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The Loess and the Origin of Chinese Agriculture

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FEW problems in human history are more fundamental and challenging than the origins of agriculture. It was cereal agriculture, probably more than anything else, that gave rise to the first civilizations in both the Old and New World.[1] The origins of agriculture in Mesopotamia and Meso-America have been intensively studied by archaeologists and scientists of many disciplines, for all except a handful of extreme diffusionists have conceded that these areas were the two independent nuclei from which agriculture and early civilizations developed and spread throughout the hemispheres. Because of the multifarious data concerning the origin of Chinese agriculture, however, there is reason to believe that, in so far as theories of the genesis of culture are concerned, China may well hold as crucial a position as do Mesopotamia and Meso-America.

An examination of the massive new archaeological and many-sided scientific findings regarding the nuclear area of Neolithic China and an integration of them with the rich store of ancient Chinese written records reveal that the natural en-

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1 The relationship between cereal agriculture and the rise of higher culture is systematically discussed in E. D. Merrill, "Plants and Civilizations," *Scientific Monthly*, XLIII (Nov. 1936), 430–39,

vironment of the nuclear area of Neolithic China is basically different from that of Mesopotamia; that the beginnings of Chinese agriculture had nothing directly to do with the great flood plain of the lower Yellow River; that irrigation did not begin in China until Chinese agriculture was four millenniums old; and that the earliest Chinese agricultural crops are botanically quite different from those cropping systems based on a common core of wheat and barley. To be sure, wheat and barley, which were first cultivated on the hilly flanks of the Fertile Crescent as early as 7000 B.C. and then on the irrigated fields of the Tigris-Euphrates Valley some time after 5000 B.C., were belatedly introduced into North China, probably not much earlier than 1300 B.C. But for over a millennium after their introduction into China they were grown neither along foothills—as they originally were in Mesopotamia—nor in irrigated fields—as they were after 5000 B.C. in Mesopotamia, Egypt, and the Indus Valley; they were grown as dry-land crops on semiarid loess plains where the climatic pattern is exactly opposite to that of Mesopotamia, an area of abundant winter rain. The ancient Chinese agricultural complex was, therefore, distinctly Sinitic and fundamentally different from the grain-centered agricultural systems of the other three earliest developed regions of the Old World.

While the distinctly Sinitic character of Chinese agriculture may be of interest to those who are in the process of re-examining the once seemingly unquestioned theory of the monogenesis of Old-World civilizations, my findings on rice may persuade botanists and phytogeographers to reconsider their deep-rooted belief that rice is indigenous to India and was introduced from India into China. The aggregate archaeological, botanical, historical, and philological evidence indicates that the southern half of China, as much as India and Southeast Asia, is one of the original homes of rice and that rice culture began in China at least a full millennium earlier than in India.

Since no historian can get away from time and space, I shall first discuss a datum chronology and the natural environment of the nuclear area in which Chinese agriculture began.

The first well-defined Neolithic culture in China is the Yang-shao culture, named after the village in western Honan where in 1921 the Swedish geologist J. G. Andersson discovered painted pottery and other Neolithic artifacts. In 1928 at the village of Ch'eng-tzu-ya near the capital city of Chi-nan, in Shantung

but it is most effectively stated by Paul C. Mangelsdorf in "Wheat," *Scientific American,* CLXXXIX (July 1953), 50–59: "No civilization worthy of the name has ever been founded on any agricultural basis other than the cereals. . . . It may be primarily a question of nutrition. . . . Cereal grains, like eggs and milk, are foodstuffs designed by nature for the nutrition of the young of the species. They represent a five-in-one food supply which contains carbonhydrates, proteins, fats, minerals and vitamins. . . . Perhaps the relationship between cereals and civilization is also a product of the discipline which cereals impose upon their growers. The cereals are grown only from seed and must be planted and harvested in their proper season. In this respect they differ from the root crops, which in mild climates can be planted and harvested at almost any time of the year. . . . The growing of cereals has always been accompanied by a stable mode of life. . . . Cereal agriculture in providing a stable food supply created leisure, and leisure in turn fostered the arts, crafts and sciences. It has been said that 'cereal agriculture, alone among the forms of food production, taxes, recompenses and stimulates labor and ingenuity in an equal degree.' "

Province, the Institute of History and Philology of Academia Sinica discovered another Neolithic culture, characterized by black pottery and oracle bones and named after the nearest township of Lung-shan. Although Yang-shao, Lung-shan, and Shang dynasty cultural remains were subsequently found in temporal succession in several northern Honan sites, the time span separating these two cultures and the problem of their interrelationship remained matters of conjecture and debate throughout the 1930's and 1940's. The relative chronologies suggested and revised by Andersson were probably the only ones widely known in the West until 1949, but they were little more than educated and sometimes self-contradictory guesswork. Not until the discovery in the 1950's of a number of important local and regional Neolithic cultures throughout China were archaeologists able to reclassify China's major Neolithic cultures with more systematic data. It is now reasonably clear that these newly discovered Neolithic cultures, such as the Miao-ti-kou II culture of Honan, eastern Shensi and southern Shansi, the Ta-wen-k'ou culture of Shantung, the Ch'ing-lien-kang culture of the Huai River region, and the Ch'ü-chia-ling culture of the lower Han River area in Hupei, represent a fairly long period of cultural transition from the Yang-shao to the Lung-shan stage.

By using the method of developmental classification, an archaeologist from Yale University has formulated the following hypothesis:

> Largely speaking these phases [that is, the newly discovered Miao-ti-kou II culture, and so forth] are all characterized by painted pottery but differ substantially from the Yang-shao, and the features on which they differ from the Yang-shao are similar to those of Lung-shan. In time they were without exception demonstrably earlier than the Lung-shan cultures wherever they occurred with these cultures, but at the same time they were later than the Yang-shao within the area in which the latter occurred.[2]

Up to the present the only relatively firm dating with which to estimate the chronologies of China's major Neolithic cultures is the one about the beginnings of the so-called Taiwan Lungshanoid culture, provided by the Yale University expedition to Taiwan in 1964–1965. Based on a series of carbon-14 tests and other materials, the Yale report suggests 2500 B.C. as the date for the emergence of the Taiwan Lungshanoid culture,[3] which is unmistakably a derivative of and hence considerably later than mainland Lungshanoid cultures. In view of the necessary time lag between the appearance of Lungshanoid cultures on the mainland and their gradual spread southward, it seems reasonable to suggest 3000 B.C. as their upper chronological boundary. Since the evolution of the earliest culture usually takes a longer period of time than later cultures, the Yang-shao culture seems to have emerged in the fifth millennium B.C., possibly even earlier.

The proto-Chinese of the Yang-shao period lived in the southeastern part of

[2] Kwang-chih Chang, *The Archaeology of Ancient China* (New Haven, Conn., 1968), 132.

[3] K. C. Chang and Minze Stuiver, "Recent Advances in the Prehistoric Archaeology of Formosa," *Proceedings of the National Academy of Sciences*, LV (Mar. 1966); and K. C. Chang, "The Yale Expedition to Taiwan and the Southeast Asian Horticultural Evolution," *Discovery*, I (Spring 1967).

the loess highland, which from the geological point of view may be regarded as a "classic" loess area. Here, not only are the loess deposits unusually thick, but the fine particles that make up the loessic soil are exceptionally homogeneous in texture. The exceptional textural homogeneity of the soil of this area can be explained only by the high probability that it was wind, rather than any other natural agent, that transported the loess material from far and near and deposited it during long periods of desiccation that characterized the Pleistocene climate of North China.[4] Indeed, recurrent deposition of loess by the wind on various parts of North China is well attested by three thousand years of Chinese historical records.[5]

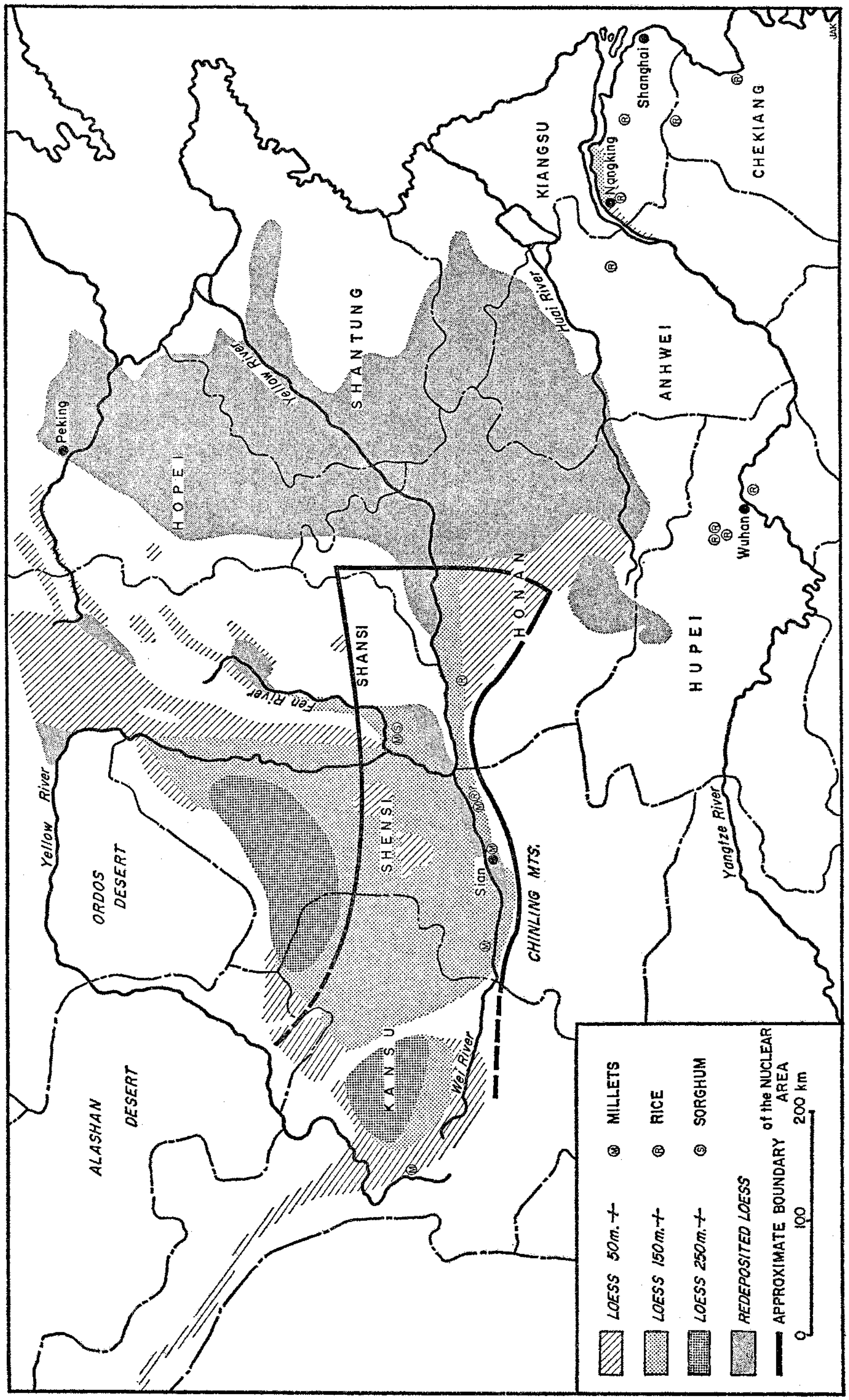
During the past million years there have been four periods of desiccation interrupted by three periods of relative abundance of rain. It was during the comparatively rainy periods that erosion on a large scale took place; as a result, the loess material was carried by water from higher grounds to the low plains of North China. Although the causes of the formation of the loess of the low plains are highly complex, much of the soil of this area is of alluvial and diluvial origins. In many localities in the low plains the soil contains a mixture of pebbles, gravels, and conglomerates. In contrast, the loess of the highland area, which is largely of aeolian origin, is texturally uniform, fine, pliable, and porous, and hence offered much less resistance to primitive wooden digging sticks. This may have been one of the reasons why, in spite of more arid climatic conditions, the loess highland area was the cradle of Chinese Neolithic culture.

The climate of North China is severe, noted for its icy winters, hot summers, and frequent spring sandstorms. The average rainfall of the loess highland is between 250 and 500 millimeters (slightly less than 10 and 20 inches). The average rainfall of the low plains is between 400 and 750 millimeters. The 750-millimeter rainfall line generally marks the southern and eastern boundary of the redeposited loess. An annual rainfall of between 10 and 20 inches, if evenly distributed over the four seasons, should meet the minimal requirements of ordinary dry-land farming. But in the loess area much of the rain is concentrated in the summer, when the temperature and rate of evaporation are both very high; there is usually inadequate moisture in winter and spring. All this, together with the fact that much of North China lies on the margins of the two main rain-producing systems of warm-season monsoons and cool-season cyclonic storms, makes the loess area of China a semiarid region.

During the past few decades there has been considerable controversy about the paleoclimate of North China. The latest opinion on the subject, based on scientific investigations of the Chinese loess, is that, despite the alternations between very dry and relatively wet periods during the entire Pleistocene epoch, the long-

[4] Liu Tung-sheng *et al.*, *Chung-kuo ti huang-t'u tui-chi* [The Loess Deposits of China] (Peking, 1965), probably the most systematic study of the loess in any language, have arrived at this conclusion from various scientific angles.

[5] Wang Chia-yin, "Li-shih-shang-ti huang-t'u wen-t'i" [The Problem of Loess Deposition in Chinese History], *Chung-kuo ti-ssu-chi yen-chiu* [*Quaternaria Sinica*], IV (No. 1, 1965), 1–8.



Adapted from Liu Tung-sheng *et al.*, *Chung-kuo ti huang-t'u tui-chi* (Peking, 1965).

range climatic tendency has been one of periodic and probably progressive desiccation.[6]

The arid conditions in which the loess was formed are best reflected in the physical and chemical property of the soil. As is well known, soils of humid regions are well weathered, leached, and acidic whereas soils of dry belts are little weathered, unleached, and alkaline. The loess of the highland area of China has undergone little weathering, has retained many of its minerals, and is almost invariably alkaline. After meticulous comparison with the loess of several European countries, Chinese geologists conclude that the Chinese loess was formed under climatic conditions more arid than those during the process of loessification in Europe.[7]

For the sake of studying climatic changes in North China during the Pleistocene epoch, Chinese geologists in recent years have paid much attention to the various layers of reddish soil buried in the thick loess deposits. The buried soil is of considerable scientific interest because only under conditions of above-normal warmth and humidity could the loess be weathered into reddish soil. Yet a systematic analysis of various samples of the reddish soil taken from the loess profile of Li-shih County, Shansi Province, shows pH values ranging from 7.5 to 8.8.[8] In other words, the buried soil is still moderately or fairly strongly alkaline. What is even more revealing is the composition of the pollen found in the uppermost layer of the buried soil in a loess profile of Wu-ch'eng County, Shansi Province. This particular layer lies between 10.6 and 12.9 meters under the surface, a stratum that should represent a "humid" subperiod of a rather recent geological age. Of forty-seven grains of pollen found in this stratum, only four are arboreal (*Abies*, 1; *Pinus*, 3); the remaining forty-three are accounted for by the single genus of *Artemisia*,[9] one of the best botanical indicators of an arid and semiarid environment. As is well known, the most typical and ubiquitous plant in the driest belt of the United States, located between the Rocky Mountains and the Cascades and Sierras, is sagebrush (*Artemisia tridentata*).[10] In discussing the paleoclimate of North China, the word "pluvial" must therefore be used with caution and only in a relative sense.

Of all the scientific factors relating to the paleoenvironment of North China, the most puzzling is the faunal assemblage, which runs the whole gamut from animals of tundral and subarctic habitats, such as the two species of haired rhinoceros (*Coelodonta antiquitatis* and *Rhinoceros tichorhinus*) and mammoth

[6] J. S. Lee, *The Geology of China* (London, 1939), 371. Lee's early views on the Pleistocene climate of North China are now fully upheld by many recent studies, of which Liu *et al.*, *Chung-kuo ti huang-t'u tui-chi*, may be regarded as the best preliminary synthesis.

[7] *Ibid.*, 141–227.

[8] Liu Tung-sheng and Chang Tsung-yu, "Chung-kuo ti huang-t'u" [The Loess of China], *Ti-chih hsüeh-pao* [*Acta Geologica Sinica*], XLII (Mar. 1962), Table 1, p. 2.

[9] *Ibid.*, Table 2, p. 6.

[10] For a discussion of the predominance of sagebrush in the dry belt of the United States, see W. R. Chapline and C. K. Cooperrider, "Climate and Grazing," in *Climate and Man* (Washington, D. C., 1941), esp. 364–65.

(Mammuths primigenius), to animals of warm areas, such as the elephant *(Elephas indicus)* and the ordinary rhinoceros (*Rhinoceros* sp.). Some scholars today would still use the elephant and the rhinoceros as evidence to argue that the paleoenvironment of North China must have been warm and humid at certain times in the past. This argument can be offset easily by an equally partial listing of haired rhinoceroses and mammoths, normally of subarctic habitats, and of camels and ostriches, now confined almost exclusively to desert and semidesert areas. Besides, many fossils of elephants and rhinoceroses found in North China during the early decades of this century were not accompanied by detailed stratigraphic reports, with the result that they were wrongly attributed to various strata of loess. A recent systematic re-examination of the relevant verified paleontological data shows that fossils of elephants and rhinoceroses almost always came from lacustrine beds, which were formed during periods of erosion and which are as a rule unconformably overlain by deposits of loess. After considering all aspects of the faunal data, a leading synthesist of the Chinese loess concludes that ever since the mid-Pleistocene epoch the faunal assemblage of the loess area has been dominated by species of rodents, especially *Myosplax* sp., a clear indication of a semiarid steppe environment.[11]

Probably the most remarkable recent advance in the study of the paleoenvironment of the loess region lies in the field of palynology. Of the ten available pollen studies relating to North China,[12] the analysis of the pollen of an entire loess profile of Liu-shu-kou, Wu-ch'eng County, Shansi Province, is for various reasons

[11] Liu *et al., Chung-kuo ti huang-t'u tui-chi,* 115–32. It should be noted that in ancient times North China, especially the low plains, had marshes where elephants and rhinoceroses lived. Elephants trekked south in Shang times, but rhinoceroses are known to have lingered in marshy areas of North China until rather late in Chou times (1027[?]–256 B.C.). For details, see Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* 24, n. 18, 19. Possibly the puzzle of elephants and rhinoceroses in ancient North China may be accounted for by the animals' remarkable range of mobility and equally remarkable ability to adapt themselves over a certain length of time to environments different from those of their favorite habitats.

[12] These studies are so valuable that a complete listing may be useful to Western scientists: Sung Chih-ch'en, "San-men-hsi chih-wu-hua-shih ho p'ao-tzu-hua-fen-tsu-ho ti yen-chiu" [A Study of the Fossilized Plants and Pollen Spectrum of the San-men Series], *Quaternaria Sinica,* I (No. 1, 1958); Chou K'un-shu *et al.,* "Shan-hsi Li-shih Wang-chia-kou Ch'en-chia-yai lao-huang-t'u mai-ts'ang-t'u-jang chung ti p'ao-fen chi chih-wu-ts'an-t'i" [The Pollen and Paleobotanical Remains of the Buried Soils in the Old Loess Deposits of Ch'en-chia-yai, Wang-chia-kou, Li-shih County, Shansi Province], *ibid.,* III (Nos. 1–2, 1960); Hsü Jen, "Chung-kuo-yüan-jen shih-tai ti Pei-ching ch'i-hou-huan-ching" [The Climatic Environment of the Peking Area during the Times of the Chinese Ape Men], *ibid.,* IV (No. 1, 1965); Sun Meng-jung, "Chou-k'ou-tien Chung-kuo-yüan-jen-hua-shih-ts'eng ti p'ao-tzu-hua-fen tsu-ho" [The Pollen Spectrum of the Stratum of the Chinese Ape Men of Chou-k'ou-tien], *ibid.;* Liu Chin-ling *et al.,* "Yen-shan nan-lu ni-t'anti p'ao-fen tsu-ho" [The Pollen Profile of the Peat Bogs of the Southern Foothill of Yen-shan], *ibid.;* Chou K'un-shu, "Tui Pei-ching-shih fu-chin liang-ke mai-ts'ang-ni-t'an-chao ti tiao-ch'a chi ch'i p'ao-fen fen-hsi" [A Field Survey of Two Peat Bog Marshes Near Peking and an Analysis of Their Pollen Composition], *ibid.;* Liu Mu-ling, "Ho-nan Shan-hsien Hui-hsing-chen Hui-hsing-kou tsao-keng-hsin-shih tui-chi chung ti p'ao-fen-tsu-ho ch'u-pu yen-chiu" [A Preliminary Study of the Pollen Composition of an Early Pleistocene Deposit at Hui-hsing-kou, Hui-hsing-chen, Shan-hsien, Honan], *ibid.;* Ch'en ch'eng-hui *et al.,* "Liao-tung-pan-tao P'u-lan-tien fu-chin han ku-lien-tzu ti ch'üan-hsin-shih tui-chih-wu ti p'ao-fen fen-hsi" [An Analysis of the Pollen of the Holocene Deposit of P'u-lan-tien, Liao-tung Peninsula, Which Contains Ancient Lotus Seeds], *ibid.;* Liu and Chang, "Chung-kuo ti huang-t'u," which offers by far the most systematic palynological data of a classic loess area, Wu-ch'eng County, Shansi Province; Chou K'un-shu, "Hsi-an Pan-p'o hsin-shih-ch'i-shih-tai i-chih ti p'ao-fen fen-hsi" [An Analysis of the Pollen Gathered at the Pan-p'o Neolithic Site Near Sian], *K'ao-ku* [*Archaeology*] (No. 9, 1963).

the most relevant. Few localities can offer a more complete loess profile than Wu-ch'eng, a name that in recent years has been used by Chinese geologists to exemplify all strata of the loess deposited during the early Pleistocene period. Unlike other studies of the pollen of North China, which deal with certain specific periods of the Pleistocene epoch, the Wu-ch'eng study chronologically covers the past million years. The entire Wu-ch'eng profile of 121 meters is divided, for palynological study, into as many as 106 strata, so that vegetational and implied climatic changes can be studied in minute detail. Since my study is more concerned with the vegetation and climate of the geological period nearest to the dawning of Chinese agriculture, I have tabulated separately the pollen of the loess profile of the upper twenty meters.[13]

Table I
Analysis of the Pollen of the Loess Profile of Wu-ch'eng

Plant	Total Number of Pollen Grains (1–20 m.)	Total Number of Pollen Grains (20–121 m.)	Total Number of Pollen Grains (Entire Profile, 1–121 m.)
A. Arboreal			
Abies	2	0	2
Pinus	15	13	28
Cupressaceae	3	0	3
Juglans	0	3	3
Carpinus	0	3	3
Quercus	2	6	8
Ulmus	0	1	1
Morus	2	0	2
Acer	0	1	1
Ephadra	0	2	2
Salix	7	12	19
Corylus	2	0	2
Total (Arboreal)	33	41	74
B. Nonarboreal			
Typha	1	1	2
Gramineae	56	118	174
Cyperaceae	3	3	6
Humulus	3	16	19
Chenopodiaceae	18	58	76
Caryophyllaceae	1	1	2
Clematis	48	5	53
Convolvulus	14	0	14
Artemisia	722	330	1,052
Compositae	32	45	77
Dicotyledoneae	72	1	73
Total (Nonarboreal)	970	578	1,548
Total (A + B)	1,003	619	1,622

[13] My table is based on Liu and Chang "Chung-kuo ti huang-t'u." In the original table *Filicales* and *Bryales* constitute a small separate category; since the latter has not been counted in the original table, I omit these two species entirely from the summary.

This table reveals several important aspects of the paleoenvironment of the loess highland. First, the fact that trees and shrubs account for merely 74 of the 1,622 grains of pollen testifies that this area was, much as it is today, rather meager in forest resources. The relative significance of *Pinus* (pines) and *Salix* (willows), which account for forty-seven of a total of seventy-four arboreal pollen grains, should be briefly discussed. It is well known that with its two air sacks pine pollen can travel a long distance from its mountainous habitat, and willows generally grow along edges of water. In other words, the over-all meager forest resources and the likely special habitats of the two numerically significant groups of trees would indicate that the level areas of the semiarid loess highland were little, if at all, forested.

Second, the most striking phenomenon in the pollen profile is the overwhelming predominance of herbaceous plants, which account for 1,548 grains of pollen or 95.4 per cent of the total. There can be little doubt that the loess highland area, except for its mountains, hills, slopes, and places near watercourses, has always been a nonwooded steppe. The fact that *Artemisia* alone accounts for as much as 64.8 per cent of the pollen emphatically reflects the ecology of a semiarid steppe.

Third, whereas *Artemisia* represents 53.3 per cent of the pollen found deeper than twenty meters, it represents 71.8 per cent of the pollen found in the upper twenty meters. This sharp increase in the percentage of *Artemisia* indicates that the climate in the late Pleistocene epoch was becoming cooler and drier.

Fourth, next to *Artemisia* the most significant groups of herbaceous plants are the family of Gramineae, which consists of many kinds of weeds later domesticated by men as food crops, and the family of Chenopodiaceae, which consists of a large number of spinach-like wild plants sometimes used as vegetables and often grown by primitive men for their seeds.[14] Gramineae account for 10.7 per cent of the pollen total and are fairly evenly distributed chronologically throughout the past million years. In the light of archaeological and literary evidence concerning the earliest Chinese cereal crops, the prevalence of Gramineae cannot be interpreted as an indication that a wide range of potential food plants has existed since the early Pleistocene epoch; on the contrary, it indicates the existence of rather few kinds of potential cereal plants which, in spite of the prolonged and relentless struggle against such xerophytic plants as *Artemisia* and Chenopodiaceae, had survived in a semiarid area in sufficient quantities to be utilized eventually by the Yang-shao farmers.

The main characteristics of the paleoenvironment revealed by the above table are corroborated not only by studies of pollen profiles gathered from other localities in North China but also by the botanical records preserved in ancient Chi-

[14] For a discussion of the extensive use of Chenopodiaceae by primitive men, see *Sturtevant's Notes on Edible Plants,* ed. U. P. Hederick (Albany, N. Y., 1919), 160–61. That Chenopodiaceae were possibly extensively grown by the Yang-shao farmers of Pan-p'o, near Sian, is reflected in Chou, "Hsi-an Pan-p'o hsin-shih-ch'i-shih-tai i-chih ti p'ao-fen fen-hsi." Of a total of 278 pollen grains found in a Yang-shao cultural stratum 2.8 meters deep, arboreal pollen grains account for only 40, but Chenopodiaceae and *Artemisia* account for 141 and 38, respectively.

nese literary works. Of all the literary works, *The Book of Odes (Shih-ching)* contains by far the most extensive botanical records. Sinologists the world over agree on the authenticity and textual excellence of this ancient work, which illuminates the life of the Chinese from the late eleventh century to the middle of the sixth century B.C. It is true that this anthology of 305 songs and odes collected from the Chou royal domain and the feudal states[15] mentions less than 150 plants, a number that is infinitesimal as compared with the number of species known to botanists today. But when it is remembered that the total numbers of plants known to and mentioned by the ancient Egyptians, the Bible, Homer, and Herodotus are only fifty-five, eighty-three, sixty, and sixty-three, respectively,[16] *The Book of Odes* is really a mine of information for historians and botanists. For a majority of cases, moreover, *The Book of Odes* states the type of topography in which a plant grows—mountain, plain, wet lowland near water, marsh, pond, or river. The geographic areas covered by the 305 songs and odes are Shensi, Shansi, and Honan Provinces, the Han River Valley down to the middle Yangtze Valley, western and central Shantung, northwestern Anhwei, and southern Hopei. It is fortunate that the volume's botanical records on the southeastern part of the loess highland are especially comprehensive.

Using archaic Chinese written records to check recent scientific findings on the loess area, I have identified, analyzed, and tabulated all the arboreal and non-arboreal plants in *The Book of Odes* except the aquatic plants and cereals, since my concern is the ancient "natural" vegetation. I have supplemented the botanical data of *The Book of Odes* with information culled from various classics, historical, geographical, and philosophical works written or compiled mostly before and during the Former Han period (206 B.C.–A.D. 8), and from *Wen-hsüan,* the earliest comprehensive literary anthology compiled during the first half of the sixth century A.D. By comparing literary records with modern scientific findings I have reached the following conclusions.[17]

First, there has been little, if any, significant change in the composition of

[15] The Swedish Sinologist Bernhard Karlgren, after a meticulous study of the strict rhyming system of the odes, concludes that most if not the entire text of *The Book of Odes* seems to have been edited by officials in the court of the Chou kings. In other words, the odes as they now stand were written in the elite language of Chou times rather than in ancient regional and local dialects. Sinologists generally agree on this major conclusion. But Karlgren's other conclusion that the odes are musical airs and do not in any way reflect the life of the Chinese from the late eleventh to the middle of the sixth century B.C. is shared by none except the late Henri Maspero. For Karlgren's opinion on *The Book of Odes,* see his introductory remarks in "Glosses on *The Book of Documents,*" *Bulletin of the Museum of Far Eastern Antiquities* (No. 20, 1948). For the more important ancient sources and modern research supporting the view that the odes were collected from, or submitted to the Chou court by, the various feudal states, see Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* 36–37.

[16] F. Kanngiesser, "Die Flora des Herodot," *Archiv für die Geschichte der Naturwissenschaften und der Technik,* III (1912), 81.

[17] Much of Part II of Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* deals with the identification and tabulation of fifty-four arboreal and forty-one herbaceous plants, along with bamboos, recorded in *The Book of Odes.* Table 3 (pp. 42–45) provides the Chinese and scientific names of such plants, together with their habitats, described in *The Book of Odes.* The types of trees and shrubs named in *The Book of Odes* and other ancient Chinese literary works are compared in Table 4 (pp. 57–64) with results of recent pollen analyses.

North China's forests since the late Pleistocene epoch, and deciduous trees have always been numerically more important than conifers.

Second, an examination of the habitats of trees and shrubs mentioned in *The Book of Odes* reveals that they were virtually confined to mountains, hills, slopes, and places near watercourses. In other words, apart from the uneven seasonal distribution of rain and high evaporation in summer, the level loess areas of North China do not seem to have been able to retain enough water for the growth of trees and shrubs. The statements made by the late V. K. Ting, founder of the China Geological Survey, in his famous review of Marcel Granet's *La civilisation chinoise,* which depicts the loess highland as a dense woodland dotted with marshes, are largely valid and still worth citing:

> Now all geologists agree that in the loess there has never been any forestation. . . . the water table is so low that even today trees planted in the loess need to be watered in their young stages until the roots become sufficiently deep. . . . It is not denied that forests existed on mountain slopes, but the loess area has always been a semi-steppe. Marshes exist even today in the alluvial plains, but most of Professor Granet's marshes lay in loess-land.[18]

My only revision of Ting's view is that the Wei River Basin in Shensi Province even today has marshes, caused by poor drainage owing to special physiographic factors.[19] In spite of climatic conditions that cannot be regarded as humid, the poorly drained areas in the low plains abounded in marshes and peat bogs, some of which are known to have been formed during late prehistoric and early historic times.

Third, it is by no means coincidental that *The Book of Odes* provides an eloquent testimonial to the predominance of *Artemisia* on the loess plains, which can be gauged from the number of its varietal names and from its frequency of occurrence. The single genus of *Artemisia,* with ten varietal names, leads all the plants recorded in this ancient work, arboreal and nonarboreal, by a wide margin. In terms of the number of times various plants appear in the odes, *Artemisia* is barely exceeded by mulberry by a ratio of nineteen to twenty and followed by the *shu* and *chi* subspecies of millet *(Panicum miliaceum),* which appear in fifteen and twelve odes, respectively. Since *P. miliaceum* was the most important source of food for the ancient Chinese and since mulberry was vital to sericulture and was extensively grown in various parts of North China during Shang-Chou times, the fact that weeds of the *Artemisia* genus receive such prominent mention in *The Book of Odes* is an unmistakable indication that the loess area was a semiarid steppe.[20]

[18] V. K. Ting, "Professor Granet's *La civilisation chinoise,*" *Chinese Social and Political Science Review,* XV (1931), 267–69.

[19] Kuan En-wei, "Wei-ho-ku-ti ti-mao-fa-yü-shih chi ch'i yu-kuan wen-t'i ti t'ao-lun" [A Discussion of the Physiographical History of the Wei River Basin and Other Related Problems], *Quaternaria Sinica,* IV (No. 1, 1965), 195–203.

[20] For more details, see Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* 73–79. For varietal names of *Artemisia,* see Glossary, p. 36.

Fourth, while *The Book of Odes* mentions Chenopodiaceae only twice, the combined evidence of other ancient works shows their prevalence on the loess plains. Unless weeds of the family of Chenopodiaceae were truly endemic, it would be hard for modern scholars to explain why in Chou times the fallow land was generally called *lai* (Chenopodiaceae) and the virgin soil *ts'ao-lai* (literally grasses and Chenopodiaceae).[21] As is well known to botanists and phytogeographers, although Chenopodiaceae require more water than *Artemisia* for growth and perpetuation, many species of this family can tolerate alkalinity and salinity of the soil better than most plants. Species of Chenopodiaceae are known to have thrived in the sun-baked saline and alkaline desert of south central Iraq where few plants can survive.[22]

The main characteristics of the ancient vegetation of the loess plains revealed in archaic Chinese literature concur, therefore, remarkably well with those of recent palynological studies. Taking into account such major factors as the climatic conditions under which the loess was deposited, the physical and chemical property of the loessic soil, the predominance of typical steppe animals in the faunal assemblage, the relative sparsity of arboreal plants, and the preponderance of such xerophytic and halophytic plants as *Artemisia* and Chenopodiaceae in both geological and early historical times, it is difficult not to arrive at the conclusion that the natural environment of the loess highland, in ancient and modern times, has always been one of a semiarid steppe.

It is important for scholars interested in the origin of Chinese agriculture to keep in mind that, although the natural environment of the loess highland has been unquestionably harsh, it nevertheless has had certain advantages. Precisely because of its aeolian origin and the prolonged arid and semiarid conditions in which the loess was formed, the soil is unusually homogeneous in texture, pliable, and porous, and was amenable to primitive wooden digging sticks. There is reason to believe that the grass cover of the loess highland has never been as dense as is usually found in other major steppe and forest-steppe belts of Eurasia. It is significant to observe that while "the most current surface rocks [of the forest-steppe zone of the USSR] are loess and loesslike formations," the characteristic soils of this belt are blackish "meadow-chernozem" and those of Russia's "steppe zone" are the classic dark chernozem, an indication of their much denser cover of grass.[23] A leading synthesist of world history is certainly right in pointing out that agriculture in the Old World first appeared, as a rule, on wooded slopes and foothills because "natural grassland offered stubborn resistance to the wooden digging sticks."[24] That in the Old World the only major exception is Yang-shao China is substantially explained by the peculiar property of the loess and its relatively

[21] Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan*, 80–85.

[22] Nicholas Polunin, *Introduction to Plant Geography and Some Related Sciences* (London, 1960), 386.

[23] A. A. Rode, *Soil Science* (Washington, D. C., 1962), 364; for a detailed description of the soils of these two belts, see *ibid.*, 363–420.

[24] William H. McNeill, *The Rise of the West: A History of the Human Community* (Chicago, 1963), 16.

sparse cover of grass. Since the loess is little weathered, it has retained many of its minerals and is therefore reasonably fertile. In spite of a limited annual rainfall of less than twenty inches, its concentration in summer enabled the Yang-shao farmers to grow successfully the few kinds of cereal plants that survived the prolonged process of natural selection in a semiarid environment. All in all, therefore, the natural environment of the nuclear area in which Chinese agriculture and Neolithic culture first occurred definitely imposed certain restrictions on its early inhabitants, but a limited range of opportunities peculiar probably only to China's loess highland partially compensated for these restrictions.

In addition to the peculiarities of the natural environment of the loess highland, which had so much to do with setting the pattern of Yang-shao agriculture, the earliest Chinese agricultural system was also characterized by its freedom from the influence of the great flood plain of the lower Yellow River and, as a corollary, by the absence of primitive irrigation.

In the early decades of the present century little was known about China's prehistory. Scholars generally believed that the cradle of Chinese civilization was probably the great flood plain of the Yellow River because, among other things, since the turn of the nineteenth century, tens of thousands of oracle bones had been unearthed in An-yang, a locality in northern Honan that lies within the area of the low plains. In the West this view was systematically expounded by the late Henri Maspero and, through Arnold Toynbee's monumental synthesis of history, has gained currency among Western historians.[25] During the past twenty years so many Neolithic sites have been excavated and so much more about the general sequence of major Chinese Neolithic cultures has become known that there can be little doubt that the cradle of Chinese civilization is the southeastern part of the loess highland, an area that has little in common with the great flood plain of the lower Yellow River.

From generalized and specific descriptions given in massive archaeological reports on northern Chinese sites that belong to the Yang-shao, Lung-shan, and other prehistoric cultures, the following facts have clearly emerged. Most of such sites, in the highland as well as the low plains, are loess terraces or mounds along various tributaries of the Yellow River rather than along the great river itself. A closer examination of these sites shows that most are clustered along numerous small rivers and streams that often do not appear on detailed general maps of China and are known only locally. This is an important testimonial to the basic fact that the birth of China owed little to the Yellow River itself, although in theory such numerous small rivers and streams are within the drainage of the Yellow River.[26]

[25] Henri Maspero, *La Chine antique* (Paris, 1927), 20–26; Arnold Toynbee, *A Study of History* (10 vols., London, 1934–54), I, 318-21.

[26] For detailed discussion of the topography of Neolithic sites in North China, see Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* 107–17. Even by Chou times the major cities were still along tributaries of the Yellow River or at various foothills. (See Tsou Pao-chün, "Chung-kuo wen-hua ch'i-yüan-

There are, to be sure, a few scores of prehistoric sites in Kansu, northwestern and southwestern Shansi, and western Honan, which are along the upper and middle course of the Yellow River itself. Topographically, however, these sites are exactly like all the rest: loess terraces or mounds of varying altitudes ranging from fifteen or twenty to hundreds of feet above riverbeds. All the prehistoric sites of North China are, in other words, close to water, but are also sufficiently high to be safe from floods. The elevated terraces and mounds provide the best argument against the possibility of irrigation before the invention of sophisticated water wheels and water pumps.

Although the generalized descriptions of the environments of over a thousand Neolithic sites already imply the impossibility of irrigation in very early times, I shall present positive evidence that irrigation arrived late in China. It is true that ditches and trenches have been discovered at the Yang-shao site of Pan-p'o near Sian and also at Hsiao-t'un in An-yang, the last Shang capital. But the main trench of the Pan-p'o site is believed by Chinese archaeologists to have existed for the purpose of defense, and the smaller ditches which all pass through the residential area cannot possibly have been used for irrigation.[27] The more elaborate network of ditches of Hsiao-t'un, which cuts through much of the ensemble of royal palaces, ancestral halls, residential houses, and workshops, is clearly for the purpose of drainage.[28] Indeed, in an extensive study of relevant inscriptions on Shang oracle bones, a leading Chinese paleographer is struck by the people's fear of floodwater and general ignorance of diking, water-conservancy, and irrigation.[29]

The first account of the construction of ditches in the fields, most probably for the purpose of irrigation, is given in the *Tso-chuan* (Chronicles of Feudal States). It declares that some time after Tzu-ssu's appointment as the chief minister of the Cheng state in north central Honan in 571 B.C., "in laying out the ditches through the fields, [he] had occasioned the loss of fields" to five aristocratic clans; consequently Tzu-ssu was assassinated in 563 B.C. by a band of "ruffians" instigated by the five clans. While the exact year for constructing these ditches is not given, it is likely to be nearer 563 B.C. than 571 B.C. This abortive irrigation project was resumed some twenty years later by Tzu-ch'an, the most famous statesman of Cheng. In so doing he first incurred the wrath of the people, but three years later won their high praises when the benefits of irrigation became known.[30] Unless irrigation had been novel and little known, these two statesmen would not have

ti" [The Region of Early Chinese Culture], *Ch'ing-hua hsüeh-pao* [*Tsing Hua Journal of Chinese Studies*], New Ser., VI [Dec. 1967], 22–34.)

[27] *Hsi-an Pan-p'o* [Report on the Archaeological Site of Pan-p'o, Near Sian] (Peking, 1963), 52.

[28] Shih Chang-ju, *Hsiao-t'un*, I, *Yin-hsü chien-chu i-ts'un* [Architectural Remains of the Last Shang Capital City] (Taipei, 1959), 268.

[29] Yü Hsing-wu, "Ts'ung chia-ku-wen k'an Shang-tai she-hui hsing-chih" [The Characteristics of the Shang Society Revealed in Oracle Inscriptions], *Tung-pei jen-min-ta-hsüeh jen-wen-k'e-hsüeh hsüeh-pao* [*Journal of Humanistic Studies of the People's University of the Northeast*] (Nos. 2–3, 1957), 103–104.

[30] *The Chinese Classics*, V, *The Ch'un Ts'ew with the Tso Chuen*, tr. James Legge (Hong Kong, 1872), 447–48, 558.

encountered such initial resistance. The *Tso-chuan* further states that in 548 B.C. the powerful Ch'u state of the central Yangtze began "enumerating the boundaries of flooded districts [and] raising small banks on the plains between dykes."[31]

The late beginnings of irrigation are further reflected in the scale of the first famous irrigation network, completed by the Wei state between 424 and 296 B.C., in the Chang River area in northern Honan. From the meticulous description in the *Shui-ching-chu* (Commentaries on the Classic of Waterways) of the fifth century A.D., we learn that this whole irrigation system was only twenty li in length, a little over five miles.[32] Not until the third century B.C. did large-scale irrigation networks appear in the Wei River Basin in Shensi and in the Red Basin of Szechwan.

It is sufficiently clear, therefore, that the rise of Chinese agriculture and civilization bore no direct relationship whatever to the flood plain of the Yellow River and that, of all the ancient peoples who developed higher civilizations in the Old and the New World, the Chinese were the last to know irrigation.[33] In so far as ancient China is concerned, the theory of the "hydraulic" genesis of culture or of "despotism" is completely groundless.[34]

The origin of cultivated plants has been a favorite topic of botanical scientists and geographers. There is considerable existing Western literature on the subject, but it usually does not treat systematically those cereal plants that are indigenous to China and were first cultivated by the Chinese. The language and disciplinary barriers are so great that the vast body of Chinese literature concerning food plants has been little known to Western scientists and seldom systematically utilized by Chinese botanists. Because of the relative abundance of recent archaeological finds concerning ancient cereal grains, coupled with the richness of archaic Chinese literature, one can discuss the origin of each of the major indigenous and introduced food plants and suggest possibilities of revising certain views held by Western scientists, which do not seem to stand the test of the aggregate Chinese evidence. These plants—millets, sorghum, rice, wheat and barley, soybeans, hemp and mulberry—will be discussed in turn.

Chinese millets consist of plants, domesticated and wild, that belong to the two different genera of *Setaria* and *Panicum*. The former is chiefly represented by

[31] *Ibid.*, 517. It ought to be noted that *Hou-Han-shu* [History of the Later Han Dynasty] (Taipei, I-wen-shu-chü photographic reproduction), Chap. LXXVI, 6b, states that in A.D. 83 Wang Ching, governor of Lu-chiang (south of the Huai River in northern Anhwei), revived and expanded the irrigation network that was said to have been started by the Ch'u Prime Minister, Sun-shu Ngo, around 600 B.C. But this is likely an attribution to a famous ancient man and may not be authentic.

[32] Yu Yü, "Kuan-tzu tu-ti-p'ien t'an-wei" [A Study of the Chapter on Hydraulic Engineering in *Kuan-tzu*], *Nung-shih yen-chiu chi-k'an* [*Bulletin of Studies in Agricultural History*], I (1959), 2.

[33] Irrigation began in Meso-America around 800 B.C. (See Richard S. MacNeish, "Mesoamerican Archaeology," in *Biennial Review of Anthropology*, ed. Bernard J. Siegel and Alan R. Beals [Stanford, Calif., 1967].)

[34] Karl A. Wittfogel, *Oriental Despotism: A Comparative Study of Total Power* (New Haven, Conn., 1957), expounds the theory of "hydraulic" genesis of "oriental despotism." When this theory is applied to China, the most important and most enduring of the "oriental depotisms," it is against all known historical facts.

the species *Setaria italica,* which the Chinese call *su,* and the latter by the two subspecies of *P. miliaceum,* which the Chinese call *shu* and *chi.* This taxonomic division was of course not always understood by ancient and later Chinese etymologists and herbalists. There is reason to believe that some confusion in the nomenclature of Chinese millets has persisted from the beginning of China's recorded history; Neolithic millets are reported to have been largely *S. italica,* but Shang oracle inscriptions and *The Book of Odes* both indicate an overwhelming importance of *shu* and *chi* as a source of food. Yet in the works written and compiled during the fourth and third centuries B.C. *Setaria* regains its dominant position.[35] This seemingly sharp vicissitude of the relative importance of *Setaria* and *Panicum* can be accounted for only by certain confusion in nomenclature.

What we do know clearly is that *S. italica* was extensively grown in the loess highland during Yang-shao times. The most important archaeological proof is the fact that at the typical, early Yang-shao site of Pan-p'o near Sian bushels of husks of *S. italica* have been found in several storage places. The quantity of the stored millets, along with the abundance of agricultural implements and the whole complex layout of the village, establishes beyond doubt that *S. italica* was a crop cultivated and harvested by men.[36] Husks of the *Setaria* millet have been found in three more Yang-shao sites in Shensi and southern Shansi and in a site at Ta-ho-chuang, Lin-hsia County, Kansu Province, which belongs to a later Neolithic culture called Ch'i-chia. While most of the millets are *Setaria,* those found in Ching-ts'un, southern Shansi, are reported to contain *P. miliaceum.*[37] If my suggested chronology for Yang-shao culture is not too far wrong, millets began to be cultivated by the proto-Chinese in the fifth millennium B.C., if not earlier.

Two independent experiments carried out by American botanists show that among common cereal plants *S. italica* has the highest "efficiency of transpiration," that is, best suited to dry conditions.[38] While no similar field experiment has ever been done for *P. miliaceum,* its ability to resist drought is well known. *The Book of Odes* mentions the existence of black, red, early-ripening, late-ripening, nonsticky, and glutinous millets, an indication of their varietal richness. Even today wild species of millets can be found in the loess area. All this, together with the extreme antiquity of their cultivation, should establish the *Setaria* and *Panicum* millets as indigenous plants.

Although two pioneering investigators of the origin of cultivated plants, Alphonse DeCandolle and N. I. Vavilov, both regarded *Setaria* and *Panicum* as native Chinese plants, there is still considerable confusion about their original habitats. The 1936 edition of the famous *A. Engler's Syllabus der Pflanzenfamil-*

[35] For detailed discussions on the nomenclature and history of millets in China, see Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* 121–33.
[36] *Hsi-an Pan-p'o,* 223.
[37] Carl W. Bishop, "The Neolithic Age in Northern China," *Antiquity,* VII (Dec. 1938), 369.
[38] Lawrence J. King, *Weeds of the World: Biology and Control* (London, 1966), Table 4, p. 180.

ien, for example, attributes the original habitat of *P. miliaceum* to India. A leading Indian expert on millets thinks that millets in general are native to tropical and subtropical areas rather than to China.[39] Hermann von Wissmann, a geographer known for his studies of the dry belts, states, without giving any evidence, that millets originated in northwestern India.[40] All this, and much else, calls for a re-examination of millets in the context of world history.

Indeed, as Vavilov suggested, there are millets other than *Setaria* and *Panicum* that are likely to have originated in Abyssinia. These species are *Eleusine coracana* and *Pennisetum spicatum.*[41] Recent archaeological research on Africa suggests that these African millets may have been cultivated by the people of the "Stone Bowl" culture sometime during the second millennium B.C.[42] This suggested chronology, if fully substantiated by future archaeological work in Africa, would still be too late to challenge the primacy of the Chinese in the history of the domestication of millets.

The view that *Panicum* is indigenous to India does not stand close scrutiny. For one thing, Indian botanists admit that no wild species are known to exist in the subcontinent of India.[43] For another, in India no *Panicum* has ever been discovered in cultural strata that contain India's most ancient cereal grains, wheat and barley. What is more, the philological evidence is overwhelmingly against India as a country of origin. The Sanskrit name for *P. miliaceum* is *cīnaḳa,* which means "Chinese."[44] The Hindi names of *chena* and *cheen,* the Bengali name of *cheena,* and the Gujarati name of *chino* all sound suspiciously close to "China."[45] A variant Bengali name of *bhutta* clearly indicates Bhutan, the Himalayan foothill country, as a steppingstone in the long route of its introduction from China.[46] It is also known that the Sanskrit names for a number of cultivated plants introduced from China faithfully reflect their origin, for example, *cīnanī* ("Chinese fruit") for peach and *cīnarājaputra* ("crown prince of China") for pear.[47] The Persian name of *šušu* for *P. miliaceum,* which is undoubtedly derived from the Chinese *shu-shu (P. miliaceum glutinosa),* is additional philological evidence that this food plant was introduced into Western Asia from China.[48]

It is true that in the study of the origin of cultivated plants philological evidence

[39] N. Krishnaswamy, "Origin and Distribution of Cultivated Plants of South Asia: Millets," *Indian Journal of Genetics and Plant Breeding,* XI (June 1951), 67–74.

[40] Hermann von Wissmann, "On the Role of Nature and Man in Changing the Face of the Dry Belt of Asia," in *Man's Role in Changing the Face of the Earth,* ed. William L. Thomas, Jr. (Chicago, 1956), 285.

[41] N. I. Vavilov, *The Origin, Variation, Immunity and Breeding of Cultivated Plants* (*Chronica Botanica,* XIII [Nos. 1–6, 1949–50]), 38.

[42] J. Desmond Clark, "Africa South of the Sahara" and "Conclusions and Afterthoughts," in *Courses toward Urban Life,* ed. Robert J. Braidwood and G. R. Willey (Chicago, 1962), 19–21.

[43] *The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products* (New Delhi, 1966), VII, *s.v.* "Panicum."

[44] Berthold Laufer, *Sino-Iranica* (Chicago, 1919), 595.

[45] *Wealth of India,* VII, *s.v.* "Panicum."

[46] I owe this valuable information to my colleague, Edward C. Dimock.

[47] Laufer, *Sino-Iranica,* 540, 567.

[48] *Ibid.,* 565.

alone is seldom decisive. But my evidence is at once archaeological, botanical, historical, and philological; there is also geological and palynological evidence. In the light of various types of evidence presented above, the significant position held by the family of Gramineae in the pollen profile of Wu-ch'eng, Shansi, which chronologically covers the past million years, can have been substantially accounted for only by *Setaria* and *Panicum*. Indeed, ever since the beginning of agriculture the life of the inhabitants of the loess highland had been so dependent on millets that even the name of Hou Chi, the legendary ancestor of the Chou tribe, literally means the "God of Millets."

Sorghum was discovered in 1931 at a Yang-shao site in Ching-ts'un, southern Shansi, along with millets and various primitive agricultural implements. A Japanese botanist subsequently identified it as *Andropogon sorghum* var. *vulgaris,* or common sorghum, which in modern times is more widely grown in Manchuria and the low plains of North China than in the loess highland. In the 1950's traces of sorghum were found in southern Manchuria, Hopei, Lo-yang in western Honan, and northern Kiangsu. Chronologically these new finds of sorghum fall within the range of Shang-Chou and Former Han times, with the find in Ching-ts'un remaining the only prehistoric one.[49]

Outside of North China, the antiquity of this plant is mainly attested to by ancient wall paintings in Egypt.[50] Extensive research by British plant geneticists has firmly established the northeastern quadrant of Africa as the most important area of origin of sorghum.[51] That no sorghum has ever been found in any prehistoric site in the vast area between Egypt and North China seems to support Vavilov's view that sorghum may have originated in northeastern Africa and North China.[52]

According to modern experiments, among common cereal plants sorghum ranks second only to *S. italica* in "efficiency of transpiration."[53] That some varieties of sorghum are indigenous to semiarid North China is indeed to be expected. What is puzzling, however, is the entire lack of reference to sorghum in the Shang oracle and Chou bronze inscriptions and in any ancient Chinese literature written prior to A.D. 300. The total lack of reference to sorghum in early Chinese literature is partially accounted for no doubt by some confusion in the nomenclature of small-grain cereals, but also indicates the probability that those early indigenous varieties were not as satisfactory as later varieties introduced from abroad. Not until after the Mongol conquest did sorghum begin to be extensively grown in China.[54]

[49] Sorghum is discussed in detail in Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan*, 133–40.

[50] Alphonse DeCandolle, *Origin of Cultivated Plants* (New York, 1898), 381.

[51] H. Doggett, "The Development of the Cultivated Sorghums," in *Essays on Crop Plant Evolution*, ed. Sir Joseph Hutchinson (Cambridge, Eng., 1965), 50–69.

[52] Vavilov, *Origin, Variation, Immunity and Breeding of Cultivated Plants,* 21, 38.

[53] King, *Weeds of the World,* 180.

[54] Michael Hagerty, "Comments on Writings concerning Chinese Sorghum," *Harvard Journal of Asiatic Studies,* V (1940), 234–60; see also Ping-ti Ho, *Studies on the Population of China, 1368–1953* (Cambridge, Mass., 1959), 181–83.

Of the various Neolithic artifacts discovered in 1921 at the Yang-shao village and brought back to Sweden by J. G. Andersson for further study, no single finding can be more significant than the identification by two Swedish botanists of the imprints of cultivated rice *(Oryza sativa)* on a fragment of a pottery jar.[55] "The discovery was," in the words of Andersson, "in a high degree sensational not only because it sets back the history of rice an immense distance in time, but also because it points, not to dry Central Asia, but to rainy Southern Asia, which is the homeland of rice."[56] Although the name for the earliest known Chinese Neolithic culture is derived from the village of Yang-shao, the whole cultural assemblage discovered at this village is now generally believed to be of a much later type than that of Pan-p'o, which best represents the early Yang-shao stage. The approximate date of rice culture at the Yang-shao village is probably close to the dawning of Lungshoid cultures around 3000 B.C.

Finds of prehistoric rice in China after 1949 are exceptionally rich. While the rice discovered in 1921 at the Yang-shao village in western Honan has remained the only verified case of rice culture within the southeastern part of the loess highland, prehistoric rice has been found in nine more localities in the area south of the Huai River and in the central and lower Yangtze regions,[57] which lie outside the Neolithic nuclear area. Since typologically these newly discovered Neolithic cultures of the Huai River region and the central Yangtze represent a fairly long period of cultural transition from Yang-shao to Lung-shan, most of the rice finds should probably be dated somewhere around 3000 B.C., although the lower chronological boundary of the Liang-chu Neolithic culture of northern Chekiang may correspond to the first verified historic period of Shang. The unusually large quantities of rice husks found in the baked red clay in several Hupei sites belonging to the Ch'ü-chia-ling culture indicate the cultivation of rice on a considerable scale. At the Chu-chia-tsui site, Ching-shan County, Hupei Province, where similar evidence of large-scale rice cultivation is found, the cultural assemblage reveals an especially primitive character and therefore indicates an even greater antiquity of rice culture.[58] From existing evidence there is reason to believe that rice may have been cultivated first in the lower Han River area late in the fourth millennium B.C. before it was introduced into the Neolithic nuclear area.

Recent Chinese archaeological finds also raise serious doubt as to the general view held by botanical scientists that rice is indigenous only to Southern and Southeastern Asia and that rice was introduced from India into China; the opinion of Vavilov, which is widely accepted, is worth citing:

> Even though tropical India may stand second to China in the number of species [of cultivated plants], its *rice,* which was introduced into China, where it has been the

[55] G. Edman and E. Söderberg, "Auffindung von Reis in einer Tonscherte aus einer etwa fünftausendjährigen chinesischen Siedlung," *Bulletin of the Geological Society of China,* VIII (No. 4, 1929), 363–68.

[56] J. G. Andersson, *Children of the Yellow Earth* (London, 1934), 336.

[57] See Ho, *Huang-t'u yü Chung-kuo nung-yehti ch'i-yüan,* 140–45.

[58] For this earliest rice find in Hupei, see *Archaelogy* (No. 5, 1964), 215–19.

staple food plant for the past thousand years, makes tropical India even more important in world agriculture. That India is the native home of rice is borne out by the presence there of a number of wild rice species, as well as common rice, growing wild, as weeds, and possessing a character common to wild grasses, namely, shedding of the grain at maturity, which insures self-sowing. Here are also found intermediate forms connecting wild and cultivated rice. The varietal diversity of the cultivated rice of India is the richest in the world, the coarse-grained primitive varieties being especially typical. India differs from China and other secondary regions of cultivation in Asia by the prevalence of dominant genes in its rice varieties.[59]

The scientific reasons given by so eminent a botanist as Vavilov for regarding tropical India as the original home of rice merit respect. But historians must further investigate whether rice was indeed introduced into China from India; whether China, at least the area south of the natural geographic demarcation of Ch'in-ling and the Huai River, may not have been one of the original homes of rice; and whether there is sufficiently strong botanical and historical evidence for the existence of wild species of rice in China.

When the problem of rice culture is studied in the context of world history, what is most surprising is the fact that the existing Indian archaeological and written records all indicate a much later beginning of rice culture. Sir Mortimer Wheeler summarizes well the recent archaeological findings on rice in India:

Now rice-impressions have been recognized at the Harappan site of Lothal in Phase A, which on radio-carbon dating lasted until 1700 B.C. or somewhat later. At about the same time, rice appears in Periods II–IV on the little site of Navdatoli, far away on the central reaches of the Narbadā or Narmadā. Here radio-carbon analysis gives a date of 1660 B.C. $\pm$ 130 for a late level of Period II. In Period I, which seems not to have been very much earlier, wheat had been found, but not rice; so that, if the evidence is representative, rice was known in western India in the eighteenth century B.C., and in central India perhaps a century later. No earlier dates for the grain appear at present to be available anywhere.[60]

Our comparative archaeological data show that rice culture in China anticipated rice culture in India by at least a thousand years.

It is equally significant to note that the Rig-Veda, the earliest sacred book in Sanskrit compiled probably around 1000 B.C. or slightly earlier, never mentions rice, but often alludes to wheat and barley. The Sanskrit name for rice, *vrīhi,* appears only in the Atharva-Veda and other works written after 1000 B.C.[61] In contrast, the oracle records of the Shang and various works of the Chou periods all testify to rice culture and the brewing of rice wine, although throughout ancient times rice remained an "aristocrat" among cereal grains, consumed by the ruling class on ceremonial occasions only.

Twenty-three species of the swampy grasses of *Oryza* have been recognized

[59] Vavilov, *Origin, Variation, Immunity and Breeding of Cultivated Plants,* 29; his view is upheld fully in the long article on "Oryza" in *Wealth of India,* VII, esp. 115–16.

[60] Sir Mortimer Wheeler, *Civilizations of the Indus Valley and Beyond* (New York, 1966), 90. More rice finds, all of the Harappan (ca. 2150–1750 B.C.) and later periods, are reported in Bridget and Raymond Allchin's *The Birth of Indian Civilization* (Baltimore, 1968). The Allchins' lack of exact carbon datings of rice of the Harappan period makes it necessary for me to rely on Wheeler's datings.

[61] A. A. MacDonell and A. B. Keith, *Vedix Index of Names and Subjects* (London, 1912); Sir Monier Monier-Williams, *A Sanskrit-English Dictionary* (London, 1956).

taxonomically by scientists, and only two of the twenty-three have been domesticated. Of the domesticated species, *Oryza glaberrima* is strictly a regional crop confined to Western Africa, and only *O. sativa* has world-wide significance. The regions known to Western scientists where wild species of rice have been discovered are India, Indochina, Indonesia, Taiwan, Western Africa, Madagascar, Central and South America, and Australia.[62] Since the geographic distribution of wild species of rice is truly world wide and since climatically and phytogeographically the southern half of China, the world's largest single rice-producing area, has much in common with the rest of monsoon Asia, no generalization about the original homelands of rice is convincing without a thorough search of the historical and modern records of wild species of rice in China.

Not only is the nomenclature of Chinese rice highly complex but Chinese historical records on rice are the richest in the world. In addition to references to cultivated rice, records of Shang oracles significantly mention a wild species called *ni*.[63] *Shuo-wen-chieh-tzu,* the earliest systematic Chinese lexicon compiled shortly after A.D. 100, explains: "The kind of rice that ripens this year and will grow all by itself again next year is called *ni*." *Ni* is almost certainly the common *Oryza perennis,* which is believed by an increasing number of experts on rice to have been the probable progenitor of cultivated rice.[64]

The Chinese vocabulary was rapidly expanding from Shang to Han times. Because of different pronunciations in different regional dialects and because of the inevitable process of corruption of the original usage, by Han times four homonyms of *lü* and a character *li* had been derived from the original character *ni*.[65] *Huai-nan-tzu,* an eclectic work of the second century B.C. compiled by scholars employed by the Prince of Huai-nan, contains an important entry about the *li* wild rice: "*Li* ripens somewhat earlier than [cultivated] rice, but farmers treat it as a weed for fear that whatever small crop it might yield would be more than offset by the harm it might do to the main harvest [of cultivated rice]."[66] Kao Yu, who made systematic commentaries on this work around A.D. 205, explains that "the *li* [wild rice] usually grows alongside the [cultivated] rice." This passage from *Huai-nan-tzu* provides not only the rationale for destroying the wild perennial rice but also the best explanation as to why through conscious elimination the species of wild rice in ancient China had been reduced.

In all likelihood, the term *li* in ancient times might have been peculiar only

[62] *Wealth of India,* VII, *s.v.* "Oryza."

[63] Yü Hsing-wu, "Shang-tai ti ku-lei-tso-wu" [The Cereal Crops of Shang Times], *Journal of Humanistic Studies of the People's University of the Northeast* (No. 1, 1957), 101.

[64] *Wealth of India,* VII, 114–16.

[65] See Glossary, p. 35.

[66] *Huai-nan-tzu* [Works Compiled under the Auspices of the Prince of Huai-nan] (Ssu-pu-pei-yao ed.), Chap. xx, 18b; for the identification of the *li* wild perennial rice, see Tuan Yü-ts'ai, *Shuo-wen-chieh-tzu chu* [Commentaries on the Lexicon *Shuo-wen*] (Commercial Press ed.), Chap. VIIA, 87–88. The etymology and evolution of the terminology of the perennial wild rice are highly complex; the most systematic treatment of this subject is Liu Pao-nan, *Shih-ku* [Etymological Studies of Cereal Grains], in *Huang-Ch'ing ching-chieh hsü-pien* [Imperially Compiled Commentaries on Ancient Classics, 2d Ser.].

to the dialect of the area immediately south of the Huai. From Han times onward the common term for wild rice is *lü* in four variant forms. Though used at first as a noun to mean wild rice exclusively, *lü* acquired so many new meanings that it was soon employed as a general term for all kinds of wild cereal plants and also as an adjective or adverb describing the naturally wild state of any food plant. Because of the ever-broadening meaning of *lü,* I have excluded some fifteen entries culled from various dynastic histories in which the character *lü* was used in a general sense without a specific association with rice. It should be noted, however, that among these excluded entries some might well have actually referred to the occurrence of wild rice, especially when the recorded habitats of such *lü-sheng*

Table II
Post-Han Records on Wild Species of Rice[67]

Year (A. D.)	Place (Modern Names)	Essential Description
231	Chia-hsing (Chekiang)	Wild rice ripened naturally.
446	Chia-hsing	"Wild rices ripened naturally, being of more than thirty varieties."
537	Kiangsu (south of Huai)	In the ninth lunar month "wild rices had grown over an area of 200,000 mu (about 30,000 acres)."
537	Wu-hsing (Chekiang)	Wild rice ripened, much to the benefit of the local poor and hungry.
731	Yang-chou (Kiangsu)	In early spring wild rice ripened in an area of 21,000 mu, and perennial wild rices ripened in an area of 180,000 mu.
852	Kao-yu and T'ai-hsien (Kiangsu)	Poor people of the two counties procured "strange rice" by straining its grains in public rivers; they called it "divine rice."
874	Ts'ang-chou (Hopei)	Wild rice ripened in an area of more than 200,000 mu, much to the benefit of the poor of local and neighboring counties.
979	Su-hsien (Anhwei)	In the eighth lunar month wild rice ripened in lakes; harvest was gathered by the poor who called it "divine rice."
1010	Kung-an (Hupei)	In the second lunar month wild rice ripened, and people procured a harvest of four hundred bushels.
1013	4 counties of T'ai-chou (Kiangsu)	In the second lunar month "divine rice" ripened in various places in the four counties.
1023	Soochow (Kiangsu) and Chia-hsing (Chekiang)	"Divine rice" ripened in the sixth month in the lakes of these areas; harvests were gathered by the poor.

[67] For a complete listing of primary sources, see Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* 137–39.

(wildly grown) grains were marshes and edges of rivers and lakes south of the Huai River. For prudence I have eliminated all entries that are not precisely phrased and checked through various post-Han dynastic histories so that none of the entries presented in the above table can be construed as escapes from cultivation as a result of temporary abandonment of fields caused by wars or natural calamities.

The above entries probably represent only a very small fraction of the reports submitted to the imperial government by various provincial and local authorities. Concerning the frequency of reports on the appearance of wild rice in early Sung times, Ma Tuan-lin, the great encyclopedist of the late thirteenth century, said that they were so numerous that he could choose only a few for inclusion in his encyclopedia in the chapter on unusual plants.[68] The founder of the Ming dynasty, who reigned from 1368 to 1398, ordered that only natural calamities, but not auspicious natural phenomena, be regularly reported to the throne.[69] This regulation, which was observed by later rulers of the Ming and Ch'ing periods, caused the virtual disappearance of the mention of wild rice from all the central government's records. The continual dissemination of early-ripening and relatively drought-resistant rice since the beginning of the eleventh century, the endless process of breeding better strains of rice, and an increasingly labor-intensive system of rice culture during the past millennium have all contributed to a drastic decline in the incidence of wild rice in China.[70] Despite all this, the late E. D. Merrill found in the 1910's some wild species of rice in Kwangtung, and Chinese botanists have recently discovered more in Kwangtung, Kwangsi, and Yunnan.[71]

The entries of wild rice tabulated above deserve further analysis. The extents of the areas in which wild rice grew and ripened were so large as to rule out the possibility of accidental escape from cultivation. The places in which wild rice appeared—public and untitled lakes, rivers, and marshes—further show that the rice must have truly grown wild. Those kinds of wild rice that ripened in early spring were obviously different from cultivated rice that usually ripened in late summer and early fall. It is most interesting that the vulgar name of "divine rice" suggests not only its wild origin but also the likelihood that it might be *Oryza fatua,* a weed that some rice experts believe to have been the progenitor of cultivated rice. I. H. Burkill, an authority on the flora of Southern and Southeastern Asia, describes the peculiarities of *O. fatua:*

In the fields of south-western and western India, it [*O. fatua*] is exactly like the annual *O. sativa* in every respect except that it shatters at maturity. In the Gangetic

[68] *Wen-hsien t'ung-k'ao* [Historical Investigation on Government Institutions and Culture] (Commercial Press ed.), Chap. CCXCIX, 2367.

[69] *Ta-Ming hui-tien* [Collected Statutes of the Ming Dynasty] (1587 ed., Taipei photostat reproduction), Chap. CIII, 3b–4a.

[70] For details, see Ping-ti Ho, "Early-Ripening Rice in Chinese History," *Economic History Review,* 2d Ser., IX (Dec. 1956), 200–18.

[71] Recent reports of discoveries of wild species of rice in southern China are not available; a brief mention of these recent discoveries is given in Hsia Nai, "Ch'ang-chiang-liu-yü k'ao-ku wen-t'i" [Archaeological Problems of the Yangtze Area], *Archaeology* (No. 2, 1960).

plains it is seen in a different form, but still is just like *O. sativa* except for shattering. The poor do not ignore it, but tying the awns together before maturity save the grain for themselves, or they collect the fallen grain, which is made an easier process by the length of the awns.[72]

Had it not been for the fact that the "divine rice" shattered at maturity, the poor would not have had to collect the grains by straining through river and lake water. The records on wild species of rice in three thousand years of Chinese literature are impressive.

Of particular interest to plant geneticists is the fact that most of the varieties of rice recorded in Chinese literature prior to A.D. 1000 are of the *keng* subspecies, or *Oryza sativa japonica*.[73] The *keng* varieties are, in other words, usually confined to the temperate zone of Eastern Asia and characterized by their shorter and more rounded grains, as compared with grains of the tropical *Oryza sativa indica*. It is well known to geneticists that "the two groups differ in morphological and several physiological features including response to temperature and day length."[74] A preliminary morphological study of the prehistoric and ancient rice husks found in North China and the middle Yangtze Valley shows that they are of the *keng* subspecies. A leading Chinese expert on rice is of the opinion that "the *keng* varieties of [Neolithic] Hupei may have a certain pedigree relationship with those found in the Han tombs of Lo-yang and the Yellow River Valley, as well as with those discovered at the Yang-shao sites."[75]

In any case, our combined archaeological and historical data seem reasonably to have established China as one of the original homes of rice and as the first area in the world where rice was cultivated. When it is remembered that rice is the main food for more than half of humanity and that the temperate zone of Eastern Asia accounts for more than 60 per cent of the world's output, with China as the largest single producer, the contribution that China has made to world agriculture has been much greater than Vavilov and other botanical scientists realized. Whereas wheat has assumed an eminent position in the agriculture of the Western world only during the last 150 years, rice has supported a larger portion of the human race during the past millennium. China's contribution to world agriculture is therefore greater than that of Mesopotamia, which first supplied the world with wheat and barley.

Two problems about rice remain to be solved in the discussion on the origin of Chinese agriculture. First, while rice is generally a tropical and subtropical plant, archaeological evidence shows that it was cultivated in the semiarid loess highland. When a scientific identification of the rice found at a Yang-shao site at Liu-

[72] I. H. Burkill, *A Dictionary of the Economic Products of the Malay Peninsula* (2 vols., London, 1935), II, 1593.

[73] See Ho, "Early-Ripening Rice in Chinese History."

[74] *Wealth of India,* VII, 116.

[75] Ting Ying, "Chiang-Han-p'ing-yüan hsin-shih-ch'i-shih-tai hung-shao-t'u chung ti tao-ku-k'e k'ao-ch'a" [Notes on the Neolithic Rice Husks Unearthed in Hupei], *K'ao-ku hsüeh-pao* [*Archaeological Review*] (No. 4, 1959), 31–34; *Ching-shan Ch'ü-chia-ling* [Report on the Archaeological Site of Ch'ü-chia-ling, Ching-shan County] (Peking, 1965), Appendix, 78–80.

tzu-chen, Hua-hsien, Shensi, is made,[76] the early cultivation of rice in the loess highland will be even more firmly established. As has been pointed out, there have been marshes in both the highland and low plains of North China, largely for physiographical reasons. Besides water, the rice plant requires a fairly high range of temperature and long exposure to sunlight for growth and maturation. Because of the continental type of climate, the loess provinces have average temperatures of 24° to 26° C., or 75° to 79° F., in July and August; the average is actually considerably higher than a minimal average temperature of 20.5° C. required to bear a normal crop of rice in the temperate zone of Eastern Asia. Solar radiation is considerably stronger in North China than in the areas south of the Yangtze. Experiments in recent years show that the highest yield of rice per acre in China is not found in the southern provinces but in Shensi, the nuclear area.[77] Our knowledge of the summer climatic conditions of North China shows that there is actually nothing strange about the growing of rice in the marshes of North China in prehistoric and ancient times.

The second problem is whether rice culture in prehistoric times does not necessarily imply some form of irrigation. Indeed, some Chinese paleographers are so sure of the absence of irrigation before the sixth century B.C. and also of the dependence of rice on irrigation that they are reluctant to identify the character for rice in the inscriptions on Shang oracles. The truth is that primitive rice culture does not depend on irrigation, as two Western experts testify concerning Southeastern Asia:

> A dry-land crop like wheat requires some sort of tool for working the ground, though it be only a digging stick. For lowland rice no such tool is required. Even today there are localities [in Southeastern Asia] where the rice field is neither plowed, spaded, or hoed. The soil may be thoroughly puddled and all the weeds destroyed merely by driving a carabao around in the flooded field, or the farmer and his family may accomplish the same purpose by splashing around in bare feet.[78]

Chou Ch'ü-fei, a twelfth-century official, described primitive rice culture in southernmost China:

> Of all the boundless land that lies beyond what human eyes can reach, not 1 per cent of such land has been brought under cultivation. In preparing the fields for rice planting, the peasants choose only the kind of land that is evenly submerged under water all year round. If the land is a bit too high [to be submerged constantly], they would reject it. Even when they do cultivate, they would barely break up the ground without deep plowing or hoeing. They simply broadcast the [rice] seeds, never transplant the shoots. After the seeds are broadcast, they do not water the fields during drought; nor do they drain off [the surplus] water after excessive rain. Caring nothing about manuring, deep plowing, and weeding, they leave everything to heaven.[79]

[76] This preliminary report on the excavation at Liu-tzu-chen is in *Archaeology* (No. 2, 1959), 73.

[77] Chu K'e-chen, "Lun wo-kuo ch'i-hou ti chi-ke t'e-tien chi ch'i yü liang-shih-tso-wu sheng-ch'an ti kuan-hsi" [Some Characteristics of the Climate of China and Their Relationship to Agricultural Production], *Ti-li hsüeh-pao* [*Acta Geographica Sinica*], XXX (No. 1, 1964).

[78] V. D. Wichizer and M. K. Bennett, *The Rice Economy of Monsoon Asia* (Stanford, Calif., 1941), 14–15.

[79] Chou Ch'ü-fei, *Ling-wai tai-ta* [Answers to Queries on Southernmost China] (Ts'ung-shu-chi-ch'eng ed.), 36.

Chou's description of primitive rice culture in the twelfth century A.D. must have been true for the prehistoric method of growing rice. That rice seeds were broadcast in prehistoric times is almost certain, for not until after the time of Christ did the Chinese character *yang* (young rice shoot) begin to appear in *Shuo-wen,* and not until the second century A.D. was the method of transplanting young rice shoots from nursery beds to the main paddies described in a short agricultural treatise.[80] The technique of transplantation, which contributes so much to the increase of yield per acre, was undoubtedly a Chinese invention because even today in many parts of India transplantation of rice shoots is not practiced.

The addition of rice to the cropping system accentuated the Sinitic character of prehistoric and ancient Chinese agriculture.

Although records of Shang oracles contain the characters for wheat and barley, there has not been a single verified prehistoric find of wheat and barley in China. It is true that nearly a kilogram of carbonized wheat grains is reported to have been found in a Lung-shan site in northern Anhwei along the Huai River, but the fact that the grains are contained in a Chou-type pottery jar makes the preliminary dating of wheat highly suspect.[81]

The amount and quality of Western scientific and archaeological studies of wheat and barley make it unnecessary for historians of Chinese agriculture to examine the original habitats of these two food plants. North China must be excluded from the homelands of wheat and barley because they are indigenous to areas of winter rain, and North China offers a climatic and rainfall pattern that is the exact opposite of that of Southwestern Asia and the eastern Mediterranean. Even today wheat growing in many localities in North China is difficult without irrigation because of uneven distribution of rain and especially because of frequent spring droughts.[82]

In sharp contrast to the Chinese characters for other cereal plants which have the radical *ho* (cereal plant), the characters for wheat, *lai* and *mai,* and barley, *mou,* are all derived philologically from the character *lai,* which literally means "come" and which is used as a radical. Whereas the native origin of millets is vividly reflected in many ancient odes, those few odes that mention wheat and barley never fail to point out that they were bestowed on the people by the Supreme Ancestor, that is, God on High. Knowing that they were not native to North China but not knowing exactly where they had come from, the men of genius who created new characters could only regard these food plants as coming from God, hence the radical "come." Since the character for wheat is already found in records of Shang oracles but the character for barley first appears in *The Book of Odes,* wheat was introduced into North China some time before 1300 B.C., and

[80] The best edition of this agricultural treatise of the Later Han period is *Ssu-min yüeh-ling chiao-chu* [Modern Annotation on Monthly Ordinances for Four Groups of Commoners], ed. Shih Sheng-han (Peking, 1965).

[81] For details, see Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* 160–61.

[82] Chu, "Lun wo-kuo ch'i-hou ti chi-ke t'e-tien chi ch'i yü liang-shih-tso-wu sheng-ch'an ti kuan-hsi."

barley was introduced into the same area somewhat later. Wheat and barley are, therefore, cases that indicate some cultural contacts between North China and the Eurasian steppe during the latter half of the second millennium B.C.

For over a millennium after their introduction, wheat and barley do not seem to have made rapid progress in North China. Various late Chou and Han works testify to their better adaptability to the low plains, where rainfall is considerably heavier than that of the loess highland. The difficulty with which wheat and barley were adapted to the semiarid highland is fully reflected in a memorial by Tung Chung-shu, a leading scholar of the second century B.C., who, in addition to urging the Emperor to exhort the people of the loess highland to grow more wheat, testified that the people of the metropolitan Shensi area had been generally reluctant to grow wheat.[83]

It is worth noting that until the time of Christ wheat and barley had always been grown as dry-land crops in North China. The dry-land culture had been made possible only by the discovery through trial and error of certain special devices for saving soil moisture. Fragments of *Fan Sheng-chih shu,* a famous agricultural treatise of the first century B.C., give interesting information on the peculiarly Sinitic method of growing wheat and barley:

> If at the time of wheat planting the weather has been rainless and dry for some time, one is advised first to soak the wheat seeds in a thin starchy congee which, being slightly acidic [through fermentation], should be mixed with discharges of silkworms. [Wheat seeds] should be soaked at midnight and must be sown shortly before dawn, so that the congee and the ground dew will all go down into the soil.
>
> Amidst the autumn drought, [wheat] should be watered menially at the time when the mulberry sheds its leaves.
>
> In winter after the snow comes to an end, one should use a tool to press the snow into the ground and then have it duly covered, so that the snow will not be blown away by the wind. This process should be repeated after each snow.[84]

This work mentions for the first time the existence of spring wheat. Since spring wheat had been grown in the cooler foothill country of ancient Greece,[85] if not earlier elsewhere in Southwestern Asia, and since the Former Han Empire did have diplomatic and military contacts with the Greco-Bactrian states in Central Asia, spring wheat was almost certainly introduced into China not much earlier than the time of Christ.

Like rice, wheat was a luxury food in ancient China, consumed mainly by members of the ruling class on ceremonial occasions. What is really significant about wheat and barley in ancient China is that, despite their Southwestern Asian origin, they were not grown in China on irrigated fields, but were adapted to the typically northern Sinitic system of dry-land farming. This fact helps to

[83] *Han-shu* [History of the Former Han Dynasty] (Taipei photostat reproduction), Chap. XXIVA, 16a.

[84] The best modern edition is *Fan-Sheng-chih shu chin-shih* [Modern Commentaries on the Agricultural Treatise by Fan Sheng-chih], ed. Shih Sheng-han (Peking, 1956); the quotations are on page 20.

[85] Naum Jasny, *The Wheat of Classical Antiquity* (Baltimore, 1944), 70–71.

sharpen our perception that ancient Chinese agriculture had its peculiar regional traits and characteristics, developed independently from Mesopotamia.

An additional significant difference between the earliest Chinese and other ancient agricultural systems of the Old World is the conspicuous absence in the former of leguminous plants rich in protein. No trace of legumes has been found in any Neolithic site in North China or in records of Shang oracles. Not until Chou times did the soybean simultaneously appear in bronze inscriptions and *The Book of Odes.*

There is little doubt, however, that the soybean (*Glycine max* L. Merrill) is indigenous to China, for many varieties of semiwild (*Glycine gracilis* Skvortzow) and wild (*Glycine ussuriensis* Regel et Maack) soybeans exist in China today. The typical habitats of wild soybeans are wet lowlands and edges of rivers and lakes where the soybeans grow together with reeds. While, according to extensive field observations by two Chinese botanists, wild varieties of soybeans are found in many parts of China including the loess highland, they are concentrated mostly in the eastern provinces north of the Yangtze.[86] Despite the existence of wild soybeans in the loess highland in modern times, it is not known whether they have been native to that area since ancient times. Modern experiments do show that the soybean requires about three times as much water as does *S. italica* to produce the same amount of solid matter (excluding root) and that its "efficiency of transpiration" is the lowest among common food plants.[87] Botanists know that the soybean can adapt itself only to a narrow range of environmental conditions and usually requires a long growing season with a plentiful water supply. The natural environment of the loess highland apparently does not seem to have been congenial to this plant, at least not before suitable strains were developed by men. The absence of Leguminosae in the pollen profiles gathered from Wu-ch'eng and Li-shih in Shansi and from the Yang-shao site at Pan-p'o near Sian is significant.[88] On the other hand, pollen profiles gathered near Peking, whether of the middle and late Pleistocene epoch or of late prehistoric and early historic times, invariably contain Leguminosae.[89] All this, together with its geographic concentration in modern times in Manchuria and the eastern provinces of North China, seems to suggest that the soybean may not have been native to the semiarid loess highland; it may have been domesticated first in the low plains of North China.

The lateness of the domestication of the soybean is indirectly reflected in several

[86] Sun Hsing-tung and Keng Ch'ing-han, "Ta-tou p'in-chung ti fen-lei" [A Taxonomic Study of Soybeans], *Chih-wu-fen-lei hsüeh-pao* [*Acta Phytotaxonomica Sinica*], II (No. 1, 1959); for earlier observations on soybeans of Manchuria, see B. V. Skvortzow, "The Soybean—Wild and Cultivated in Eastern Asia," *Manchurian Research Society Publications,* Natural History Section, Ser. A (No. 2, 1927).

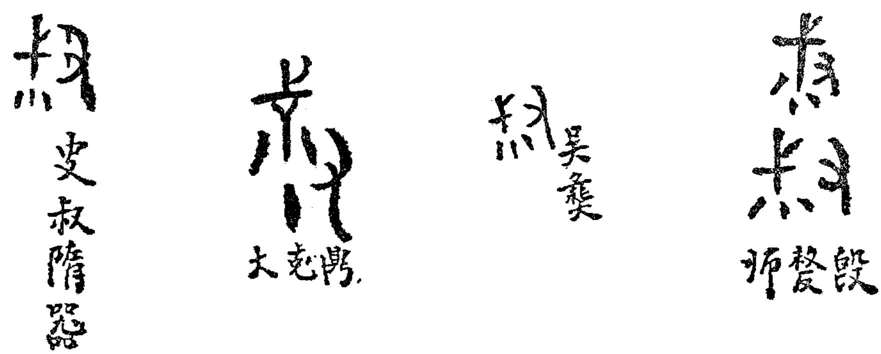
[87] King, *Weeds of the World,* 180.

[88] Chou *et al.,* "Shan-hsi Li-shih Wang-chia-kou Ch'en-chia-yai lao-huang-t'u mai-ts'ang-t'u-jang chung ti p'ao-fen chi chih-wu-ts'an-t'i"; Liu and Chang, "Chung-kuo ti huang-t'u"; Chou, "Hsi-an Pan-p'o hsin-shih-ch'i-shih-tai i-chih ti p'ao-fen fen-hsi."

[89] Hsü, "Chung-kuo-yüan-jen shih-tai ti Pei-ching ch'i-hou-huan-ching"; Sun, "Chou-k'ou-tien Chung-kuo-yüan-jen-hua-shih-ts'eng ti p'ao-tzu-hua-fen tsu-ho"; Liu *et al.,* "Yen-Shan nan-lu ni-t'an ti p'ao-fen tsu-ho."

physical-anthropological and historical phenomena. Judging from the human skeletons unearthed at the early Yang-shao site of Pan-p'o, most of the Yang-shao adults died young, between thirty and forty years of age. An unusually large portion of the skeletons of children further indicates possible serious malnutrition accounted for at least in part by the lack of staple food rich in protein.[90] Large numbers of animal bones and skeletons unearthed in An-yang, the last Shang capital, also reflect the dependence of the ruling class on meat as a source for protein and fat. Recent studies of early Chou artifacts in the Shensi area show the lingering importance of hunting and fishing tools at a time when agriculture based chiefly on millets was three millenniums old.[91]

The beginnings of the domestication of the soybean may never be exactly known except that the plant was probably first domesticated successfully in the eastern half of North China, probably not too much earlier than the eleventh century B.C. By Chou times the peculiar nitrogen-bearing nodules of the root of the soybean plant apparently had been well observed by peasants and by those learned men who enlarged the Chinese vocabulary. Unlike the early Chinese logographs for other cereal plants, which emphasize the stem and leaves, the emphasis of the new character *shu* (soybean) was on the nodules of its root. Since the numeral three symbolizes many, the three elongated dots at the lower left half of the character pictographically represent the root's bulging nodules caused by rhizobium.[92]



The effect of the domestication of the soybean on Chinese agriculture and on the nutrition of the ancient Chinese cannot be exaggerated. At long last, the Chou Chinese had found a food plant that, instead of causing soil exhaustion, actually helped greatly to preserve and enhance the fertility of the soil. The soybean supplied all classes of the population with cheaper and more abundant protein and also with an important source for oil, although the art of extracting oil was as yet

[90] *Hsin-Chung-kuo ti k'ao-ku shou-huo* [New China's Archaeological Accomplishments] (Peking, 1962), 11.

[91] *Ibid.*, 53.

[92] Hu Tao-ching, "Shih shu p'ien" [Discourse on the Character *Shu* (Soybean)], in *Chung-hua wen-shih lun-ts'ung* [Essays on Chinese Literature and History], 3d Ser. (Shanghai, 1963), 111–15.

unknown. Not until the soybean was domesticated did the ancient Chinese cropping system become well balanced. Once the benefits of the soybean became known, its subsequent dissemination was fairly rapid. The various works written or compiled during the fourth and third centuries B.C. usually mention the soybean and millets as the two most important sources of food. The unusually long time between the first domestication of millets and that of the soybean is yet another indication that the maturation of the ancient Chinese agricultural system was an outcome of prolonged trial and error.

Hemp and mulberry are the final plants to be discussed. Imprints of textiles on Yang-shao pottery have been repeatedly discovered, but a scientific identification of the fiber of such textiles cannot be done easily from imprints. Andersson suggests, probably quite rightly, that the fiber may be hemp (*Cannabis sativa* L.).[93] With his broad knowledge of phytogeography, Vavilov thought that North China might have been one of the original homes of hemp.[94] Modern research indicates that no fiber plant other than hemp could have been grown in North China in Yang-shao times, for the cotton shrub was introduced late in the thirteenth century A.D., and ramie is native to more southerly parts of China. The character for hemp is missing in both Shang oracle and Chou bronze inscriptions, but in *The Book of Odes* hemp appears seven times. It is well known that the ancient Chinese not only used hemp for its fiber but also consumed its seeds as auxiliary food.

Much more is known about mulberry *(Morus alba)* and several kinds of "wild mountain mulberries," one of which has been identified as *Broussonetia papyrifera* Vent.[95] Several pollen profiles gathered from the loess highland and the low plains contain mulberry. In 1927 a Chinese archaeologist made a sensational find at the Yang-shao site of Hsi-yin-ts'un, in southern Shansi, of one-half of a silk cocoon that had been artificially cut.[96] Remnants of textiles on some Shang bronzes have also been identified as fine silk.[97] Shang oracle inscriptions contain characters for mulberry, silk, and kinds of silk fabrics. If the two subspecies of *P. miliaceum, shu* and *chi,* are counted separately, then mulberry leads all the plants of *The Book of Odes* with twenty occurrences. The areas represented by the odes in which mulberry is mentioned show that mulberry was much more widely distributed in North China in ancient times than it is now. Unlike hemp, which was essentially the fiber for the common people, mulberry was grown exclusively for the production of silk for the ruling class.

To conclude this article, I will recapitulate certain salient aspects of the origin of Chinese agriculture. The southeastern part of the loess highland is an area of

[93] J. G. Andersson, "An Early Chinese Culture," *Bulletin of the Geological Survey of China* (No. 5, Pt. 1, 1923), 26.

[94] Vavilov, *Origin, Variation, Immunity and Breeding of Cultivated Plants,* 26.

[95] See Ho, *Huang-t'u yü Chung-kuo nung-yeh ti ch'i-yüan,* Table 3, pp. 42–55.

[96] Li Chi, *Hsi-yin-ts'un shih-ch'ien ti i-ts'un* [Prehistoric Remains of Hsi-yin Village] (Peking, 1927).

[97] Vivi Sylwan, "Silk from the Yin Dynasty," *Bulletin of the Museum of Far Eastern Antiquities* (No. 9, 1937), 119–26.

yellow earth par excellence. The many-sided scientific findings and ancient Chinese written records concur remarkably well in indicating that the homeland of the Yang-shao Chinese has always been a semiarid steppe, at least since the late Pleistocene epoch. The effect of this semiarid steppe environment surely imposed certain restrictions on its early inhabitants; the environment also offered them a narrow range of peculiar opportunities: the classic loessic soil of homogeneous, fine, and soft texture, which is not only reasonably fertile, but was amenable to primitive agricultural tools; the availability of a few kinds of exceptionally drought-resistant potential cereal plants that, hardened by a million years of relentless struggle for survival, would be fairly easy for primitive men of ingenuity to domesticate; and the concentration of a limited annual rainfall in summer, which was practically all that was needed by such few hardy food plants for growth and maturation. The Yang-shao Chinese made full use of these opportunities to lay the foundation of what may justifiably be called a typically Sinitic agricultural system.

This agricultural system was typically Sinitic because during the first four millenniums of its history it knew no irrigation and consisted almost exclusively of dry-land farming, except that nature took care of the rice in the marshes. It was thus fundamentally different from other major ancient agricultural systems of Mesopotamia, Egypt, and the Indus Valley, which were all based on the common triad of flood plains, primitive irrigation, and a cropping system with wheat and barley as a core.

The autochthonous character of ancient Chinese agriculture becomes even more obvious after a detailed study of the origin of each of its major crops. Going through the list of major food and fiber crops, such as the *Setaria* and *Panicum* species of millets, sorghum, rice, the soybean, hemp, and mulberry, one cannot fail to be impressed by the fact that it was with these indigenous plants that the Chinese from Yang-shao times created and enriched their agriculture. A major exception is, of course, wheat and barley, which are likely to have been introduced into North China directly or indirectly from Southwestern Asia, probably not much earlier than the emergence of the higher Shang culture. But their introduction was too late to have any important impact on the established pattern of the Sinitic system of dry-land farming, which was already about three thousand years old. No proof of the strength and stubbornness of the Sinitic system of farming can be more eloquent than the fact that the ancient Chinese, instead of slavishly adopting the entire complex of wheat and barley culture of Southwestern Asia based on flood plains and irrigation, resolutely grew these grains as dry-land crops. This fact further sharpens our perception that ancient Chinese agriculture, with such a distinct and deep-rooted regional trait-complex, can only have been developed independently of Mesopotamia, the ancestral hearth of most of the major ancient agricultural systems of the Old World.

My over-all conclusion of an indigenous origin of Chinese agriculture would have raised the eyebrows of most archaeologists and ancient historians of the past generation who practically toook for granted that anything worthy of the name of agriculture or civilization in the Old World must have originated from the single oldest hearth. Even some leading botanical scientists, wary of the risk of theoretical speculation and concerned with concrete regional scientific evidence, were inclined to believe that, while agriculture in the New World is unquestionably of independent origin, the limits of prehistoric diffusion of agricultural crops and knowledge could only have been hemispherical.[98] As archaeology has benefited increasingly from the natural sciences, a few archaeologists have become less certain of the validity of the theory of monogenesis of agriculture in the Old World. What Robert J. Braidwood said in 1960 was prophetic:

> The first successful experiment in food production took place in southwestern Asia, on the hilly flanks of the "fertile crescent." Later experiments in agriculture occurred (possibly independently) in China and (certainly independently) in the New World. The multiple occurrence of the agricultural revolution suggests that it was a highly probable outcome of the prior cultural evolution of mankind and a peculiar combination of environmental circumstances. It is in the record of culture, therefore, that the origin of agriculture must be sought.[99]

While it is obviously beyond the scope of this article to examine all "the records of culture" of pre-Yang-shao and Yang-shao China, it has discussed the "peculiar combination of environmental circumstances" as a prelude to more detailed analysis of the main characteristics of ancient Sinitic agriculture.

The outcome of the recent intensive multidisciplinary study of Meso-American archaeology clearly indicates "the multiple origins of agriculture in Mesoamerica," a finding that "may signal a revolution in our thinking about the development of culture and the rise of civilization everywhere."[100] It is hoped that this paper may be useful not only to students of Chinese history and culture but to theorists of the origins of civilizations as well.

POSTSCRIPT

Soon after the completion of this article two anthropologists brought to my attention two preliminary reports on evidence of early domestication of plants discovered by the University of Hawaii-Thailand Archaeological Salvage Program at Spirit Cave, sixty kilometers north of Mae Hongson in northwestern Thailand near the Burmese border. Although radiocarbon datings for domesticated plant material given in these two reports do not agree with each other, being respectively 7000 and 8000 B.C., even the later dating is as early as the beginnings of wheat and barley culture on the hilly flanks of the Fertile Crescent of Mesopotamia. Chester F. Gorman, the discoverer of the Spirit Cave site, reports:

98 Merrill, "Plants and Civilizations," 439.

99 Robert J. Braidwood, "The Agricultural Revolution," *Scientific American*, CCIII (Sept. 1960), 131. Shortly after 5000 B.C. wheat and barley were moved from the foothills to the flood plains of the Tigris and Euphrates, where irrigation began.

100 MacNeish, "Mesoamerican Archaeology," 324–28.

In addition to the lithic and faunal material a number of botanical macro-fossils have been tentatively identified from Cultural Level I. Layer 4: Species of *Prunus* (almond), *Terminalia, Areca* (betel), *Vicia* (bean) or *Phaseolus* (bean), *Pisum* (pea) or *Raphia, Lagenaria* (bottle gourd), and *Trapa* (Chinese water chestnut). Layer 4/3 interface: *Piper* (pepper tree), *Madhuca* (butternut), *Canarium, Aleurites* (candlenut), and *Areca.* Layer 3: *Canarium, Lagenaria,* and *Cucumis* (cucumber). Layer 2: *Piper, Areca,* and *Canarium*

The pattern of plant consumption indicated by these remains and the ethnographic information on use of such plants in modern indigenous contexts for the area is one of exploitation of wild or tended nuts for food, butternut *(Madhuca), Canarium,* and *Terminalia;* for lighting and possibly consumption, candlenut *(Aleurites);* pepper *(Piper)* as a condiment; and the betel nut *(Areca)* as a stimulant. The use of the bottle gourd *(Legenaria)* and *Cucumis,* a cucumber type, with Chinese water chestnut *(Trapa),* the leguminous beans *(Phaseolus, Vicia),* and possibly the pea *(Pisum),* however, form a group of food plants which suggests economic development beyond simple food-gathering. The leguminous plants in particular point to a very early use of domesticated plants.[101]

Wilhelm G. Solheim, director of the program, is reported to have made the following remarks: "This points to Southeast Asia as the area for the origin of agriculture and shows it to be very much more important than anyone has thought. This will change history and may embarrass China by indicating [that] she was not the first to develop agriculture in the Far East."[102]

The above reports and claims, however, cannot be fully accepted without further inquiry. Jack R. Harlan, professor of plant genetics of the Crop Evolution Laboratory of the University of Illinois, has kindly allowed me to use his comments which will later appear in a scientific journal:

From the point of view of the plant specialists there are two points that need to be answered. First the identification, in some cases, appears suspect. If the material was really well preserved one could surely tell a pea from a palm and *Vicia* from *Phaseolus.* The other problem is a strange association of tropical plants with cool-temperate plants adapted to Mediterranean climates *(Pisum* and *Vicia).* The almond also seems out of place along with very tropical species such as *Areca* and *Aleurites.* I do not know of a large-seeded *Phaseolus* in that part of the world, but the material might have been *Dolichos* (?). The pea-palm suggests the material was an unidentified round seed, but perhaps not much more could be said than that.

The case of cultivated plants is based primarily on the leguminous grains and these are the most suspect of the identifications.

For a proper understanding of the problem of agricultural origins in the entire Far East, one has to differentiate two types of agriculture and to grasp the fundamental difference in natural environment between China's loess area and monsoon East Asia. The loess area of China, where cereal farming began, is characterized by a harsh and semiarid climate and sparsity of natural vegetation. Monsoon East Asia, which includes China south of the Yangtze and the South-

[101] Chester F. Gorman, "Hoabinhian: A Pebble-Tool Complex with Early Plant Associations in Southeast Asia," *Science,* CLXIII (Feb. 14, 1969).

[102] "Origin of Agriculture Seen in Southeast Asia," *Asian Student,* XVII (Mar. 29, 1969). The latter is not an article by Solheim but merely a report that cites some of his remarks.

east Asian mainland and archipelagoes,[103] is an area with a year-round warm climate and extremely rich plant resources. That monsoon East Asia may have given rise to an early phase of more intensive plant-food collecting or even of protohorticulture, based mainly on fruits, nuts, and root crops, is indeed to be expected. The implications of a recent palynological study of Taiwan sponsored by Yale University indicate the possibility of rather early protohorticultural activities on this subtropical island.[104]

But protohorticulture and horticulture cannot be equated with agriculture. The most important type of agriculture is the one based on cereal grains. Although anthropologists are able to name certain minor sophisticated cultures that have little concern with cereal agriculture, virtually all of what historians consider to be major early civilizations, such as those of Mesopotamia, Egypt, the Indus Valley, and North China, were invariably based on cereal agriculture. In so far as grain-centered agriculture of the Far East is concerned, our aggregate evidence clearly indicates that it made its debut in the southeastern part of the loess highland of China. While in very early times protohorticulture and horticulture in the southern half of China may have been partially developed *in situ* and partially enriched by cultural influx from Southeast Asia, what is truly instructive is that monsoon China had remained economically and culturally much more backward than North China down to Former Han times. The Grand Historian Ssu-ma Ch'ien described the regions south of the Yangtze and the Huai River—monsoon China—as of the late second century B.C.:

> [People there] are able to gather all the fruit, berries, univalve and bivalve shellfish they want without waiting for merchants to come around selling them. Since the land is so rich in edible products, there is no fear of famine, and therefore the people are content to live along from day to day; they do not lay away stores of goods, and many of them are poor. As a result, in the region south of the Yangtze and Huai rivers no one ever freezes or starves to death, but on the other hand there are no very wealthy families.[105]

In conclusion, there is nothing definite as yet in the Spirit Cave finds that really challenges the loess area of China as the first in the entire Far East to develop ordinary field agriculture. What this article has demonstrated still remains valid: Old World field agriculture based on grains arose from two widely separated hearths—Mesopotamia and the loess area of China.

GLOSSARY OF SOME ANCIENT CHINESE PLANT NAMES

chi (Panicum miliaceum) 稷

[103] The Anthropology Division of the Eleventh Pacific Science Congress held in Tokyo in August–September 1966 approved the recommendation that East Asia south of the Yangtze and Taiwan be included, for purposes of scientific research, in the term "Southeast Asia." (See Wilhelm G. Solheim, "Southeast Asia and the West," *Science,* CLVII [Aug. 25, 1967], 896–902.)

[104] Chang, *Archaeology of Ancient China,* 82–83.

[105] *Records of the Grand Historian of China, Translated from the Shih Chi of Ssu-ma Ch'ien* by Burton Watson, II (New York, 1961), 490.

ho (cereal plants in general; also a radical of characters for most cereal plants)	禾
keng (*Oryza sativa* subsp. *japonica*)	秔.稉
lai ("come"; wheat; also a radical for wheat and barley)	來
lai (Chenopodiaceae; also fallow land)	萊
li (*Oryza perennis*)	離
lü (*Oryza perennis;* but also all kinds of wildly grown cereals)	穭.稆.梠.旅
mai (wheat)	麥
mou (barley)	牟.麰
ni (*Oryza perennis*)	秜
shu (*Panicum miliaceum*)	黍
shu (soybean)	菽
shu-shu (*Panicum miliaceum glutinosa*)	黍秫

su (Setaria italica) 粟

ts'ao-lai ("grasses and Chenopodiaceae"; often as a general term for weeds) 草 萊

yang (young rice shoots) 秧

The following are ten varietal names of *Artemisia* recorded in *The Book of Odes,* but not mentioned in the text of this article:

ai 艾

ch'in 芩

fan 蘩

hao 蒿

hsiao 蕭

lü 蔞

ô 莪

p'eng 蓬

p'ing 苹

wei 蔚

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[Footnotes]

[1] **Plants and Civilizations**
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[101] **Hoabinhian: A Pebble-Tool Complex with Early Plant Associations in Southeast Asia**

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