

This Week's Citation Classic

Kende H. Kinetinlike factors in the root exudate of sunflowers.

Proc. Nat. Acad. Sci. US 53:1302-7, 1965.

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This paper describes evidence that at least two cytokinins are produced in the root of plants and are translocated to the shoot through the xylem. These cytokinins appear to fulfill the role of the 'root hormones' that have been postulated to regulate protein metabolism in leaves. [The SCJ® indicates that this paper has been cited in over 175 publications since 1965.]

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"In 1963, I was working as a postdoctoral fellow in the group of Anton Lang at the California Institute of Technology. I had just accepted a position at the Negev Institute for Arid Zone Research in Israel and was casting around for ideas that might bridge my research interests in developmental plant biology and those of my future colleagues in plant-water relations and ion uptake. One of the most stimulating features of our academic life at Caltech was the weekly plant physiology journal club. At one of these sessions, Lang reported on a recent paper by Kulaeva¹ where evidence for the existence of a hereto hypothetical root factor was given.

"In 1939, Chibnall² had reported that the protein content of a detached leaf declined rapidly, leading to senescence and death of the organ. This process was reversed when adventitious roots developed on the petiole. Chibnall concluded that a hormone supplied by the root was necessary to maintain normal protein metabolism in the leaves. In

1957, Richmond and Lang³ discovered that the plant growth regulator kinetin, a synthetic cytokinin, retarded senescence and protein loss in isolated leaves. Thus, Kulaeva's finding raised the question of whether Chibnall's hypothetical root hormone was a cytokinin. I decided immediately that hormonal relations between the root and the shoot would be my new research project at the Negev Institute. The possibility existed that environmental factors which affected the physiology of the root influenced developmental processes in the shoot via cytokinins.

"I joined the Negev Institute in the fall of 1963 eager to start my research on root hormones. Kulaeva's idea to assay xylem exudate of detopped plants for compounds that retarded chlorophyll loss in detached leaves had been an excellent one, but the effects she had observed were marginal. They had been obtained with unpurified and unconcentrated sap, and her bioassay was not specific for cytokinins. I concentrated and partially purified the xylem sap of sunflowers and set out to test whether it contained cytokinins, i.e., factors that induced cell divisions in plant tissue cultures. At that time, the Negev Institute neither possessed an autoclave nor facilities for sterile work. For the first experiments, I brought our pressure cooker from home to sterilize culture flasks and media. Later, we were allowed to use the autoclave at the Beersheva Hospital and, with time, the institute acquired its own autoclave. Using a tissue culture bioassay, I was able to show that the xylem exudate of sunflowers contained a cytokinin and that a second compound could be converted to an active cytokinin by acid hydrolysis. Indirect evidence indicated that these cytokinins were produced in the root.

"This paper has often been cited in the context of hormonal root-shoot relations, a topic reviewed by Torrey.⁴ It established an important physiological function of cytokinins and described a case where a plant hormone was transported through the vascular system to play the role of a messenger between two distinct organs of a plant."

1. Kulaeva O N. The effect of roots on leaf metabolism in relation to the action of kinetin on leaves. *Sov. Plant Physiol.—Engl. Tr.* 9:182-9, 1962.
2. Chibnall A C. *Protein metabolism in the plant*. New Haven, CT: Yale University Press, 1939. 306 p.
3. Richmond A E & Lang A. Effect of kinetin on protein content and survival of detached *Xanthium* leaves. *Science* 125:650-1, 1957.
4. Torrey J G. Root hormones and plant growth. *Annu. Rev. Plant Physiol.* 27:435-59, 1976.