cycles, carbon exits the chloroplast in two molecules of glycolate and returns in one molecule of glycerate. In the other cycle, nitrogen exits the chloroplast in one molecule of glutamate and returns in one molecule of ammonia (together with one molecule of α-ketoglutarate).

4. The C2 oxidative photosynthetic carbon cycle acts as a scavenger operation to recover fixed carbon lost during photorespiration by the oxygenase reaction of rubisco. Overall, two molecules of phosphoglycolate (four carbon atoms), lost from the Calvin cycle by the oxygenation of RuBP, are converted into one molecule of 3-phosphoglycerate (three carbon atoms) and one CO_2. In other words, 75% of the carbon lost by the oxygenation of ribulose-1,5-bisphosphate is recovered by the C2 oxidative photosynthetic carbon cycle and returned to the Calvin cycle.

Unlike mitochondrial respiration, photorespiration does not conserve energy and may actually inhibit net biomass formation as much as 50%. This inefficiency has led to evolutionary adaptations in the carbon assimilation processes, particularly in plants that have evolved in warm climates. The apparent inefficiency of rubisco, and its effect in limiting biomass production, has inspired efforts to genetically engineer a "better" rubisco, but this goal is not, as yet, within reach.