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This Week's Citation Classic

Chollet R & Ogren W L. Regulation of photorespiration in C_3 and C_4 species.
Bot. Rev. 41:137-79, 1975.
[Central Res. Dept., Du Pont Exp. Station, Wilmington, DE and US Regional Soybean Lab., Agricultural Res. Serv., US Dept. Agriculture, Urbana, IL]

The process of photorespiration in C_3 plants, as discussed in this review, comprises the oxygenation of ribulosebisphosphate (RuBP) and the metabolic pathway taken by the phosphoglycolate produced in this reaction. This process is less important in C_4 species because a biochemical CO_2-concentrating mechanism provides high CO_2 levels which competitively inhibit RuBP oxygenation. [The SCI® indicates that this paper has been cited over 185 times since 1975.]

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"In 1974, we were invited by the editor of *Botanical Review* to write a sequel to Andrew Goldsworthy's excellent article on photorespiration which had appeared in the journal in 1970.[1] While the previous review presented thorough coverage of the physiology of photorespiration, major advances had occurred in the intervening years with respect to the biochemistry of this complex process. Although it was generally accepted that glycolic acid, the substrate for photorespiration, was photosynthesized in the chloroplast and subsequently oxidized to CO_2 via the peroxisomal-mitochondrial pathway elucidated in Ed Tolbert's laboratory at Michigan State,[2] the mechanism of glycolate formation was both uncertain and heatedly debated. A major breakthrough in this area was the demonstration by George Bowes, a postdoc at Illinois, that the *in vitro* activity of the photosynthetic CO_2 fixing enzyme, ribulose 1,5-bisphosphate (RuBP) carboxylase, was competitively inhibited by O_2 with respect to CO_2 and that the same protein also catalyzed the oxygenation of RuBP to phosphoglycerate and phosphoglycolate, a precursor of glycolic acid, in the presence of molecular O_2.[3] Subsequently, Bill Laing, a doctoral student at Illinois, demonstrated that the effects of CO_2 and O_2 on leaf photosynthesis and photorespiration could be explained by the kinetic properties of RuBP carboxylase with respect to these two gaseous substrates.[4] Thus a primary objective of our review was to marshal evidence supporting the theory that the balance between photosynthesis and photorespiration was based on the dual activities of this bifunctional enzyme in that high CO_2 or low O_2 favored carboxylation and therefore photosynthesis, while low CO_2 or high O_2 favored oxygenation and therefore glycolate synthesis and photorespiration. Although this view was by no means generally accepted at the time,[5] it has since withstood critical experimental scrutiny at the biochemical and physiological levels.[6] This is perhaps one of the reasons why our review article has been so frequently cited over the past six years.

"A related controversy in 1974 was the mechanism by which certain higher plants, the so-called C_4 species, reduced photorespiratory CO_2 efflux from their leaves. The commonly held view at the time was that C_4 plants indeed photorespired at significant rates, but the resultant CO_2 evolved specifically in the chlorophyllous bundle sheath layer was efficiently refixed by phosphoenolpyruvate carboxylase in the tightly surrounding mesophyll cells before it escaped from the leaf. However, progress in research related to the enzymic properties of RuBP carboxylase and the biochemistry of C_4 photosynthesis in our own and other laboratories suggested a more attractive mechanism—C_4 plants had reduced photorespiration through the evolution of a specialized leaf anatomy and intercellularly compartmented enzyme complement which served as a biochemical CO_2-concentrating mechanism at the site of RuBP carboxylase/oxygenase in the bundle sheath. An elevated CO_2/O_2 ratio would allow CO_2 to compete more effectively with O_2 for RuBP, thereby decreasing the amount of glycolate available for photorespiratory oxidation to CO_2."

1. **Goldsworthy A.** Photorespiration. *Bot. Rev.* 36:321-40, 1970.
2. **Tolbert N E.** Photorespiration. (Davies D D, ed.) *The biochemistry of plants.* New York: Academic Press, 1980. Vol. 2. p. 487-523.
3. **Bowes G & Ogren W L.** O_2 inhibition and other properties of soybean ribulose 1,5-diphosphate carboxylase. *J. Biol. Chem.* 247:2171-6, 1972.
4. **Laing W A, Ogren W L & Hageman R H.** Regulation of soybean net photosynthetic CO_2 fixation by the interaction of CO_2, O_2, and ribulose 1,5-diphosphate carboxylase. *Plant Physiol.* 54:678-85, 1974.
5. **Zelitch I.** Pathways of carbon fixation in green plants. *Annu. Rev. Biochem.* 44:123-45, 1975.
6. **Lorimer G H & Andrews T J.** The C_2 chemo- and photorespiratory carbon oxidation cycle. (Hatch M D & Boardman N K, eds.) *The biochemistry of plants.* New York: Academic Press, 1981. Vol. 8. p. 329-74.