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This Week's Citation Classic

Leonard R T & Hodges T K. Characterization of plasma membrane-associated adenosine triphosphatase activity of oat roots. *Plant Physiol.* **52**:6-12, 1973. [Dept. Botany and Plant Pathology, Purdue Univ., Lafayette, IN]

ATPase activity of plasma membrane vesicles isolated from oat (*Avena sativa* L. cv. Goodfield) roots is shown to have properties which are consistent with the view that the enzyme functions in energy transduction for potassium transport. The kinetic data for K^+ stimulation of ATPase activity were similar to those for $^{42}K^+$ influx into oat roots and neither set of data followed the Michaelis-Menten equation but rather were best described by a single activity curve with continually changing kinetic parameters. [The *SCI*® indicates that this paper has been cited over 120 times since 1973.]

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"During the late-1960s, Thomas Hodges, then at the University of Illinois, Urbana, began research on the mechanism and energetics of ion transport in plant cells. At that time, there was considerable debate over whether or not ATP was the direct source of energy for ion transport in plants. Hodges reasoned that if ATP was directly utilized at the plasma membrane for ion transport, then there should be an enzyme associated with the plasma membrane which hydrolyzed ATP and which was specifically affected by transported ions such as potassium.

"When I began postdoctoral study with Hodges in 1971, he and his colleagues had demonstrated that the amount of membrane-associated, K + -stimulated ATPase activity in homogenates of roots was highly correlated with the rates of K^+ transport in root tissues of several plant species.[1] For some time they had tried unsuccessfully to show that the K+-stimulated ATPase activity was associated with the plasma membrane.

"Shortly after I joined the group, Hodges accepted a position at Purdue University. The research was interrupted while we moved to Purdue and set up the laboratory. When we resumed the research in the new laboratory facilities, including some different centrifuge rotors, we were forced to change, somewhat, the approach being used to develop a procedure for isolating plasma membrane vesicles. These changes contributed to our success in showing that K^+ -stimulated ATPase activity copurified with plasma membrane vesicles from oat roots.[2] Once this was accomplished, the process of characterizing the ATPase activity of the plasma membrane fraction was straightforward. The manuscript describing the results, although vigorously reviewed, was immediately accepted for publication.

"The results clearly demonstrated that a plasma membrane fraction from plant cells contains a K^+ -stimulated ATPase activity with properties that are consistent with a role for the enzyme in energy coupling to K^+ transport. The paper also proposed that the unique kinetic data observed for both K^+ -ATPase and K^+ transport may represent the action of a multisubunit enzyme which exhibits negative cooperativity (half-of-the-sites reactivity). Presently, there is debate over whether or not the plasma membrane ATPase is a primary K^+ pump,[3] and the significance of the kinetic data for K + -ATPase and K^+ transport is not fully understood. The fact that the paper is relevant to both questions is probably why it is highly cited.

"In 1975, the American Society of Plant Physiologists gave the Charles Albert Shull Award to Hodges for his work on the plant ATPase. For my part in the research I also received a special award: a tenure track position in university teaching and research!"

1. **Fisher J D, Hansen D & Hodges T K.** Correlation between ion fluxes and ion-stimulated adenosine triphosphatase activity of plant roots. *Plant Physiol.* **46**:812-14, 1970
2. **Hodges T K, Leonard R T, Bracker C E & Keenan T W.** Purification of an ion stimulated ATPase from plant roots: association with plasma membranes. *Proc. Nat. Acad. Sci. US* **69**:3307-11, 1972.
3. **Leonard RT**. The plasma membrane ATPase of plant cells: cation or proton pump? (Martonosi A N, ed.) *Membranes and transport: a critical review.* New York: Plenum. In press, 1981.