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SCIENCE | REMARKABLE CREATURES

Tracking the Ancestry of Corn Back 9,000 Years

By SEAN B. CARROLL MAY 24, 2010

It is now growing season across the Corn Belt of the United States. Seeds that have just been sown will, with the right mixture of sunshine and rain, be knee-high plants by the Fourth of July and tall stalks with ears ripe for picking by late August.

Corn is much more than great summer picnic food, however. Civilization owes much to this plant, and to the early people who first cultivated it.

For most of human history, our ancestors relied entirely on hunting animals and gathering seeds, fruits, nuts, tubers and other plant parts from the wild for food. It was only about 10,000 years ago that humans in many parts of the world began raising livestock and growing food through deliberate planting. These advances provided more reliable sources of food and allowed for larger, more permanent settlements. Native Americans alone domesticated nine of the most important food crops in the world, including corn, more properly called maize (Zea mays), which now provides about 21 percent of human nutrition across the globe.

But despite its abundance and importance, the biological origin of maize has been a long-running mystery. The bright yellow, mouth-watering treat we know so well does not grow in the wild anywhere on the planet, so its ancestry was not at all obvious. Recently, however, the combined detective work of botanists, geneticists and archeologists has been able to identify the wild ancestor of maize, to pinpoint where the plant originated, and to determine when early people were cultivating it and using it in their diets.

The greatest surprise, and the source of much past controversy in corn archeology, was the identification of the ancestor of maize. Many botanists did not see any connection between maize and other living plants. Some concluded that the crop plant arose through the domestication by early agriculturalists of a wild maize that was now extinct, or at least undiscovered.

However, a few scientists working during the first part of the 20th century uncovered evidence that they believed linked maize to what, at first glance, would seem to be a very unlikely parent, a Mexican grass called teosinte. Looking at the skinny ears of teosinte, with just a dozen kernels wrapped inside a stone-hard casing, it is hard to see how they could be the forerunners of corn cobs with their many rows of juicy, naked kernels. Indeed, teosinte was at first classified as a closer relative of rice than of maize.

But George W. Beadle, while a graduate student at Cornell University in the early 1930s, found that maize and teosinte had very similar chromosomes. Moreover, he made fertile hybrids between maize and teosinte that looked like intermediates between the two plants. He even reported that he could get teosinte kernels to pop. Dr. Beadle concluded that the two plants were members of the same species, with maize being the domesticated form of teosinte. Dr. Beadle went on to make other, more fundamental discoveries in genetics for which he shared the Nobel Prize in 1958. He later became chancellor and president of the University of Chicago.

Despite Dr. Beadle's illustrious reputation, his theory still remained in doubt three decades after he proposed it. The differences between the two plants appeared to many scientists to be too great to have evolved in just a few thousand years of domestication. So, after he formally retired, Dr. Beadle returned to the issue and sought ways to gather more evidence. As a great geneticist, he knew that one way to examine the parentage of two individuals was to cross them and then to cross their offspring and see how often the parental forms appeared. He crossed maize and teosinte, then crossed the hybrids, and grew 50,000 plants. He obtained plants that resembled teosinte and maize at a frequency that indicated that just four or five genes controlled the major differences between the two plants.

Dr. Beadle's results showed that maize and teosinte were without any doubt remarkably and closely related. But to pinpoint the geographic origins of maize, more definitive forensic techniques were needed. This was DNA typing, exactly the same technology used by the courts to determine paternity.

In order to trace maize's paternity, botanists led by my colleague John Doebley of the University of Wisconsin rounded up more than 60 samples of teosinte from across its entire geographic range in the Western Hemisphere and compared their DNA profile with all varieties of maize. They discovered that all maize was genetically most similar to a teosinte type from the tropical Central Balsas River Valley of southern Mexico, suggesting that this region was the "cradle" of maize evolution. Furthermore, by calculating the genetic distance between modern maize and Balsas teosinte, they estimated that domestication occurred about 9,000 years ago.

These genetic discoveries inspired recent archeological excavations of the Balsas region that sought evidence of maize use and to better understand the lifestyles of the people who were planting and harvesting it. Researchers led by Anthony Ranere of Temple University and Dolores Piperno of the Smithsonian National Museum of Natural History excavated caves and rock shelters in the region, searching for tools used by their inhabitants, maize starch grains and other microscopic evidence of maize.

In the Xihuatoxtla shelter, they discovered an array of stone milling tools with maize residue on them. The oldest tools were found in a layer of deposits that were 8,700 years old. This is the earliest physical evidence of maize use obtained to date, and it coincides very nicely with the time frame of maize domestication estimated from DNA analysis.

The most impressive aspect of the maize story is what it tells us about the capabilities of agriculturalists 9,000 years ago. These people were living in small groups and shifting their settlements seasonally. Yet they were able to transform a grass with many inconvenient, unwanted features into a high-yielding, easily harvested food crop. The domestication process must have occurred in many stages over a considerable length of time as many different, independent characteristics of the plant were modified.

The most crucial step was freeing the teosinte kernels from their stony cases. Another step was developing plants where the kernels remained intact on the cobs, unlike the teosinte ears, which shatter into individual kernels. Early cultivators had to notice among their stands of plants variants in which the nutritious kernels were at least partially exposed, or whose ears held together better, or that had more rows of kernels, and they had to selectively breed them. It is estimated that the initial domestication process that produced the basic maize form required at least several hundred to perhaps a few thousand years.

Every August, I thank these pioneer geneticists for their skill and patience.

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