Genetic roots of cauliflower formation revealed by plant biologists at UC San Diego

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The genetic roots guiding the formation of cauliflower in plants have been revealed by plant biologists at the University of California, San Diego, leading to new insights into flower formation and a potential new way to create new vegetables.

The discovery, published in the January 27 issue of the journal Science, describes a gene called CAULIFLOWER necessary for the development of floral meristems, a small group of cells destined to divide and differentiate to become a flower.

When this gene and another previously isolated gene called APETALA1 are mutated, flowers fail to develop. The result is the formation of a curd-like structure that resembles dinner-table cauliflower.

Martin Yanofsky, associate professor of biology at UCSD, says the experiments may significantly reduce the time needed to produce larger, tastier or even pest-resistant cauliflower.

It also means that plant breeders, in essence, could create cauliflower-edible curds for any plant.

"It opens up an enormous possibility for creating new vegetable types," Yanofsky said.

The article, coauthored with UCSD graduate students Sherry A. Kempin and Beth Savidge, describes genetic and molecular studies with 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 now study Arabidopsis the way animal geneticists study fruit flies.

Much of Yanofsky's work has been focused on the first steps in the development of a flower, in a region called the floral meristem. It's here, at the tip of a stem, where certain molecular signals tell the 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.

The precise mechanisms responsible for signaling a plant to form a flower remain, for the most part, a mystery that has confounded biologists for centuries. Clearly, however, plants respond to all kinds of factors including light, temperature and nutrient conditions.

"When you starve a plant, if it's running out of nutrients and thinks it's going to die, it says I better hurry up and flower," says Yanofsky.

"But how a plant perceives these environmental stimuli," he continued, "and transmits this information to the apex which is deciding to form a flower or shoot, that's something we would like to understand."

During the past three years, Yanofsky's lab has been harvesting some important clues. Among other things, his group has isolated two of the three genes from Arabidopsis--APETALA1 and CAULIFLOWER--that play a major role in telling a plant to form a flower. The third gene called LEAFY was isolated at Caltech by Detlet Weigel, a plant biologist now at the Salk Institute who collaborated with Yanofsky on the discovery.

By analyzing the protein structures coded by these genes, Yanofsky has learned that APETALA1 and CAULIFLOWER work in tandem as transcription factors--genes that regulate other as-yet unknown genes that ultimately control the formation of floral organs. The role played by LEAFY has yet to be defined.

If any one of these three genes do not function, flowers nevertheless still develop.

However, as described in his Science paper, 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.

Yanofsky says that it's likely that the same mutated genes that produce cauliflower curds in Arabidopsis are also responsible for giving us the supermarket variety of cauliflower.

In their Science paper, the researchers report that the cauliflower gene in the dinner-table variety is nonfunctional, pointing to a likely cause for this distinct characteristic.

"This suggests a molecular basis for one of the oldest recognized flower abnormalities," said Yanofsky.

As a final proof of the idea, the researchers are introducing functional APETALA1 and CAULIFLOWER genes into the dinner-table cauliflower.

Yanofsky said he anticipates the experiment that the cauliflower curd will be transformed "into a perfectly normal flower."