Jumping gene enabled key step in corn domestication

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Corn split off from its closest relative teosinte, a wild Mexican grass, about 10,000 years ago thanks to the breeding efforts of early Mexican farmers. Today it's hard to tell that the two plants were ever close kin: Corn plants stand tall, on a single sturdy stalk, and produce a handful of large, kernel-filled ears. By contrast, teosinte is branchy and bushy, with scores of thumb-sized "ears," each containing only a dozen or so hard-shelled kernels.

In seeking to better understand how teosinte gave rise to corn, a scientific team has pinpointed one of the key genetic changes that paved the way for corn's domestication. As reported today on the Nature Genetics website, a major change occurred about 23,000 years ago, when a small piece of DNA — a jumping gene known as Hopscotch — inserted itself into the control region of a teosinte gene that affects plant architecture. This case is among the first to show that a jumping gene can cause alterations in gene expression that impact evolution.

"Hopscotch cranked up the gene's expression, which helped the plant produce larger ears with more kernels, plus become less branchy, and so those early farmers picked plants with the Hopscotch to breed," says University of Wisconsin-Madison plant geneticist John Doebley, a corn evolution expert who led the team.

Jumping genes are strange genetic entities. Found in all sorts of organisms, these pieces of DNA, which carry just a few genes, have the ability to splice themselves out of their current position in the genome and "jump" to other spots. As they mix and mingle with the genome, jumping genes, which are also known as transposable elements, create genetic variation that evolution can act upon. Typically, jumping genes' effects are neutral or bad, as when they land in a stretch of junk DNA or disrupt a critical gene.

"But occasionally, they do something good," says Doebley. "So we found a case where the mutation caused by a transposable element has done something good."

In corn, Hopscotch dials up expression of the teosinte branched 1 (tb1) gene, which produces a transcriptional regulator protein that represses branching, encouraging the plant to grow a single stalk and produce larger ears with more kernels. When early Mexican farmers first encountered teosinte with this Hopscotch insertion, the rare plants must have been prized breeding stock: Today 95 percent of modern corn has this particular genetic alteration.

In recent years, researchers have begun finding more and more cases where transposable elements are associated with altered gene expression, but the links are often only correlative. For this project, however, the paper's first author, Anthony Studer, Doebley's former graduate student who now works as a postdoctoral researcher at Cornell, took the time to show that Hopscotch does in fact cause elevated gene expression. In doing so, this study is among the first to prove that jumping genes can impact gene expression, and, in turn, evolution.

"It's rare that geneticists can explain the genetic changes involved in domestication at this level of detail," notes Doebley, who has made a number of impressive contributions to the corn evolution field over the years.

Early in his career, Doebley helped identify teosinte as corn's closest relative, and in 2005, his team showed that a single genetic mutation was responsible for removing the hard casing around teosinte's kernels, exposing soft grain, another critical step in corn's domestication.

While Doebley's motivation comes from the desire to understand basic evolutionary processes, his work, he notes, could also have real-world applications. "People in plant breeding and plant biotechnology take some interest in this work because they are basically trying to continue the domestication process," he explains. "So understanding what's worked in the past could influence what they do in the present to improve corn."

Provided by University of Wisconsin-Madison

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