Regulation of flowering time in perennial herbaceous plant

Under a research project funded by the National Natural Science Foundation of China, Dr. Wang Jiawei and his colleagues at the Institute of Plant Physiology and Ecology, Shanghai Institutes for Biological Sciences published their research findings in an article entitled "Molecular Basis of Age-Dependent Vernalization in *Cardamine flexuosa*" in *Science* (**2013**, 340: 1097—1100).

Plants have different life forms, such as annual, biennial and perennial. Most polycarpic perennials flower over many seasons in their lifetime. How perennials undergo repeated cycles of vegetative growth and flowering is poorly understood. *C. flexuosa*, a member of the Brassicaceae, is a herbaceous perennial. *C. flexuosa* has an obligate requirement for a week- to month-long cold temperature, a treatment known as vernalization, to induce flowering (Figure **A**). The plants younger than 4 weeks old could not respond to cold. Dr. Wang and his colleagues revealed that the levels of two microRNAs (miRNAs) contribute to regulate the timing of acquisition of floral competence in response to cold treatment in *C. flexuosa*. Floral induction is achieved only when the old plants are exposed to cold for at least two months (Figure **B**).

Mechanistically, age and cold coordinate to regulate floral induction in *C. flexuosa* by removal of two repressors, CfFLC, which is repressed by cold treatment, and CfTOE1, which is down-regulated by the miR156-SPL-miR172 cascade. In the young seedling, high levels of miR156 lead to the accumulation of CfTOE1. CfTOE1 represses *CfSOC1* expression regardless of cold treatment; as the plant grows, the endogenous sugar content is elevated, resulting in a decreased level of miR156 and the concomitant increase in miR172. As a consequence, the occupation of CfTOE1 at *CfSOC1* promoter was reduced, leading to a "cold-sensitive" state. Flowering can be successfully induced when *CfFLC* expression is reduced by cold treatment.

The integration of age and cold response offers advantage for perennial growth habit, by ensuring plants do not flower until they develop axillary shoots and gain enough biomass. This work also suggests that the species-specific imbalance of repressive versus inductive floral inductive signals determines the life cycle strategy of flowering plants.

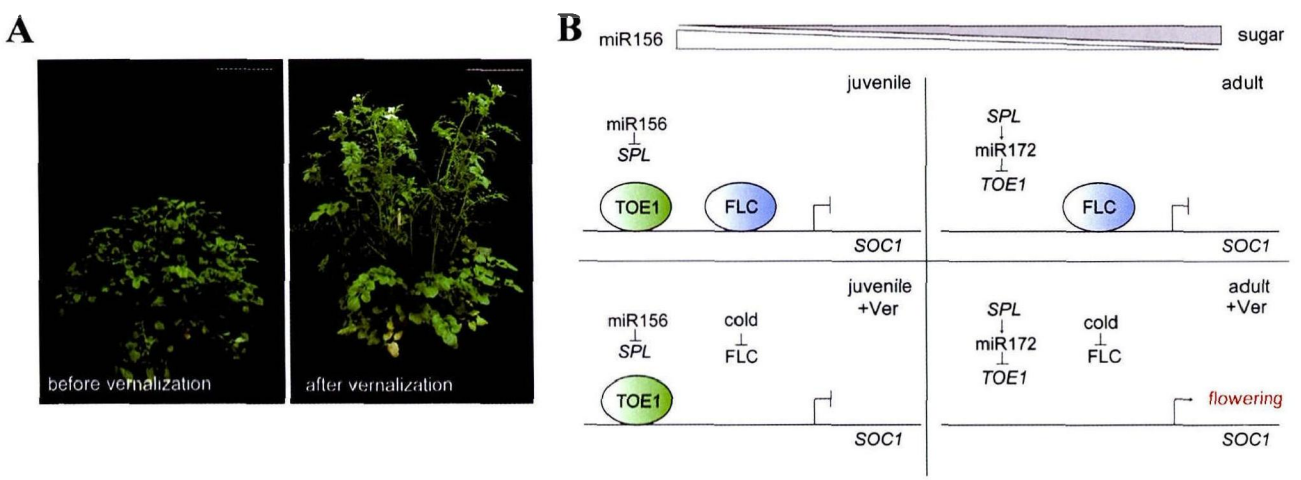

Figure **A** Growth habit of *C. flexuosa*. **B** A model for the regulation of flowering time in *C. flexuosa*. The level of miR156, by responding to sugar, decreases over time. As a consequence, the expression of miR156 target *SPLs* is gradually increased. Flowering only occurs when the old plants are vernalized, where the level of *TOE1* and *FLC* are low.