

Pollen tube growth: critical link in stress tolerance and evolution of angiosperm reproduction?

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Sexual reproduction in flowering plants relies on cell-cell interactions such as between the male gametophyte and the female gametophyte during pollen tube reception, which involves pollen tube stopping its growth and releasing sperm cells to affect fertilization and seed formation. We characterized the role of Arabidopsis LORELEI (LRE), a glycosylphosphatidylinositol (GPI)-anchored membrane protein (GAP), in pollen tube reception and how it functions with its co-receptor FERONIA in inducing the release of sperm cells for fertilization. Genes encoding these proteins are members of multi-gene families in most angiosperms and in Arabidopsis, variants of this signaling complex mediate diverse processes in plant development.

We investigated evolutionary factors underlying the maintenance of gene duplicates in the *LRE* gene family. Duplicated genes may acquire new functions (neofunctionalization) and hence may be retained. Another mechanism of retention is subfunctionalization via sequence variations in the protein-coding or regulatory regions (regulatory subfunctionalization) of the duplicates. Using expression analysis and complementation of mutant phenotypes, we showed that neofunctionalization and regulatory subfunctionalization, but not subfunctionalization, as the reasons for the retention of *LRE*-like GAPs (*LLG*) paralogs in Brassicales.

Interestingly, all but one monocot and all eudicot species examined had an *LLG* copy with preferential expression in male reproductive tissues, while the other duplicate copies showed highest levels of expression in female or vegetative tissues. The single *LLG* copy in *Amborella trichopoda*, a basal angiosperm, is expressed vastly higher in male compared to female reproductive or vegetative tissues. Because Arabidopsis *LLG2* and *LLG3*, expressed specifically in male reproductive tissues, are critical for pollen tube growth through the transmitting tract, we propose that expression of *LLGs* in male gametophyte underlie the evolutionary innovation of rapid pollen tube growth in the closed carpel of angiosperms.

Heat stress tolerance is another instance where pollen tube growth is critical for plants, as at elevated temperatures, pollen tubes fail to grow through the pistil and complete seed formation. Our central hypothesis is that pollen tubes are uniquely sensitive to heat stress, but that thermotolerant variants have been selected for reproductive success at high temperature. Using tomato reproduction as a model system, we are using genomic approaches to define these molecular adaptations and determine whether they are sufficient to enhance fruit production of thermosensitive cultivars at high temperature.