Single transplanted gene turns shoots slated to be stems and leaves into flowers

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SINGLE TRANSPLANTED GENE TURNS SHOOTS SLATED TO BE STEMS AND LEAVES INTO FLOWERS

To a plant, the importance of flowering cannot be overstated. Simply put, plants produce flowers to preserve the species. Flowers produce fruit which, in turn, contains seeds that are passed on to the next generation.

Now, plant biologists from the University of California, San Diego have demonstrated that flowers are merely modified shoots that require only a single gene to change what normally would have been stems and leaves into flowers.

What's more, plants altered genetically to produce flowers where shoots normally sprout generate flowers much earlier in the plant's life cycle. If a plant normally takes about 10 weeks to flower, the genetically altered plant would take about three weeks.

The results, published in today's issue of the journal Nature, not only might increase crop yields by decreasing flowering time, it also could offer plant breeders a new tool for genetically modifying economically important crops.

"Corn is an excellent example where breeders are trying to introduce new traits that generally involve many generations of back-crossing that could take 5 to 10 years," said Martin Yanofsky, an associate professor of biology at UCSD and the study's principal investigator.

"Obviously, if you cut that down by a factor of 2 or 3, that would be terrific."

Yanofsky's research, coauthored with postdoctoral fellow M. Alejandra Mandel, revolves around the genetic alterations of a small, uneconomical and inedible weed called Arabidopsis thaliana. Known commonly as a mustard plant, Arabidopsis has one socially redeeming quality--it has the smallest complement of genetic material known in any plant, making it easy to manipulate and engineer. In many respects, plant biologists study Arabidopsis the way animal geneticists study fruit flies.

Using Arabidopsis, the UCSD researchers focused on the region of the plant known as the meristem. It's here, at the tip of a stem, where certain molecular signals tell a plant to form a shoot for stems and leaves, or to form a flower. If the decision is to flower, thousands of other genes are subsequently activated to produce different flower organs in a precisely defined pattern. Those organs typically include sepals, petals, stamens and carpels.

During the past three years, Yanofsky's lab has harvested some important clues into the early genetic mechanisms responsible for flowering. Among other things, his group has isolated two of the three genes from

Arabidopsis--APETALA1 (API) and CAULIFLOWER--that play a major role in tell a plant to form a flower. The third gene called LEAFY was isolated at Caltech by Detlef Weigel, a plant biologist now at the Salk Institute.

Curiously, if one of these genes were eliminated, the plant would still produce flowers. However, if two of the three are eliminated, flowers do not develop. Instead, the plant produces a series of new non-flowering meristems that resemble cauliflower.

In his Nature paper, Yanofsky created genetically altered Arabidopsis plants that express AP1--and therefore flowers--in meristems that normally produce stems and leaves.

"We asked the question, is one single gene sufficient to trigger this development switch of a shoot to a flower," said Yanofsky. "And the answer is yes."

Flowering in the Arabidopsis took place in less than a third of the time it would take a normal plant. A separate paper in the current issue of Nature, authored by Weigel, demonstrates that a transplanted LEAFY gene also causes early flowering in Arabidopsis and two other plants, including a long-lived tree, the aspen.

"One reasons for the shortened time stems from the fact that we are converting shoot meristems into floral meristems and shoot meristems arise earlier in the life cycle of plants," said Yanofsky. "But it's much more dramatic than we would have expected. Something in addition is going on that we haven't quite put our finger on."

Potentially, earlier flowering could be a boon to plant breeders seeking to shorten the time for introducing new traits--such as pesticide resistance--into seeds.

Earlier flowering also might offer farmers the opportunity to boost crop yield in a given field, or increase the number of flowers on plants for horticulture.

"This study has implications for virtually everything you can imagine with plants," said Yanofsky.

Yanofsky is the recipient of young investigator awards from the David and Lucile Packard Foundation and the Arnold and Mabel Beckman Foundation. His study was supported by grants from the National Science Foundation.

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