ARCHAEOLOGY:

On Maize and the Sunflower

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The study of agricultural origins has been equated to the search for the Holy Grail, such is the importance granted to it by members of diverse scientific communities, from archaeology to botany to molecular biology. There are good reasons for this belief: food surpluses made possible by agricultural economies have fueled major cultural developments during the past 10,000 years, culminating in the emergence of urban societies and advanced civilizations around the world.

The current consensus is that agriculture arose independently in six to eight regions of the world, including both hemispheres of the Americas, after the termination of the last Ice Age 12,000 years ago (1, 2). Mexico is one of the primary centers of agriculture. Maize (*Zea mays* L.) was domesticated here, and new evidence suggests that it was also a birthplace of another important American crop plant, the sunflower (*Helianthus annuus* L.).

The earliest macrofossils (cobs) of maize have been found in the arid, highland Tehuacán and Oaxaca valleys (see the figure) (3). It has been argued on the basis of these macrofossils that corn was domesticated much later, about 6000 years ago, than other major cereals such as wheat and rice (4, 5). Recently, a team led by K. Pope and M. Pohl recovered 7100-year-old maize pollen from the site of San Andrés, on the tropical Gulf coast of Mexico (see the figure), in association with indicators of land clearance resulting from slash-and-burn cultivation (6). This is the oldest evidence for maize in Mexico, predating the earlier macrofossil evidence by 1000 years. It is now apparent that well before 6000 years ago, maize spread out from its cradle in the seasonally dry tropical forest of southwestern Mexico (3) and was incorporated into lowland tropical food producing economies elsewhere. An earlier genesis from its genetically fingerprinted wild ancestor, teosinte, remains to be documented.

The origins of mesoamerican agriculture. This map of Mexico shows the location of the sites discussed in the text and the probable cradle of maize domestication in the Central Balsas River Valley. Arrows indicate likely diffusion routes of early maize out of the Balsas Valley through lowland areas to San Andrés and south out of Mexico. Shaded area: location of wild Mexican sunflowers.

The study by Pope *et al.* (6) strengthens the already strong case made on the basis of plant microfossils (pollen, phytoliths, and starch grains) for the appearance of maize in southern Central and northern South America between 7700 and 6000 years ago and for the existence of horticultural systems using both seed and root crops during this period (2, 7, 8). Much of the data from countries south of Mexico fits comfortably into the chronological framework of early maize dispersals established by Pope *et al.* (6).

The other intriguing aspect of Pope *et al.*'s study is their discovery of the earliest fully domesticated sunflower remains at San Andrés, which date to 4700 years ago. Some archaeologists have argued that the sunflower was domesticated in eastern North America (4). The new data challenge this idea [the complete details are due to appear soon (9)]. This is all the more interesting because molecular studies of extant wild sunflower populations from several different regions of North America, including ones near the archaeological sites in question, could not identify the wild progenitor (9). However, additional studies using different genetic markers are needed.

We could resort to the unsatisfying explanation that, although other wild sunflower varieties are common in the United States, the wild ancestor may be extinct. But perhaps molecular biologists have not yet sampled the right spot. Wild Mexican sunflowers are distributed a few hundred kilometers directly north of San Andrés but were not included in the molecular analyses (see the figure). If future work identifies them as credible ancestors to the domesticated species, this would provide strong support for Pope *et al.*'s hypothesis for a Mexican origin of sunflower, but a separate origin in North America would still be possible.

The Mexican sunflower data clearly bear importance for the question of whether eastern North America

was an independent center of plant domestication. During the past 10 to 15 years, scholars have been building a case for such a scenario (4). Eastern North America stands in dramatic contrast to the other independent centers because it arose much later, about 5000 years ago, with sunflower and squash (*Cucurbita pepo* L.) consistently among the oldest components of the plant assemblages (4).

Now that a North American origin for sunflower is under reexamination, attention will also turn to what seems to be the earliest plant in the complex, squash. Some controversy already surrounds it because, as with sunflower, investigators are not willing to rule out the possibility that squash was a product of Mexico, where evidence for the domestication of *C. pepo* is 10,000 years old (10). The story is more complicated because of the probability of two separate domestication events of the *C. pepo* variety of squash (4), but again, molecular studies indicating where these events most likely took place remain to be carried out. A more complete answer will rest on such molecular studies and their convergence with future archaeological work in northeastern Mexico and the eastern United States.

Students of prehistoric agriculture have proposed numerous explanations for its beginnings, many of which rely on either the influence of the ecological changes that occurred globally at the end of the last Ice Age or processes operating from within human social systems involving the emergence of power and prestige (2). Identifying the regions where plant domestication arose independently, and regions where it did not, is crucial for our understanding of why and how agriculture emerged. More surprises are sure to come our way.

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PAGE TOP