

This Week's Citation Classic

Camm E L & Towers G H N. Review article: phenylalanine ammonia lyase. *Phytochemistry* 12:961-73, 1973. [Dept. Botany, Univ. British Columbia, Vancouver, British Columbia, Canada]

The literature concerning the physiology and biochemistry of the enzyme phenylalanine ammonia lyase (PAL) (E.C.4.1.1.5) from different organisms has been reviewed. Levels of the enzyme are affected by age, light, phytochrome, wounding, infection, and growth modifiers. The possibility that PAL is involved in the control of phenolic metabolism has been critically examined. [The SCI® indicates that this paper has been cited over 135 times since 1973.]

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"Plant biochemists were excited by the 1961 discovery of PAL,¹ the enzyme which converts phenylalanine into cinnamic acid by a reductive deamination. PAL funnels carbon out of amino acid metabolism and into the cinnamic acid polymers and other derivatives that form so much of the plant biomass. It seemed in the early-1960s that a knowledge of the behaviour of this enzyme would provide a starting point for understanding the rest of cinnamate-based metabolism.

"Between 1966 and 1973, I was a graduate student at the botany department, University of British Columbia, Vancouver, where G.H.N. Towers was doing research on phenylpropanoid metabolism. I was looking at PAL in a yeast, *Sporobolomyces roseus*, and then in potato tuber slices. The more I compared my results with those in the literature, the more confused I became, for PAL seemed to be widely variable from plant to plant. Finally, in 1973, Towers and I set about compiling the literature on PAL, in an effort to see any patterns. I recall that I was

mostly interested in clarifying the picture in my own head, but Towers, somewhat more altruistically, hoped that such a review would prove useful to others too.

"It seemed that PAL was a logical candidate to be a control enzyme for phenylpropanoid metabolism, but among the difficulties with this hypothesis was the extreme variability of enzyme activity. It seemed as if every stimulus imaginable caused enzyme levels to change, and frequently enzyme levels were not correlated with changes in, say, anthocyanin levels. So it was with some relief that we encountered the work of Hahlbrock and co-workers, who showed that at least in flavonoid synthesis, PAL and several other enzymes of early phenylpropanoid metabolism were controlled quite differently than those of later flavonoid biosynthesis.² This was a clear demonstration that PAL controls only part of phenylpropanoid metabolism. Recent work on phenylpropanoid metabolism is reviewed by Towers and Wat.³

"Since the time of the original review, questions about control, formation, and decay of PAL have become more sophisticated. Recent work on cell cultures of bean illustrates how finely balanced the PAL system can be; depending on conditions, there is either stabilization or repression of PAL by cinnamate, *de novo* synthesis in the presence of an inducer, or inhibition by a proteinaceous factor.⁴

"At the time that our original review was written, research on PAL was expanding widely. Because of the multitude of different systems, it was actually no wonder that results sometimes appeared contradictory. It really is gratifying that so many authors found this review of use, even if it arose from my personal need to organize the facts. A review written today would probably feature just as many areas of confusion as did our review, but (I note with pleasure) at a considerably more sophisticated level."

1. Koukol J & Conn E E. The metabolism of aromatic compounds in higher plants. IV. Purification and properties of the phenylalanine deaminase of *Hordeum vulgare*. *J. Biol. Chem.* 236:2692-8, 1961.
2. Hahlbrock K, Ebel J, Ortman R, Sutter A, Wellmann E & Grisebach H. Regulation of enzyme activities related to the biosynthesis of flavone glycosides in cell suspension cultures of parsley (*Petroselinum hortense*). *Biochim. Biophys. Acta* 244:7-15, 1971.
3. Towers G H N & Wat C K. Phenylpropanoid metabolism. *Planta Med.* 37:97-114, 1979.
4. Dixon R A, Browne T & Ward M. Modulation of L-phenylalanine ammonia-lyase by pathway intermediates in cell suspension culture of dwarf French bean (*Phaseolus vulgaris* L.). *Planta* 150:279-85, 1980.