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The Early History of American Agriculture: Recent Research and Current Controversy

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have been cultivated in this area are *Lagenaria*, the bottle gourd, *Capsicum*, the chili pepper, and *Cucurbita pepo*, the pumpkin. The latter is perhaps especially significant since it did not appear in the Tehuacán area until after 1500 B.C. On the other hand, another type of squash, *Cucurbita moschata*, seems to have been domesticated in the Tehuacán region before 3500 B.C. but did not reach the northeast until after 2000 B.C. The first appearance of maize in the northeast was of a primitive but clearly domesticated type called Nal-tel between 3000 and 2200 B.C.

Oaxaca

This area is not far from the Tehuacán Valley about 150 km to the southeast. It was studied by a team under Kent Flannery, who had been one of MacNeish's team in Tehuacán, where he had reported on the animal bones. He found deposits from 7800 B.C. onwards, and deduced from them that the climate throughout differed little from that of the present day. Inhabited caves providing dry conditions for the preservation of plant remains were found some 60–90 m above the valley floor. From the beginning of the succession there were many wild plants suitable for gathering, for example squash, beans and possibly *Tripsacum*. He detected an early seasonal settlement pattern, of which I think I detect the influence in MacNeish's 1971 article in *Archaeology*, already mentioned. He found that there were large gathering and trapping camps in the summer rainy season, small deer-hunting camps in the autumn and winter, and the meagrest just before the February rains. He questions whether some members of the group may have stayed the whole year in the summer gathering camps.

The valley differs from that of Tehuacán in that it had a high water table and was frost free, whereas that in Tehuacán was low but some powerful mineral springs could be, and in later times were, harnessed to irrigate large areas by canal. The high water table of Oaxaca made various methods of small-scale irrigation possible, and brought considerable areas into cultivation. Whether because of this or not, some impressive sites grew up. Oaxaca became a nuclear area, the home of the great Zapotec state, with great ceremonial centres such as Monte Alban, whereas Tehuacán faded into a marginal area by the last few centuries B.C.

The early history of American agriculture: recent research and current controversy

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Since the completion of the Tehuacán Archaeological-Botanical Project's field work more than a decade ago our picture of the early history of agriculture in the New World from primitive food gathering through ten millennia has been broadened, both by the acquisition of further data from Mesoamerica and other parts of the continent, and by critical consideration of the Tehuacán sequence itself as expounded in the four volumes of the final report which have so far appeared (Byers 1967*a*, *b*; MacNeish 1970, 1972) as outlined by Bushnell

Recent work in Oaxaca

In an adjacent region of the Mexican highlands the sequence established at Tehuacán has been amplified by one of MacNeish's former collaborators, Kent V. Flannery, who has excavated a further series of dry caves and open sites of the pre-ceramic period as part of a project investigating the prehistory and human ecology of the valley of Oaxaca, a large upland basin some 180 km to the southeast (Flannery 1968, 1970; Flannery, Kirkby, Kirkby & Williams 1967). Two important extensions of the Tehuacán data have been the recovery of fossil pollen, and as a result the possible extension of plant husbandry back into the 8th millennium B.C. (Schoenwetter 1974).

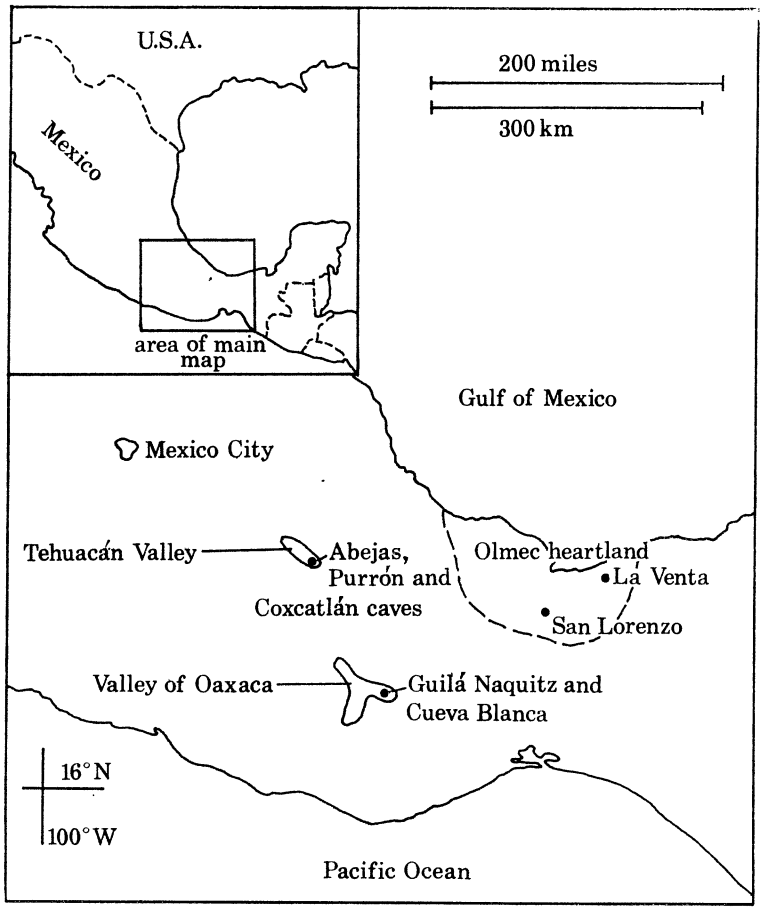

Figure 1. Southern Mexico, with the Tehuacán and Oaxaca Valleys and sites mentioned in the text.

Tehuacán had been selected specifically because MacNeish was looking for deep, well-stratified, dessicated and protected deposits in which plant remains, and in particular evidence for the evolution of maize (*Zea mays*) as a crop plant, might be preserved. He noted explicitly that Mesoamerican agriculture did not necessarily develop in the locations where the post-depositional evidence for it was best preserved: Tehuacán had been a cultural backwater from the second millennium B.C. onwards, during the rise of Mesoamerican civilization, and because

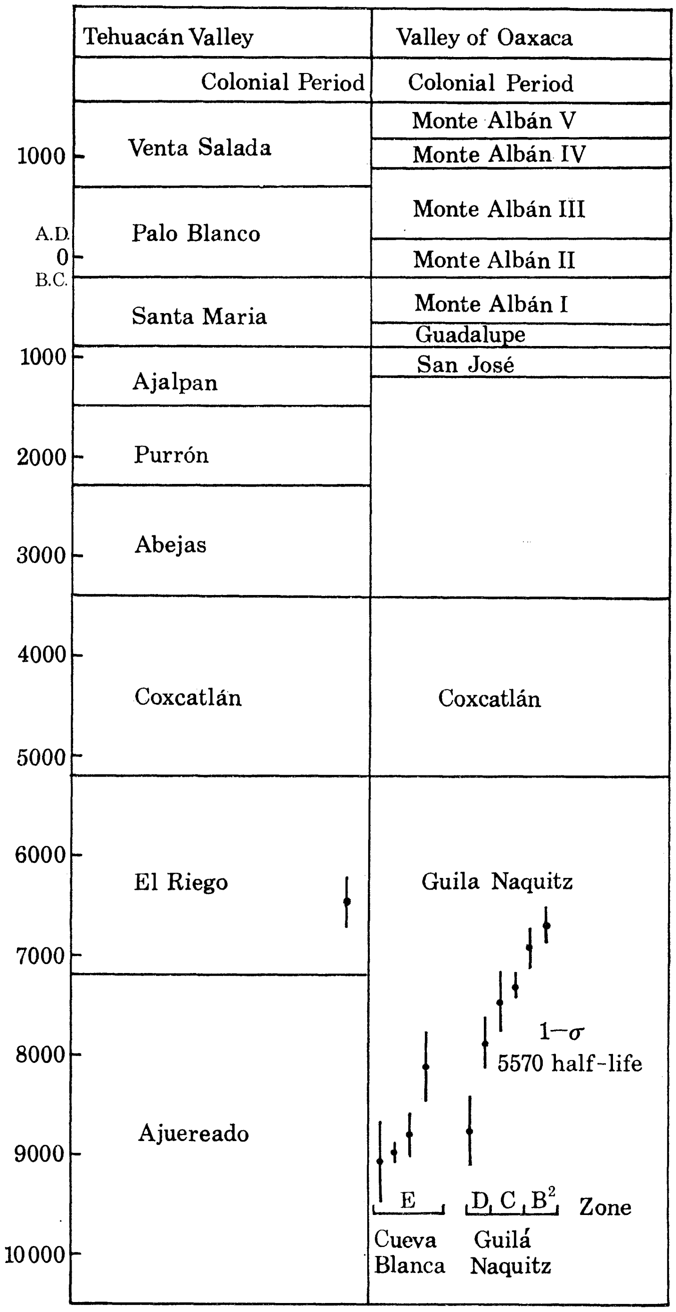

FIGURE 2. Comparative chronology for the Tehuacán Valley (after MacNeish) and the Valley of Oaxaca (after Flannery) with the pre-ceramic ^{14}C chronology interpolated. The single Tehuacán date (I-571) is the earliest acceptable determination; others are displayed in MacNeish (ed.) 1972, Fig. 2. Oaxaca dates after Flannery (ed.) 1970, pp. 16, 20.

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of its elevation and aridity may well always have been marginal. Oaxaca had been the seat of Zapotec and Mixtec civilization in the first and early second millennia A.D., and the work there investigated the possibility that the area had been innovatory from early times.

The major pre-ceramic sites were again caves, Guilá Naquitz and Cueva Blanca, close together in the more arid eastern arm of the Oaxaca valley near Mitla, the later Mixtec capital. The ^{14}C dates (5570 half-life, uncalibrated) for their early levels range from 9050–6670 B.C., about 9500–6500 at 1 standard deviation, with possibly earlier but undated basal levels in both caves. Cueva Blanca had also an occupation at 3295–2800 B.C. (3400–2600 on 1 s.d.) coeval and comparable with the Coxcatlán phase at Tehuacán. The earliest acceptable ^{14}C date from Tehuacán was 6475 ± 250 B.C. (I-571).

The plant remains from Guilá Naquitz showed that it had mainly been occupied seasonally between September and November by groups gathering acorns (*Quercus* spp.), pinon nuts (*Pinus* cf. *cembroides*), maguey (*Agave* spp.), a variety of tree crops and cactus, and hunting white-tailed deer (*Odocoileus virginianus*) and cottontail rabbit (*Silvilagus cunicularis* and *S. floridanus*). By analysing the seasonal availability of resources in the Valley Flannery (1968) showed that successively abundant plants could have been exploited by a sophisticated schedule of movement between bases, in which five critical resources – maguey, succulent cacti including organ pipe cactus and prickly pear (*Lemaireocereus* spp. and *Opuntia* spp.), tree legumes such as mequite and guajes (*Prosopis* spp.; *Lucaena*, *Mimosa*, *Acacia*), white-tailed deer and cottontail rabbit – were utilized across the wide range of econiches in which they occurred together with more localized species. This model allows for and removes some of the bias resulting from the predominance of data from valley-margin cave sites (plant preservation at open sites was poor), and was subsequently adopted by MacNeish (1971) for the Tehuacán data.

Flannery also showed that if a critical choice had to be made in the scheduling between exploiting a plant or an animal resource, the plant was collected; since plant foods are immobile, predictable, varied, acquirable at low risk, with low energy expenditure and with small chance of failure this is not surprising. Clarke (1976) has noted this, and that in temperate European forests in the Mesolithic 16 man-hours of plant gathering would yield the equivalent calorific weight of an adult red deer; the ratio in pre-ceramic highland Mesoamerica cannot have been far different. The application of such scheduling analyses to Upper Palaeolithic European material has been made by Sturdy (1975) and others, but with an emphasis on the animal resources: reanalysis using the Mesoamerican model of plant-food priority might be revealing.

Probably the most important single class of data from the Oaxaca caves for our present concern is the recovery of graminoid pollen from levels B and C at Guilá Naquitz, with ^{14}C dates of 7750–6500 B.C. This pollen may be of maize (*Zea mays*) or its wild relative teosinte (*Zea mexicana*; formerly *Euchlaena mexicana*) a name deriving from the Nahuatl *teocentli* – 'support of the gods' – suggesting a known connection with subsistence. Teosinte is genetically similar to maize (reviewed by Galinat 1971 and Mangelsdorf 1974) and research by Beadle (1972) and Galinat suggests that it is the true ancestor of cultivated maize, rather than the model of a now-extinct wild maize proposed by Mangelsdorf & Reeves (1939) and accepted by archaeologists up to and including MacNeish. If wild maize never existed then the 18 cobs from level XIII of MacNeish's excavation at Coxcatlán cave, with a ^{14}C date of 5050 ± 220 B.C. (I-457), must be of cultivated maize, morphologically distinct from the wild ancestor teosinte and therefore also at least partly domesticated. The Guilá Naquitz pollen, however, may indicate cultivation even earlier: it is disputed whether teosinte and maize pollen *can* be distinguished from each other, since neither size nor surface sculpturing is a certain indicator.

The evolution from teosinte could have begun with the mutation of a single gene, the 'tunicate allele', producing softer glumes over each kernel, which would facilitate threshing, and less well-developed abscission cell layers between the fruits, reducing the tendency of the spike to shatter and disperse its seeds upon ripening. This is precisely the mutation suggested as necessary for the domestication of the Old World cereals, as noted by Flannery (1973) in a recent survey of agricultural origins.

The morphological distinction between teosinte and maize is thus the result of human selection, with maize the end-product of selective activity exerted on the ancestral plant, the exact identity of which is less important, as Schoenwetter (1974) points out, than the behavioural patterns indicated thereby, which may be archaeologically detectable even in the absence of preserved plant material. He suggests that the maize-like pollen from Guilá Naquitz is indicative of cultivation rather than gathering because of a pattern of associations suggesting selective harvesting, association with macrofossils of other later, and possibly contemporary, cultigens including pumpkin (*Cucurbita pepo*), and occurrence in a palaeo-environment more appropriate to cultivated maize rather than a wild relative. The proportion of graminoid grains is seven times that in comparable modern econiche contexts, suggesting the proximity of the plants to the cave, while the aridity of the palaeo-environment was greater than even teosinte will tolerate and suggests human encouragement of growth.

The pollen and macro-fossil evidence combined, Schoenwetter suggests, indicate the cultivation of pumpkin, common bean (*Phaseolus vulgaris*) and a maize-like plant in the vicinity of the cave between 9125 and 6500 B.C.; these crops, the wild ancestors of which grow together in Mesoamerica (Flannery 1973, p. 291) – the beans twining round the teosinte stalk and the cucurbits growing at ground level – would have been harvested during the autumn occupation of the cave at the same time as the tree and cactus crops to provide storable food for the coming dearth of the dry season. The increased productivity of maize under cultivation and the increasing reliance on cultivated plant foods has been well documented in the Tehuacán sequence, involving as it did significant modification of other food-procurement systems, and both encouraging and enjoining increasing sedentism. Similarly an incipient agriculture, confined at first to a few species of sympatric edible plants which matured at the beginning of a stress period and could be stored for subsequent necessity, but raising the basic carrying capacity of the area and thus diminishing enforced human group splitting and mobility, is compatible with the palynological record, and Schoenwetter concludes that even if the people using Guilá Naquitz cave were not farmers *sensu stricto*, they had the technical knowledge and the potential cultigens to support a farming economy by 7000 B.C.

A continental perspective

Highland Mesoamerica, for which the Oaxaca-Tehuacán sequence is exempler, can now be seen as one of four areas in which the cultivation of plants probably began independently, albeit the earliest of these (though Pickersgill's (1975) *caveat* on the cultivated status of avocado and chili at Tehuacán prior to the mid/late 2nd millennium B.C. – several millennia later than MacNeish suggests – should be noted). The other areas are the Peruvian Andes and the adjacent Pacific coast, the Ohio River basin and adjoining parts of the upper Mississippi drainage in the United States of America, and the humid tropical lowlands of northern South America and Central America.

In Peru two species of domesticated bean are known at 5600 B.C. from Guitarrero Cave in the intermontane Callejon de Huaylas (Kaplan, Lynch & Smith 1973), with a history of cultivation extending back perhaps a further two millennia, while on the coast a fishing-gathering-hunting strategy was supplemented by cultivated squash and gourd between 5000 and 3000 B.C., followed by cotton, chili pepper, jack bean and guava, the last of these probably a trans-Andean introduction from the Amazon basin. A primarily agricultural strategy was not however adopted until the later second millennium B.C. (Patterson & Moseley 1968).

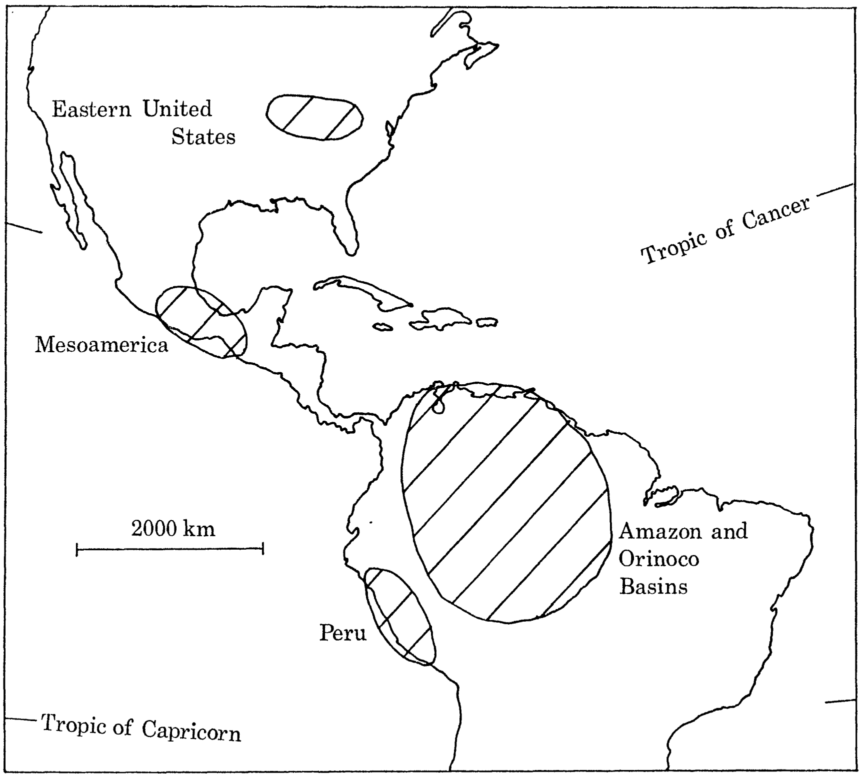

Figure 3. Four areas in which plant cultivation may have begun independently in the Americas.

Maize appears in the Andes between 3000 and 2500 B.C. in the Cachi complex of the Ayacucho basin (MacNeish 1969), and doubtfully in the preceding Chihua complex; this is well after its domestication in Mesoamerica, and the genetic similarity to the Nal-Tel race there together with the absence of any known Peruvian ancestor suggest that maize was introduced from Mexico, at a period when the purely archaeological evidence for contact is practically non-existent. This last point is of some interest in the wider context of Sir Joseph Hutchinson's remarks on the introduction of maize in South Asia, at this meeting.

There are superficially closer correspondences between the cultigens of Mesoamerica and Peru, both areas having beans, squash, chili, cotton and gourd, but Pickersgill (1971, 1975) has pointed out the specific differences and that speciation probably preceded domestication, a strong argument for independent, albeit convergent, development of agriculture in the two areas. This convergence again parallels the history of rice in Africa and Asia as outlined by Chang at this meeting.

In the upper Mississippi basin the Mesoamerican domesticated plant complex of maize, beans and squash was introduced in the mid-first millennium B.C., but Streuver & Vickery (1973) have argued that prior to this there was independent cultivation of various weedy plants for their nutritious, often oily, seeds. Species include sunflower (*Helianthus annua* L.), marsh elder (*Iva* sp.), goosefoot (*Chenopodium* sp.), pigweed (*Amaranthus* sp.), and knotweed (*Polygonum* sp.), and the possibility of human selection for large seeds was canvassed as long ago as 1939 (Blake 1939). At Salts Cave, Kentucky, the ^{14}C dates for these cultivated indigenous plants go back to 710 ± 140 B.C. (M-1770), but are not statistically separable from those for introduced tropical cultigens such as gourd (620 ± 140 B.C., M-1574). The case for independent adoption of cultivation in North America must therefore be declared at present 'not proven', although Pickersgill (1975) is inclined to accept it.

The fourth area, the humid tropical lowlands reaching from Brazil north to Mexico, presents a special problem: several of the most important domesticates, such as manioc (*Manihot esculenta* Crantz), sweet potato (*Ipomoea batatas* (L,) Lam.), and taro (*Xanthosoma* sp.) are vegetatively reproducing tubers, while tropical as well as Mediterranean (Zohary & Spiegel-Roy 1975) fruit trees can be cultivated by cloning, enabling highly heterozygous plants to be stabilized in a favourable dominant mutant. Asexual reproduction inhibits genetic change and hence the detection of human influence on plants in the archaeological record, while that record is itself often erased by poor preservation, and relevant sites are difficult to detect. At present our earliest evidence for the cultivation of manioc, at 1800 B.C., comes from its introduction to and preservation at sites on the desert coast of Peru, and the presence of pollen at about the time of Christ in a core from the Gatun basin in Panama (Bartlett, Barghoorn & Berger 1969).

Lathrap, currently the most energetic proponent of an early and independent agriculture in the tropical forest, has in the absence of plant remains argued from iconography and artefacts that manioc was cultivated in northeastern South America from at least the late third millennium B.C. (Lathrap 1973*a*, *b*), but DeBoer (1975) has shown that the supposed manioc-processing equipment is neither necessary for nor particularly indicative of manioc cultivation. Botanically the question is complicated by the fact that the genus *Manihot* has some hundred species with an American distribution from Arizona to Argentina and both Mesoamerican and South American centres of species diversity (Rogers 1963), and it would be difficult to assign any but the best-preserved macrofossils with certainty to the cultigen *M. esculenta*.

Nevertheless the simple techniques of vegeculture and the high potential productivity of the tropical forest environment (estimated by Westlake (1963) at 50–80 tonnes per hectare per year) combined with the rich plant and protein resources of the swamps, lagoons and rivers would allow early sedentary settlement: we should remember that America's first manifestation of civilization in the Olmec lands of the Gulf of Mexico emerged in the late second millennium B.C. while the maize-growing highlands were at a lower level of cultural complexity. The post-glacial rise in sea-level (Bartlett *et al.* 1969, Fig. 1) has gradually drowned a richly endowed coastal plain ranging from 20 to 120 km wide beneath the Gulf of Mexico and radically changed the lowland landscape since man first came to Mexico. At an early stage of the transgression the continuous creation of productive swamps and lagoons could have stimulated settlement, and the subsequent combination of decreasing area and rising population given rise to more complex and organised societies. The final abandonment of the great Olmec centres at San Lorenzo and La Venta may have been due to the eventual rise in water-table diminishing agricultural productivity, through waterlogging, below the level needed to support their social superstructure.

The part played by this drowned coastal region, and the corresponding narrower plain on the Pacific coast, in the early settlement and subsequent rise to civilization of Mesoamerica is one of the outstanding questions in New World archaeology, but the difficulty of investigation has discouraged systematic field work on the period before 1500 B.C.* There is an urgent need for the formulation and execution of a research design devoted to locating and investigating the waterlogged equivalents of MacNeish's dry caves.

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* A recent (November 1975) ^{14}C date of 2050 ± 155 B.C. (UCLA 1985e), calibrating to *ca.* 2600 B.C., for the lowland Maya site of Cuello suggests a potential locus for future research in this period.

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