

# Developmental switches that hold the key to a revolution in crop biotechnology

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Kaufmann *et al.* (Regulation of transcription in plants: mechanisms controlling developmental switches. *Nature Rev. Genet.* **11**, 830–842 (2010))<sup>1</sup> have provided valuable insights into transcriptional regulation during well-known developmental switches in *Arabidopsis thaliana* — including the development of the inflorescence meristem from the apical meristem and the establishment of floral organ identities. Similar intensive studies of the developmental switches in the angiosperm nucellus are urgently needed to improve understanding of developmental reprogramming towards apomixis; characterizing the regulation of apomixis could lead to important biotechnological applications.

A nucellar cell normally undergoes meiosis to produce a haploid female gametophyte (FG, which includes the egg) during angiosperm sexual reproduction. In apomictic angiosperms, nucellar cells can avoid meiosis to produce an unreduced, diploid FG or even directly transdifferentiate into a somatic embryo (adventitious embryony) and eventually produce a clone. Manipulating these apomictic developmental switches to produce ‘clones-through-seeds’ has been a cherished objective in crop biotechnology<sup>2</sup>. As Kaufmann *et al.* discuss, transcriptional regulators are known to initiate correct developmental transitions or cell fate specifications by coordinating the expressions of required genes<sup>1</sup>. However, little is known about these aspects of apomictic developmental transitions.

For agriculture, the aim would be to produce asexual/adventitious embryos with genetic stability through generations. To achieve this, greater understanding of regulatory processes is required. Genetic variation among the progeny could be avoided by eliminating or suppressing meiotic recombination or meiosis itself. Although basic meiotic processes are conserved among species, diverse mechanisms control the mitosis-to-meiosis transition<sup>3</sup>. For example, the genes *IME1* and *IME2* in budding yeast, *mei2* in fission yeast, stimulated by retinoic acid 8 (*Stra8*) in mice and *ameiotic1* (*am1*) in maize regulate the initiation of meiosis in different ways<sup>3</sup>. In *A. thaliana*, mutants in which female meiosis is abolished — such as *dyad* (also known as *swi1*) mutants<sup>4,5</sup>, *spo11 rec8 osd1* triple mutants<sup>6</sup> or *ago9* mutants that fail to silence a transposable element-derived small RNA pathway<sup>7</sup> — produce a functional but unreduced, diploid FG. Elimination of meiosis, however, may increase ploidy of both the embryo and endosperm over successive generations, and the implication of this for crop productivity is uncertain. Another approach that has been proposed is chromosome engineering to suppress meiotic recombination by using balancer chromosomes carrying localized inversions<sup>8</sup>.

A challenge in using adventitious embryony is how to combine it with a normally developed endosperm, either through fertilization (single fertilization) or autonomous development. The molecular mechanisms

that underlie the developmental switch that directly transforms a somatic plant cell to an embryo are still elusive<sup>9</sup>. Several genes, such as *WUSCHEL* (*WUS*), *SOMATIC EMBRYO RECEPTOR-LIKE KINASE 1* (*SERK1*), *LEAFY COTYLEDON 1* (*LEC1*), *LEC2* and *BABY BOOM* (*BBM*), can induce embryonic growth in plant somatic cells<sup>10</sup>, and Polycomb group proteins are also implicated in somatic embryogenesis<sup>11</sup>. However, it is uncertain whether these pathways for reprogramming of plant somatic cells towards embryogenesis are conserved among species.

Given their immense biological and biotechnological significance, apomictic developmental switches deserve greater attention in future research.

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Published online 1 February 2011

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#### Competing interests statement

The author declares no competing financial interests.