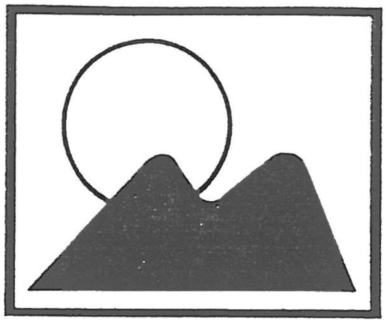

Then the Maker and Creator asked them: "What do you think of your estate? Do you not see it? Are you not able to hear? Is your speech not good and your manner of walking about? Behold! Contemplate the world; see if the mountains and valleys appear! Try, then, and see!

Mayan creation myth: Popol Vuh
(Recinos, 1947; my translation)

ARCHAEOLOGY

Agricultural complexes also arose in the New World. An impressive array of native American plants was domesticated by American Indians and agricultural systems eventually evolved sufficient to support the civilizations of Chavín, Olmec, Maya, Aztec, Inca, and others. Some extreme diffusionists have maintained that these developments were not independent of the Old World, and that the idea of cultivating plants was transmitted across the Pacific or Atlantic Ocean at a very early time (Riley et al., 1971). Basic to the argument is the implication that the American Indians were incapable of innovation and had to be taught how to cultivate plants by people who had already invented or discovered the arts of agriculture. As we shall see, the American Indians were among the most skillful of all plant domesticators and it is difficult to understand why it should be thought that they were devoid of originality with respect to plant manipulation.

Asian and African plants are conspicuously missing from American crop complexes. Most damaging to the diffusionist argument, however, is the time required to develop an indigenous American agriculture. As we have already seen, the advantages of growing plants on purpose are not conspicuous at the beginning and the differences between intensive gathering and cultivation are minimal. It is difficult to imagine that a few sailors from Asia or Africa could easily induce people to take up practices that would not achieve a developed agriculture for several thousand years. It would appear much more likely that American Indians began the processes of domestication for about the same reasons as people of the ancient Near East, Africa, China or Southeast Asia.

The archaeological evidence for the evolution of agriculture in the Americas is extremely tenuous and sketchy. The only sequences that give us much detail at the present time are the Tamaulipas Caves in northeastern Mexico, the Tehuacán Valley excavations southeast of Mexico City (Byers, 1967), the finds on coastal Peru (Rowe and Menzel, 1967; Pickersgill, 1969), and recent excavations in the intermontane zone at Ancash, Peru (Kaplan, Lynch, and Smith, 1973). This is more evidence than we have for Southeast Asia or Africa, but is hardly adequate to trace the origins and dispersals of American crops.

What information we do have is summarized in Table 1. From this it appears that the American Indians were manipulating plants by about 7000 B.C. and had domesticated some before 6000 B.C. It was a long time, however, before a fully developed agriculture emerged (MacNeish, 1964).

Surveys of archaeological sites in southern Mexico indicate a seasonally nomadic pattern of people dispersed into family-sized microbands during the fall and winter dry season and aggregating into larger macrobands for the spring and summer rainy season. The pattern was well established by the El Riego phase of the Tehuacán sequence that started about 7000 B.C. The diet was probably typical of hunter-gatherers and consisted largely of harvested wild plant materials supplemented by game that was hunted and trapped. Remains of chili peppers and avocado were found and it is likely that these people were at least manipulating several of the more useful plants of the region.

A little before 5000 B.C. the Coxcatlán phase had developed out of the El Riego. The living pattern had not changed much, but the wet-season macrobands were larger and the people were farming at the spring-summer camp sites. Early maize, squash, pumpkins, gourd, chili peppers, and avocados are represented in the plant inventory. By about 3400 B.C., Coxcatlán had merged into a phase called Abejas, which maintained essentially the same living habits but with the addition of *Cucurbita moschata*, common beans, and jack-beans (*Canavalia*) (MacNeish, 1964).

It was not until the Ajalpan phase, beginning roughly at 1500 B.C., that the people of the Tehuacán valley were full-time farmers living in villages. By this time amaranth, zapote, and cotton had been added to the crop list. The Tehuacán sequence may or may not be typical, but other surveys suggest similar developments in Tamaulipas and Oaxaca (Flannery, 1968). In Tehuacán it took over 5,000 years

Table 1
Early appearances of cultivated plants in American archaeological sites.

Approx. time	Tamaulipas	Tehuacán	Peru
7000 B.C.	*Lagenaria* *Phaseolus coccineus* "wild" *Cucurbita pepo* "wild?"	*Capsicum* *Persea*	*Phaseolus vulgaris* and *P. lunatus* (intermontane) cultivated
6000 B.C.		*Setaria*	
5000 B.C.		*Zea* *C. mixta* *C. pepo* *Lagenaria*	
4000 B.C.	*Setaria* *P. vulgaris*	*C. moschata* *Canavalia*	
3000 B.C.		*P. vulgaris*	(1)* {*Lagenaria* *P. lunatus* *Gossypium* *C. moschata* *C. ficifolia*} (2)* {*Capsicum* *Canavalia* *Cana* *Psidium*}
2000 B.C.	*C. moschata*		(3)* {*Zea* *Arachis, Capsicum chinense* *Manihot*}
		Amaranthus *Annona* *Gossypium*	*Inga* *Lucuma* *Pachyrrhizus*
1000 B.C.			
CE		(4)* {*Solanum* *Arachis* *P. lunatus*}	
	P. lunatus		

* (1) First domesticates on Coast of Peru; (2) Contact with southern Peru and Bolivia; (3) Contact with Central America, Mexico, and Argentina; (4) Contact with South America.

from the time plants were being manipulated and 3.5 millennia from the time that plants are known to have been domesticated to reach a stabilized system complete with village settlements.

By about 900 B.C. a phase called Santa Maria had emerged; farming villages were then grouped about religious centers. Ceremonial structures were located in the larger villages or towns and associated with a number of smaller villages nearby. Irrigation was beginning to come into practice. During the following Palo Blanco phase, 200 B.C. to 700 A.D., ceremonial centers expanded and elaborate pyramids were constructed. Irrigation systems were laid out and crops that can be identified as being of South American origin were added to the local ones (e.g. potato, peanut, and lima bean). Domestic turkeys were also raised.

Preliminary surveys in South America have so far failed to reveal evidence of very early agriculture in the Andean highlands, but the discovery of domesticated common beans and lima beans in Peruvian intermontane valleys, dated to 6000 B.C. or earlier, shows clearly that plant domestication was underway at the lower elevations at the same time that Mesoamerican Indians were evolving an indigenous agriculture. Unfortunately, most of our direct plant evidence for South America comes from coastal Peru. Here, the climate is essentially rainless, and plant materials are preserved in great abundance and superb condition. On the other hand, the region is too dry to have been a center of plant domestication and essentially all remains are from imported domesticates. Evidence from coastal Peru records when a particular crop reached the area but not when or where it was first domesticated.

In the Near East and Africa, we have some indication that climatic changes might have been involved in producing food procurement crises and thereby stimulating the shift from gathering to husbandry. A similar suggestion has been made for southeastern Asia where perhaps half of the land surface exposed during the Pleistocene was submerged as the sea level rose. What was the situation in the Americas? Unfortunately, our information is not only limited but sometimes conflicting. Nevertheless, the changes in climate associated with the terminal Pleistocene could hardly have failed to affect the higher elevations and latitudes, and the rise of sea level must have had some effect on peoples near the shallow waters of the Caribbean and the land to the east of the present mouth of the Amazon. Such effects are not likely to be represented in archaeological sites in coastal Peru or in Tehuacán Valley.

Logic (not evidence) would seem to indicate that one does not begin agriculture on the cold Altiplano where it is extremely difficult to practice it today even after local domesticates have been developed. Both logic and evidence agree that agriculture could not have begun on rainless coastal Peru. C. O. Sauer (1952) believes it began in northwestern South America because of the great diversity of climates and ecological habitats, the fresh water food resources, and perhaps because it would be most accessible to sailors from across the Pacific. Lathrap (in press) suggests an opposite version, at least for lowland agriculture. He advances the interesting idea that lowland agriculture, based primarily on manioc, began in regions now submerged eastward of and in the present mouth of the Amazon. The terminal Pleistocene rise in sea level may have forced a shift toward food production in that region. The agricultural system that developed moved upriver, largely confined to the small amount of fertile soils along the river banks. The cultures grew in complexity and sophistication as they expanded along the rivers of lowland Amazonia and eventually culminated in the Chavín which assumed many of the elements of civilization. The Chavín, in turn, stimulated the evolution of Olmec and other civilizations of Mesoamerica as well as the highland cultures of the Andes (Lathrap, 1971).

The archaeological evidence would indicate that while the Chavín system was developing, other agricultural systems were also evolving. The Tehuacán Valley is not much different from coastal Peru in that it is too dry for much in the way of innovation, but the region does record the arrival of innovations made elsewhere. At any rate, the Tehuacán sequence suggests the practice of agriculture well before the Chavín is identifiable in South America (about 1500 B.C.) (Rowe and Menzel, 1967).

DISPERSALS

The pattern that emerges in the Americas is somewhat similar to those that we have described for the Near East and Africa and for China and Southeast Asia. There appears to be something of a center in Mesoamerica, a region stretching from approximately Mexico City to Honduras. In this center, corn, beans, squash, agave, avocado, cotton, cacao, jícama, tomate (*Physalis*), sweet potato, papaya, and possibly the American yam became important food plants. The squashes included at least three species, and one species of capsicum pepper was also included in the complex. The corn-bean-squash component of the complex dispersed northward adding sunflower and became the basis for agriculture in the eastern woodlands of North America. The complex, in due time, spread to what is now Canada and a branch moved across the plains into the southwestern United States where the tepary bean was added. To the south, diffusion of the Mesoamerican crops can probably best be traced by maize, which is documented in South America by 1800 B.C. (Pickersgill, 1969). The Mexican beans are confounded somewhat by independent South American domestications of the wild races. Furthermore, South America also had its own species of squash. The Mesoamerican agricultural complex thus acts like a center in that a group of plants, adequate to support agricultural societies, was domesticated within a limited geographic region and at least some of them were dispersed out of the center to other areas.

The situation in South America is very complex, partly because of the extremes in habitat provided by the Andean mountain chain. The Andean highland complex of plants resembles a center, but while an impressive number of domesticates evolved in the highlands, they were self-contained and did not disperse out of that ecological zone. The complex is characterized by highland tubers such as potato, Oca, *Ullucus, Tropaeolum,* and *Lepidum*, as well as quinoa and at least one minor cereal (*Bromus mango*). Midelevation crops included peanut, *Solanum* spp., coca, amaranth, lupines, beans, arracachi, *Pachyrrhizus, Polymnia, Bunchosia,* etc. Lowland crops were diverse and included manioc, sea island cotton, *Canavalia, Inga, Canna, Xanthosoma* and a number of fruits and nuts such as *Annona* spp., pineapple, cashew, papaya, avocado, Brazil nut, other solanums, *Physalis*, and peppers.

The activities of plant domestication were wide-ranging in South America, which takes on the characteristics of a noncenter rather than a center. The key plants for measuring diffusion northward out of the noncenter are the peanut, South American peppers, large lima beans, pineapple, manioc, and tobacco. The arrival of some of these crops in Mexico has been documented (Table 1). At least two routes were involved: one up through the arc of Caribbean islands from Venezuela, the other up the mainland spine of Central America.

It must be pointed out that few, if any, of these plants were domesticated in coastal Peru. The arrival of fully domesticated forms is documented in coastal Peru, but these were domesticated elsewhere at a much earlier date. One region that seems to have been particularly active in plant domestication is Jujuy, the northwestern province of Argentina. There *Ullucus*, peanut, and beans occur in the wild. The South American squash (*Cucurbita maxima*) is found wild in the north Argentine plains. Other plants were probably domesticated over a broad range northward along the eastern slopes of the Andean ranges of Colombia and eastward in Venezuela and perhaps northeastern Brazil. Cultivated beans and lima beans have been found in intermontane valleys of Peru dated earlier than 6000 B.C. (Kaplan, Lynch, and Smith, 1973).

Whatever the times and places of domestication may have been, we must credit the American Indian with a magnificent performance. Of the 15 crops listed by Mangelsdorf (personal communication) as those that really feed the populations of the world, no less than 6 are of American origin. Staple crops are maize, potato, manioc, sweet potato, the common bean, and peanut. Furthermore, American upland cotton has become the cotton of world commerce. Sisal and henequen are other American fibers. Tobacco is not particularly nutritious, but is a popular narcotic and earns vast sums of money in commerce. The most important of the American drug plants was coca, a source of cocaine, and cinchona, a source of quinine. In addition, such crops as capsicum peppers, pineapple, papaya, avocado, guava, custard apple, cashew nut, squashes, and tomato are very popular throughout the world. American crops have been widely dispersed in post-Columbian times and many of them have been extremely competitive with domesticated plants of the Old World.

A number of American crops have increased enormously in importance after leaving the New World. Sunflower, for example, was probably a relatively minor crop to some North American Indian tribes, but has become a major source of edible oil in eastern Europe and the Soviet Union. Rubber of several kinds was extracted from wild trees by the American Indians but no rubber plants were domesticated by them. Hevea rubber has become an important plantation crop in Southeast Asia and Africa. *Cinchona,* the source of quinine, may not even have been used at all by the American Indians but did become a commercial crop in Southeast Asia. While the potato was important to the American highland Indians, it was used little elsewhere in the Americas; when taken to Europe, it created a dietary revolution.

The peanut has become an enormously important crop in China and an export crop for several African countries. The sweet potato is not only a very important food source in China but created something of a dietary revolution in New Guinea (Watson, 1965). After its introduction, probably in the 16th century, it was readily accepted by the New Guinea natives particularly those in the highlands. The sweet potato is adaptable to conditions at much higher elevations than the traditional yams and taros of New Guinea. The result was apparently increased population due to increased food supply. This may have been assisted by the fact that these elevations were above the range of malarial mosquitoes so that this population leveler was not effective (Brookfield and White, 1968). The sweet potato provides 90% of the caloric intake of some tribes in the highlands of New Guinea. Additional sweet potatoes are raised to feed pigs, which are also consumed. It seems that these people could hardly have existed where they now live without the sweet potato.

Maize was perhaps the most important of the American Indian domesticates, but even it had potential unrealized by the American Indians. The productivity of maize as a cereal was not realized until the development of Corn Belt types in the United States. These types have been transported to many other parts of the world where maize has become a major crop, replacing previous cereals.

Details of the place and time of maize domestication remain to be worked out, and there is still some debate as to the most likely progenitor. For many years P. C. Mangelsdorf has maintained that maize was domesticated from wild races that have since become extinct and that teosinte was a late derivative of wild maize X *Tripsacum* hybridization (Mangelsdorf and Reeves, 1939). Recent evidence has caused him to abandon the latter part of the theory, but he still insists that there was once a wild maize progenitor to the domesticated races. The earliest cobs found in Tehuacán Valley represent wild maize, according to his interpretation. Few maize specialists now agree with his views, and most are inclined to consider some race or races of teosinte as the most likely progenitors (Beadle, 1972; Galinat, 1971).

The only difficulty in accepting teosinte as the progenitor of maize has been the rather spectacular differences in the female inflorescences or ears. Otherwise, teosinte and maize are very much alike and no one has any problem in visualizing an evolution from one plant type to the other. The ear of teosinte differs from that of maize primarily in the following characteristics:

Teosinte	Maize
Ear fragile	Ear (cob) nonfragile
Pedicellate spikelets suppressed	Both spikelets of a pair ♀ fertile

Ear two-ranked	Ear four-ranked (or more)
Glumes very hard	Glumes soft
Glumes covering seed	Glumes short (usually)
Seed imbedded in rachis cupule	Seed exposed
Seed small	Seed large

There are some other rather minor differences, but these are the conspicuous ones. They are all under genetic control, and conversion from one state to the other does not generally appear to be especially complex. The fragile vs nonfragile inflorescence situation is found in all cereals and is in no way unusual. A single gene can suppress the fragility of a rachis. The recovery of fertility of a suppressed spikelet or floret is known in barley, wheat, and sorghum as well as in maize. Increase in rank number is associated with the development of a terminal spike in the tassel and appears to be relatively simple genetically. Reduction of glumes and increase of seed size is common in the evolution of cereals. Remnants of the rachis cupule are represented in an ear of maize (Galinat, 1971). Beadle (1972) has found that the complete morphologies of both maize and teosinte ears can be recovered in large F_2 populations of maize-teosinte hybrids. Either the differences between the two are few or they are tightly linked into a few blocks of genes. Frequency of recovery of near-parental types in the F_2 suggests the major genetic differences are on the order of five or six.

Until more convincing evidence to the contrary is presented, I would have to conclude that the teosinte origin is, by far, the most economical theory of the origin of maize and the most likely. I would add only one caution: teosinte was probably much more variable formerly than now and there may well have been races more maize-like than those that have survived.

The present known distribution of wild maize or teosinte is shown in Fig. 1. There is good evidence that the distribution was much wider at one time. Teosinte has been found archaeologically in Tamaulipas where it does not occur today (Mangelsdorf, MacNeish, and Galinat, 1967). Specimens have been collected, and are on file in herbaria, from sites where teosinte no longer occurs (Wilkes, 1967). A perennial tetraploid race has become extinct except for material maintained in various breeding nurseries. Obviously, the last word has yet to be said about the origin of maize, but I find no reason to suppose that the evolution of maize is radically different from that of any other cereal.

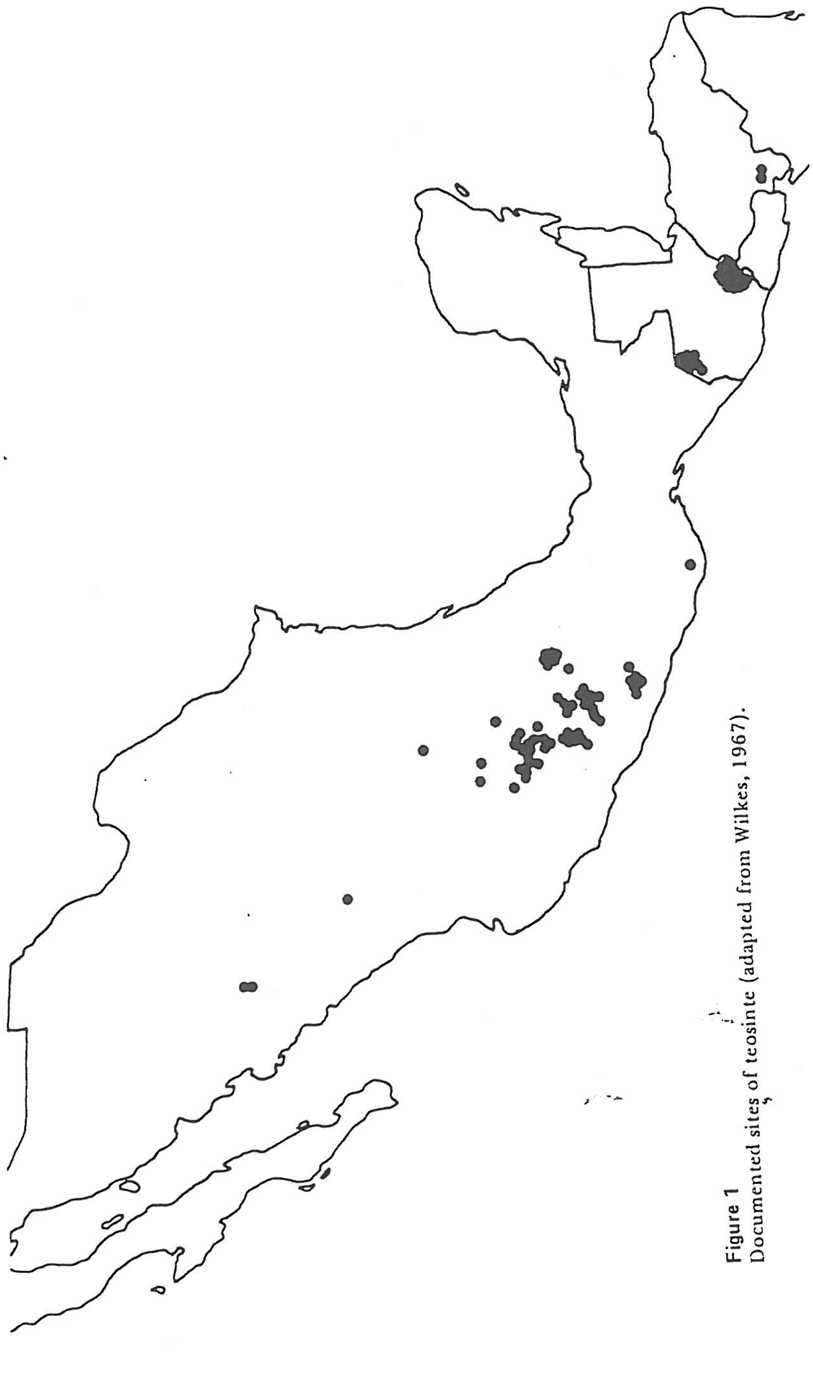

Figure 1
Documented sites of teosinte (adapted from Wilkes, 1967).


CENTERS OF
AGRICULTURAL
ORIGIN
A
B
B2
B1
N
0
400
800
EQUATORIAL MILE
CSUN GEOGRAPHY DEPT.

Figure 4.2