Studying the Regulation of Vacuole Fusion in Guard Cells by (de)phosphorylation of HOPS

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Abstract

As desertification and record breaking droughts continue to rise in frequency, understanding how plants regulate water loss becomes an increasingly important area of study. Stomata, which allow for the uptake of CO_2 when open, mitigate water vapor loss by closing. The opening and closing of stomata is regulated in part by vacuole fusion and fragmentation (Gao et al., 2005 Plant Physiol. 139: 1207). While vacuole fusion is well studied in yeast, it is less well characterized in plants. In yeast, the homotypic vacuole protein sorting proteins (HOPS) tethers apposing vacuole membranes to allow the SNAREs (soluble N-ethylmaleimide sensitive factor attachment protein receptors) to zipper together into a trans-SNARE complex. Eventually, the HOPS complex dissociates from SNARE to allow complete vacuole fusion (Song et al., 2021 eLife 9:e67578). Modeling of plant vacuole fusion events predicted a steady-state of the HOPS:SNARE association prior to fusion, and the rapid progression of fusion after HOPS dissociation from SNARE. We hypothesize that the release of HOPS from SNARE in plants is the result of rapid post-translational modifications including phosphorylation. In support of this hypothesis, we have detected multiple phosphorylation states of the HOPS-specific proteins VPS39 and VPS41 and have identified mutants of candidate kinases with impaired vacuole fusion phenotypes. These results underscore a potential role of protein phosphorylation and dephosphorylation in the regulation of vacuole fusion in plants.