Reply

Our review (Coen and Carpenter, 1993) describes how both the similarities and differences between flowers and shoots can be explained by the action of a set of genes modifying a common growth plan. This does not imply that flowers and shoots are directly derived from one another or that they serve the same function or that they express all of the same genes.

We would also like to point out that it is very misleading to claim that Goethe denied sexuality in plants because it did not fit with his theory. He only came to seriously question sexuality in plants 14 years after publication of his theory of metamorphosis after a conversation with F.J. Schelver. On hearing Schelver's doubts about the theory of sexuality, Goethe (1820) was surprised: "In my mature studies I had religiously accepted the dogma of sexuality in plants and was, therefore, taken aback now to hear a concept directly opposed to my own."

It is clear that Goethe, quite correctly, did not feel that sexuality in plants was incompatible with his theory of metamorphosis even though he was later attracted by Schelver's new scheme. "Accustomed as I had always been to preserve complete flexibility in my application of metamorphosis, I likewise found this [Schelver's] viewpoint not uncomfortable, although at the same time I could not immediately relinquish the other" (Goethe, 1820).

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REFERENCES

Coen, E., and Carpenter, R. (1993). The metamorphosis of flowers. Plant Cell **5**, 1175–1181.

Goethe, J.W. (1820). Natural Science in General; Morphology in Particular, Vol. 1, No. 3. In *Goethe's Botanical Writings*, trans. B. Mueller (Honolulu: University of Hawaii Press).

Planting Ideas in the Schools

Rapid-cycling *Brassica rapa* plants— spindly, nondescript, with bright yellow flowers—may not look like agents of dramatic change, but in classrooms across the nation and abroad they are a potent tool in a concerted effort to revolutionize the way science is taught. The speed of their reproductive cycle and the ease with which they can be grown makes these plants ideal for use in the "hands-on," "inquiry-based" approaches to teaching science that are being adopted by more and more teachers and school systems. Such approaches allow students to actually carry out scientific investigations instead of learning scientific facts by rote memorization, which has become an all-too-common method of teaching science.

The rapid-cycling Brassicas, or "Fast Plants," embody another revolution in science education as well: partnerships between scientists and teachers in which scientists develop new curriculum ideas and educate teachers about how science is actually done, and in which teachers educate scientists about what kinds of inquiry are possible or appropriate for children. Such partnerships are widely viewed as essential if today's children are to grow into tomorrow's scientifically literate adults.

Fast Plants grew out of the attempts of Paul Williams, a plant pathologist at the University of Wisconsin, Madison, to breed rapid-cycling populations of several Brassica species to enhance research into the basic properties of this economically important genus (Williams and Hill, 1986). By plucking out the fastest growers of each species from among thousands of Brassica accessions in the USDA's National Plant Germplasm System and continuously interbreeding the fastest plants within each species, Williams and his collaborators were able to develop populations that reproduced rapidly and fairly synchronously but were otherwise heterogeneous. For instance, the *Brassica rapa* population flowered within 14 days and went from seed to seed in just 35 days, with no requirement for desiccation or dormancy, a feat unequaled even by Arabidopsis.

The properties of the rapid-cycling Brassicas—not only their compressed life cycle but also their size, hardiness, and ease of growth—prompted Williams to explore their potential as teaching tools. With a grant from the National Science Foundation (NSF) and in collaboration with

Reply.

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