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Genes in a Vault?

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New research on *Arabidopsis thaliana* is again focusing on the plant's mysterious ability to defy the laws of Mendelian inheritance. Unlike most organisms, which inherit traits from their parents, *Arabidopsis* offspring have been found to have traits for which there is no information in their chromosomal genome.

Arabidopsis is a small, unassuming plant and a darling of plant geneticists. Its short life cycle of 5–6 weeks makes it possible for researchers to examine six to eight generations in a year. The plant's small size also allows it to be grown in large numbers in controlled environments. "This allows researchers to study large numbers of plants using only a modest amount of space, no matter what time of year it is," explained Susan Lolle, who studies plant genetics at the University of Waterloo in Ontario, Canada.

Because these plants self-fertilize, their genetic diversity would be expected to decline over time, giving them less ability to adapt to changing environmental conditions. However, *Arabidopsis* has maintained a degree of diversity sufficient to keep it around for a million years. Lolle and her colleagues observed inexplicable inheritance patterns in some of these little plants, hinting that their capacity for maintaining diversity may reside in hidden caches or vaults of ancestral genetic information containing additional genetic options that could be accessed when they are needed.

In 2005, she and her colleagues proposed, in an article in *Nature* (doi:10.1038/nature03380), "that these genetic restoration events are the result of a… process that makes use of an ancestral [genetic] cache." This proposal encountered considerable criticism. Contradictory evidence was published in 2006 (doi:10.1038/nature05251); it was suggested that Lolle's results were due to cross-pollination or contamination from genetic material introduced from outside sources.

But in new research, published in *F1000Research* (doi:10.3410/f1000research.2-5.v1), Lolle and others provided additional evidence of the existence of "cryptic sources of genetic variation that can be harnessed to promote greater genetic diversity." Lolle proposes that the plants can insert these cryptic sources or genetic templates into the chromosomes of tissues that lead to the production of offspring and contribute to an increased capacity for maintaining an unexpected degree of genetic diversity. This enhanced ability to cope with environmental stress and change would impart a considerable evolutionary advantage. Regarding this new work, Andy Pereira of the University of Arkansas states in his accompanying review of the paper that the data provide adequate support against contamination by outcrossing as a possible explanation.

In another study published in the same issue of *F1000Research*, Carina Barth, until recently at West Virginia University, and her colleagues subjected *Arabidopsis* mutant plants that had a reduced capacity for producing vitamin C to a chemical agent that altered the genetic information. When the researchers examined offspring of the mutants, they found that the genetic information needed to produce vitamin C at full capacity had been restored in their chromosomes. In that study, Barth states, "Our results suggest that stress can trigger a genome restoration mechanism that could be advantageous for plants to survive environmental changes for which the ancestral genes were better adapted." Other genetic information that was not present in the parents had also appeared.

Lolle suggests that her results and those of Barth present the encouraging possibility that other inbreeding species, including crop plants, may also harbor cryptic reserves of genetic variation. Could this line of research lead to agricultural applications?

Igor Kovalchuk of the University of Lethbridge, in Alberta, who reviewed both studies, does not think so. "Speaking of agriculture, I don't honestly see how it can contribute right now, [since] we don't know [the] mechanisms and are not able to apply it or control this process." He believes that the research contributes to our understanding of inheritance but that this is such a minor mechanism that it cannot be relied on to contribute to making advances in agriculture.

But, as Lolle points out, "We have only just started exploring this biological phenomenon, and there are so many questions we still don't know the answers to. If *Arabidopsis* plants have a hidden vault, what information is hidden there, and where is it hidden? What makes the plant reveal the contents of the vault, and are there ways we can tap into it? If these vaults exist in *Arabidopsis*, could they exist in other plants and other organisms?"

The next steps involve identifying the source of these novel genotypes, including whether they are composed of DNA or RNA and whether they reside in the nucleus or in the cytoplasm. Also still to be understood is the interplay of the environment with genes to produce offspring with traits that seem to transcend pure Mendelian expression.

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