Apomixis and Gene Expression in Boechera

The ability to induce apomixis, the production of seeds from maternal tissues without fertilization or meiosis, in crop plants has been referred to as a holy grail of plant biology. Apomixis leads to genetically identical progeny, which would, for instance, allow crops to retain complex features such as hybrid vigor over many generations and thus drastically reduce costs associated with seed production (reviewed in Bicknell and Koltunow, 2004). Apomixis is hypothesized to have originated as a form of sexual reproduction that underwent deregulation at some step or steps (reviewed in Koltunow and Grossniklaus, 2003). It has arisen in many different lineages of flowering plants, yet the mechanisms underlying the change from a sexual to an apomictic reproductive strategy are not understood. It frequently occurs together with polyploidy and interspecific hybridization, both of which cause major changes in gene interaction and expression, and both of which might be factors in promoting conditions that favor apomixis. However, the global changes induced by both polyploidy and hybridization make it difficult to identify those effects specifically related to apomixis.

Recently, Sharbel et al. (2009) have elegantly overcome some of these confounding effects by comparing sexual and apomictic species of the genus Boechera. This genus, a relative of Arabidopsis, includes extremely rare diploid apomicts as well as diploid sexual species, allowing for comparisons between related species of the same ploidy. In that first analysis, the authors performed transcriptome profiling of microdissected ovules at the megaspore mother cell stage and found evidence for effects of heterochrony, genome duplication, and ancient hybridization events in apomictic gene expression (Sharbel et al., 2009). Now, Sharbel et al. (pages 655–671) make use of the same genus to delve further in the role of heterochrony in promoting apomixis.

In the new work, Sharbel et al. compared transcriptomes from microdissected live ovules over the course of development in two diploid species of Boechera, one sexual and one apomictic (see figure). They identified stage-specific gene expression (genes expressed in only one stage of development in both species) and heterochronic genes (those that were expressed in both types of ovules but were differentially expressed between any two stages), although the patterns of the latter did not indicate that a simple change in the timing of a developmental pathway or pathways could explain the shift to apomixis. The authors found that, for the most part, apomictic ovules showed downregulation of expression compared with sexual ovules early in development and upregulation relative to sexual ovules at the stage corresponding to fertilized ovules.

The results are consistent with events around the time of megaspore mother cell development being important in the switch from sex to apomixis. In addition, the authors found that transcription factors were overrepresented among apomixis-specific genes, suggestive of large-scale regulatory changes in apomictic ovules. Overall, this work provides a global view of the changes in gene expression associated with apomixis in Boechera, a strong starting point for developing more refined hypotheses about the underlying molecular mechanisms leading to the expression of apomixis in general.

Nancy R. Hofmann  
Science Editor  
nhofmann@aspb.org

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Nancy R. Hofmann
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