

# This Week's Citation Classic

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**Noodén L D & Thimann K V.** Evidence for a requirement for protein synthesis for auxin-induced cell enlargement. *Proc. Nat. Acad. Sci. US* **50**:194-200, 1963. [Biological Laboratories, Harvard University, Cambridge, MA]

This paper showed a connection between protein synthesis and the induction of cell enlargement by the plant hormone auxin. Inhibitors of RNA and protein synthesis suppressed auxin-induced cell enlargement in parallel with protein synthesis; this suggested that auxin could act through the promotion of enzyme formation. [The *SCF*<sup>®</sup> indicates that this paper has been cited in over 175 publications since 1963.]

Larry D. Noodén  
Department of Botany  
University of Michigan  
Ann Arbor, MI 48109  
and

Kenneth V. Thimann  
Department of Biology  
University of California  
Santa Cruz, CA 95064

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"Cell enlargement is the fundamental growth process, and this is controlled by auxin in many plant tissues. In 1960, the problem of how auxin acts was (and still is) a central issue in plant development. Much earlier, auxin had been shown to cause a softening of the cell wall. The prevailing theory held that auxin acted as a coenzyme to activate some enzyme which loosened the cell wall. At that time, much effort was directed to production of synthetic auxins in the hope of determining which parts of the molecule were active and thereby its mechanism of action.

"Larry Noodén was a beginning graduate student at Harvard University and wanted to study the biochemical regulation of plant development. When he was looking around for a PhD thesis project in 1960, his supervisor, Kenneth Thimann, pointed out that a

previous student had demonstrated that auxin, accompanying its effect on growth, produced a large increase in protein in artichoke tuber disks.

"The findings of Jacob and Monod and others at this time on inducible enzymes in bacteria suggested to us that auxin might act by inducing enzyme formation. We considered a variety of methods for studying auxin effects on protein synthesis, but then the methods were not well enough developed to offer good prospects. About the same time, studies on protein and RNA synthesis had started to employ selective inhibitors. Thus, it seemed that the connection between auxin action and protein/RNA synthesis could be examined using inhibitors.

"This work generated special interest partly because: a) by 1963, the rapid advances in our knowledge of protein synthesis and inducible enzymes had greatly impressed the scientific public, and b) the paper boldly combined these new ideas to formulate a new explanation and a new experimental approach for auxin action at a time when a new theory was needed.

"What followed was a large number of papers on the problem, some of which went well beyond or questioned the initial idea.<sup>1</sup> These details are not relevant here; however, after much seesawing around various theories, the mechanism of auxin action has still not been resolved.<sup>2</sup> Auxin may indeed induce the formation of new RNAs and enzymes in addition to other actions.<sup>2,3</sup> In any case, the initial report generated much discussion, and both the idea of inducible enzymes as developmental controls and the approach (using selective inhibitors of RNA and protein synthesis as probes) were employed widely. All of these factors contributed to the extensive citation of this paper.

"Neither of us really followed up the leads represented in this paper; we felt that the tools required to carry out the next logical step would not be at hand for some time, and that has turned out to be true."

1. Key J L. Hormones and nucleic acid metabolism. *Annu. Rev. Plant Physiol.* **20**:449-74, 1969.
2. Hanson J B & Trewavas A J. Regulation of plant cell growth: the changing perspective. *New Phytol.* **90**:1-18, 1982.
3. Theologis A & Ray P M. Changes in messenger RNAs under the influence of auxins. (Wareing P F, ed.) *Plant growth substances 1982*. London: Academic Press. 1982. p. 43-57.