Leaf Growth Directionality Is Divergent and Involves a Conserved MicroRNA Regulatory Module

Leaf growth is polar in several model angiosperms, with cell proliferation near the base and a gradient of increasing cell maturation as you approach the tip (reviewed in Efroni et al., 2010; Powell and Lenhard, 2012). However, many questions remain about how the diversity of leaf shapes is achieved (reviewed in Tsukaya, 2014). New work from Das Gupta and Nath (2015) shows that the polarity of leaf lamina growth is divergent in nature, based on a survey of leaf growth patterns from more than 70 eudicots, and reveals that a miR396-GROWTH REGULATING FACTOR (GRF) regulatory module likely played a role in the evolution of these patterns.

Das Gupta and Nath monitored leaf growth rates at different positions along the axis of the leaf using ink spots (see figure). They analyzed the changes in relative position of the spots using principles of allometry, a long-standing field based on correlations between the growth rates of organs within an organism (reviewed in Klingenberg, 1996). Many leaves did show basipetal growth, which Das Gupta and Nath defined as positive allometry (the growth rate of the basal region of the leaf was greater than that of the tip). However, other leaves showed acropetal growth, i.e., negative allometry, in which the growth rate at the base was lower than that at the tip. Still others showed diffuse, or isometric, growth such that the growth rates were the same along the proximo-distal axis of the leaf.

The authors then explored the molecular underpinnings of these divergent leaf growth polarities. Opposite to the patterns in basipetal growth, leaves with acropetal growth had greater cell proliferation (i.e., mitotic activity) near the tip and a gradient of maturation toward the base. Importantly, Das Gupta and Nath demonstrated that the miR396-GRF regulatory module is associated with the different growth patterns in leaves. In this highly conserved module, miR396 activity delimits the accumulation of GRF gene products, which generally promote cell proliferation. Das Gupta and Nath found that miR396 accumulation patterns were consistent with the patterns of cell proliferation and maturation underlying the different growth patterns. As reported previously, in leaves with basipetal growth, miR396 accumulation is higher near the tip and lower near the base; accordingly, accumulation of target GRF transcripts is greater in the base. Conversely, Das Gupta and Nath found that the leaves with acropetal growth had more miR396 in the base (and less GRF2 transcript accumulation) than in the tip. Furthermore, the levels of miR396 (and GRF2) were uniform throughout isometric leaves. Thus, the accumulation patterns of miR396 appear pivotal in establishing the ultimate leaf growth patterns.

Together, this nice work from Das Gupta and Nath highlights the need to expand our models of how leaves grow, as even leaves of similar shape had different growth patterns. It points to the importance of changes in miR396 expression in the evolution of leaf growth and establishes this as a good model system for understanding the evolution of changes in the regulation of cellular proliferation and maturation.
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