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From small seeds to big yields

There are hundreds of different plants that we grow for our food, ranging from staple foods such as rice and wheat to more exotic ones, such as passion fruit. There are so many different plants in the world, it's hardly surprising that there are lots for us to eat! Or is it?

The truth is, the ancestors of many common foods would be almost unrecognizable to us today. Take corn, also known as maize, a staple food across much of the world.. Unlike the fat, juicy yellow ears of sweet corn we see today, the ancestor of farmed corn (known as teosinte) was a small, hard, and brittle cob of almost inedible seeds. For corn to be used as a food crop, the plant has changed significantly, through a process known as domestication. This process led to a natural increase in traits such as grain size (increasing calories available), grain accessibility, an increased number of grains and the loss of a hard protective coating. The seeds also are no longer "shattered", preventing the grain from being lost on the ground. Instead of being able to spread its own seeds, and reproduce, corn is now reliant on humans to manually propagate it.

Key words
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Domestication led to a change in corn, including grain size, number, and accessibility increasing yield for early farmers. Teosinte, closely related to the wild ancestor of corn, is seen at the top, with domesticated corn at the bottom, and a hybrid of the two in the middle.

This rainbow of produce has relied on thousands of years of domestication, with the different fruits and vegetables originating all across the globe.

How to feed a city

Early humans originally lived in small groups of hunters and gatherers. These groups were sustainable because of their mobility. They were able to gather all the edible foods in one area before moving on to the next. However, we know that the transition to sedentary societies based around agriculture rather than hunting and gathering required plants and animals that can produce enough food in one place for the whole group.

To develop agriculture, humans had to choose, or select, plants and animals that produced enough yield to sustain a group on the same land throughout the entire year.

Understanding domestication

The process of domestication is of increasing interest to many different scientists, from biologists to archaeologists. There are several main questions that research aims to answer—when and where did domestication happen; and how did it occur?

When and where crops were domesticated describes the spread around the globe of staple crops. For example some crops, such as rice, have been shown to have multiple origins of domestication. That is, humans domesticated wild rice for use as a crop independently in different locations and at different times. This suggests many separate groups of ancient humans were moving towards sedentary, agricultural lifestyles around the same time.

Unlike their wild ancestors, domesticated rice plants retain seed on their stalks. This loss of seed shattering allows humans to harvest the nutritious grains more easily.

To explain how domestication happens there has to be a focus on the genetic changes that led to new phenotypes of plants. For example, the increase in grain size in corn is partly down to the deletion of one particular gene, known as Teosinte Branched (tb1). This gene produces a protein that acts as a transcription factor, regulating the expression of other genes in the plant. In particular, tb1 prevents the growth of lateral branches while promoting the formation of female flowers. These will form corncobs, once seeds are produced. Without the tb1 gene, resources are diverted away from branch formation and into seed formation. This increases yield, making corn a more valuable crop.

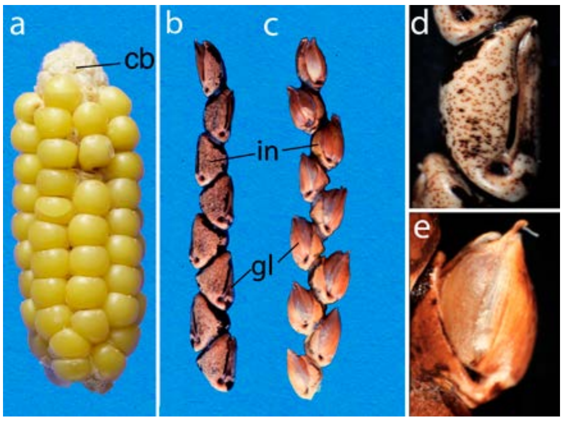
From dirt to DNA

Addressing these questions requires collaboration between scientists with a range of different specialties. Biologists can provide insight into the genetic changes that have taken place in different domesticated crops. Archaeologists on the other side are able to examine evidence from early-domesticated crops, such as ancient seeds found in archaeological sites. Together, these two disciplines can paint a picture of the process of domestication around the globe.

Understanding the spread and timing of corn domestication has relied upon a combination of genetic studies and an accumulation of archaeological data. Until recently, it was thought that corn, like rice, was domesticated several times independently across South America. By studying the genomes of multiple corn and teosinte plants, researchers were able to show that there was only a single domestication event for maize.

This idea seems feasible since it has also been shown that domestication involved small changes to only a few genes. For example, the teosinte glume architecture gene (tga1) changed in such a way as to expose the kernel on the ear so that it was easily accessible for humans to collect as food. Some researchers think this change may have taken only a few years.

At the same time, studies of ancient grains of corn have been used to demonstrate the early presence of domesticated corn, having been found in archaeological sites dating back almost 9 000 years.



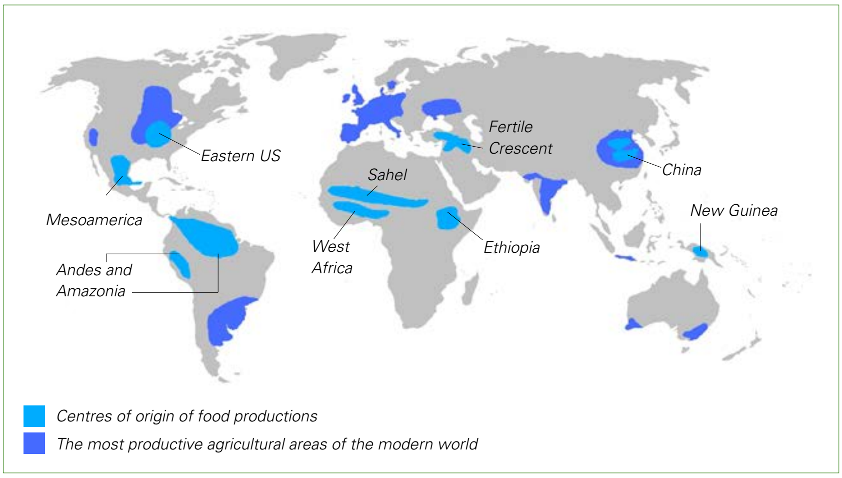
John Doebley

a Maize ear showing the cob (cb) exposed at top. b Teosinte ear with the rachis internode (in) and glume (gl) labelled. c Teosinte ear from a plant with a maize allele of tga1 inserted into it. d Close-up view of a single teosinte fruitcase. e Close-up view of a fruitcase from teosinte plant with a maize allele of tga1 introgressed into it.

Researchers focused on excavating the Xihuatoxtla Shelter in an area of the Balsas Valley in southwestern Mexico. The Xihuatoxtla archaeological site yielded evidence of maize and squash dating back 8 700 years, representing the earliest remains of maize yet discovered.

Studies of rice domestication using genomic data has shown that rice was domesticated multiple times independently. Researchers compared DNA sequences thought to be involved in domestication between different varieties of domesticated rice. The researchers showed that there are at least three different centres of domestication: southern China, Indochina, and central India and Bangladesh. This genetic data corresponds with archaeological data from sediments containing remains such as charred rice plants. Other types of archaeological data that support these conclusions include the presence of rice grains at certain sites or rice husks alongside shards of pottery.

Such a combination of biological and archaeological data is essential in helping scientists delve into the origins of our staple crops. The move from hunter-gatherer societies to sedentary, farming societies relied heavily on the selection of crop varieties with higher yield, amongst other traits. Studying crop domestication doesn't just shed light on the past, but can also help scientists working towards improving our crops today. Understanding the genetic changes needed to increase yield, nutrient content, and all sorts of other traits during domestication can direct research in those areas today.



Key centres of plant and animal domestication are found across the world, though the early centres of agriculture often don't overlap with the most productive agricultural lands today.

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