4. M. Eigen and L. De Maeyer, *Proc. Roy. Soc. London Ser. A* **247**, 505 (1958).
5. K. Fridborg, K. K. Kannan, A. Liljas, B. Lundin, B. Strandberg, S. Strandberg, B. Tilander, G. Wiren, *J. Mol. Biol.* **25**, 505 (1967).
6. E. L. Smith, *Fed. Proc.* **8**, 581 (1949); R. P. Davis, *J. Amer. Chem. Soc.* **80**, 5209 (1958).
7. J. C. Kernohan, *Biochem. Biophys. Acta* **81**, 346 (1964); ——, *ibid.* **96**, 304 (1965); B. H. Gibbons and J. T. Edsall, *J. Biol. Chem.* **238**, 3501 (1963); C. Ho and J. M. Sturtevant, *ibid.* **238**, 3499 (1963); S. Lindskog, *Biochemistry* **5**, 2641 (1966).
8. J. E. Coleman, *J. Biol. Chem.* **242**, 5212 (1967).
9. R. F. Chen and J. C. Kernohan, *ibid.*, p. 5813; L. Stryer, private communication (1967).
10. F. Schneider and M. Lieflander, *Z. Physiol. Chem.* **334**, 279 (1963); Y. Pocker and J. T. Stone, *J. Amer. Chem. Soc.* **87**, 5497 (1965); Y. Pocker and J. E. Meany, *ibid.*, p. 1809; ——, *Biochemistry* **4**, 2535 (1965); ——, *ibid.* **6**, 239 (1967); Y. Pocker and D. R. Storm, *ibid.* **7**, 1202 (1968).
11. M. L. Bender, *J. Amer. Chem. Soc.* **84**, 2580 (1962); —— and F. Kezdy, *ibid.* **86**, 3704 (1964). The idea of an acyl-enzyme intermediate was first suggested by H. Gutfreund and J. M. Sturtevant [*Proc. Nat. Acad. Sci. U.S.* **42**, 719 (1956).
12. N. K. Schaffer, L. Simet, S. Harshman, R. R. Engle, R. W. Drisko, *J. Biol. Chem.* **225**, 197 (1957); R. A. Oosterbaan and M. E. Adrichem, *Biochim. Biophys. Acta* **27**, 423 (1958); B. S. Hartley, *Nature* **201**, 1284 (1964).
13. H. Gutfreund and J. M. Sturtevant, *Proc. Nat. Acad. Sci. U.S.* **42**, 719 (1956).
14. B. W. Matthews, P. B. Sigler, R. Henderson, D. M. Blow, *Nature* **214**, 652 (1967).
15. A. Himoe and G. P. Hess, *Biochem. Biophys. Res. Commun.* **23**, 234 (1966); M. L. Bender, M. J. Gibbian, D. J. Whelan, *Proc. Nat. Acad. Sci. U.S.* **56**, 833 (1966).
16. T. Inagami, S. S. York, A. Patchornik, *J. Amer. Chem. Soc.* **87**, 126 (1965).
17. J. H. Wang and L. Parker, *Proc. Nat. Acad. Sci. U.S.* **58**, 2451 (1967).
18. M. Eigen, L. De Maeyer, H. C. Spatz, *Ber. Bunsengesellschaft* **68**, 19 (1964).
19. L. Parker and J. H. Wang, *J. Biol. Chem.*, **243**, 3729 (1968).
20. H. F. Bundy and C. L. Moore, *Biochemistry* **5**, 808 (1966).
21. M. Bergmann and J. S. Fruton, *Advan. Enzymol.* **1**, 63 (1941).
22. H. Gutfreund, *Trans. Faraday Soc.* **51**, 441 (1955).
23. L. Polgar and M. L. Bender, *J. Amer. Chem. Soc* **88**, 3153 (1966); K. E. Neet and D. E. Koshland, Jr., *Proc. Nat. Acad. Sci. U.S.* **56**, 1606 (1966).
24. G. Kartha, J. Bello, D. Harker, *Nature* **213**, 862 (1967).
25. H. W. Wyckoff, K. D. Hardman, N. M. Allewell, T. Inagami, D. Tsernoglu, L. N. Johnson, F. M. Richards, *J. Biol. Chem.* **242**, 3984 (1967). I thank Dr. H. W. Wyckoff for showing me the intricate structure of their ribonuclease model.
26. C. H. W. Hirs, S. Moore, W. H. Stein, *J. Biol. Chem.* **235**, 633 (1960); D. G. Smyth, W. H. Stein, S. Moore, *ibid.* **238**, 227 (1963); J. T. Potts, D. M. Young, C. B. Anfinsen, *ibid.*, p. 2593.
27. H. A. Scheraga and J. A. Rupley, *Advan. Enzymol.* **24**, 161 (1962); A. M. Crestfield, W. H. Stein, S. Moore, *J. Biol. Chem.* **238**, 2421 (1963).
28. A. Deavin, A. P. Mathias, B. R. Rabin, *Nature* **211**, 252 (1966); E. N. Ramsden and K. J. Laidler, *Can. J. Chem.* **44**, 2597 (1966); G. Gassen and H. Witzel, *European J. Biochem.* **1**, 36 (1967); D. G. Oakenfull, D. I. Richardson, Jr., D. A. Usher, *J. Amer. Chem. Soc.* **89**, 5491 (1967).
29. E. A. Dennis and F. H. Westheimer, *J. Amer. Chem. Soc.* **88**, 3431 (1966); ——, *ibid.*, p. 3432; R. Kluger, F. Kerst, D. G. Lee, E. A. Dennis, F. H. Westheimer, *ibid.* **89**, 3918 (1967). I thank Dr. D. A. Usher of Cornell and Dr. M. Caplow of Yale for calling my attention to this work.
30. H. Sund and H. Theorell, *Enzymes* **7**, 25 (1963); H. Sund, H. Diekmann, K. Wallenfels, *Advan. Enzymol.* **26**, 115 (1964); J. S. McKinley-McKee, *Progr. Biophys.* **14**, 223 (1964).
31. B. Vennesland and F. H. Westheimer, in *The Mechanism of Enzyme Action*, W. D. McElroy and B. Glass, Eds. (Johns Hopkins Press, Baltimore, 1954), p. 357.
32. E. M. Kosower, in *The Enzymes* (Academic Press, New York, 1960), vol. 3, pp. 171–194.
33. D. P. Hollis, *Biochemistry* **6**, 2080 (1967).
34. J. Wyman, *Advan. Protein Chem.* **4**, 436 (1948).
35. J. H. Park, B. P. Meriwether, P. Clodfelder, L. W. Cunningham, *J. Biol. Chem.* **236**, 136 (1961).
36. R. N. Perham and J. I. Harris, *J. Mol. Biol.* **7**, 316 (1963); J. I. Harris, B. P. Meriwether, J. H. Park, *Nature* **198**, 154 (1963); L. Cunningham and A. M. Schepman, *Biochim. Biophys. Acta* **73**, 406 (1963).
37. E. Fischer, *Ber. Deut. Chem. Ges.* **27**, 2985 (1894).
38. C. G. Swain and J. F. Brown, Jr., *J. Amer. Chem. Soc.* **74**, 2538 (1952).
39. Some of the experimental work mentioned in this article has been supported in part by a research grant (GM 04483 from the U.S. Public Health Service.

Natural Environment of Early Food Production North of Mesopotamia

Climatic change 11,000 years ago may have set the stage for primitive farming in the Zagros Mountains.

H. E. Wright, Jr.

In recent years the pace and detail of archeological exploration in the Near East have been so great that the chronology and locale of domestication of plants and animals are becoming fairly well established. At the same time, from paleoecological studies we are learning more about the evironmental changes during this critical period in man's cultural evolution. A major factor in both these developments is the growing inventory of radiocarbon dates, without which the necessary refinement of the chronology would be impossible. With this increased body of facts and carefully controlled inferences, the question of climatic determinism—the effects of climatic change on cultural development—deserves reexamination.

Cultural Sequence

A compilation of radiocarbon dates from Near Eastern prehistoric sites (*1*) provides a useful chronological listing of the cultural stages of the transitional period from food-collecting to food-producing (Table 1), and other summaries discuss the regional developments (*2*).

Before the phase of terminal food-collecting, cultural evolution was slow, and the radiocarbon chronology is less well established. The Zarzian stage of terminal food-collecting was preceded by the Baradostian, comparable in general technological level to the earlier part of the Upper Paleolithic of Europe. The Baradostian at Shanidar Cave in the Zagros Mountains of northeastern Iraq (Fig. 1) dates from 26,500 to > 34,000 years old, and Solecki (*3*) reports a stratigraphic unconformity between this level and the Zarzian level above—supposedly resulting from absence of occupation of the site for at least 15,000 years. However, more recent work in nearby Iran by Howe at Warwasi and by Smith at Ghar-i-Kar suggests that the Zarzian developed directly out of the Baradostian without any cultural hiatus (*4*).

The types of subsistence can be partially reconstructed from artifact types and from the remains of plants

The author is professor in the department of geology and geophysics and the department of ecology and behavioral biology, and is director of the Limnological Research Center of the University of Minnesota, Minneapolis.

and animals at these sites. The Baradostian people apparently relied primarily on wild game—largely sheep and goat at Shanidar—as had the Mousterians before them (*5*). Although the Zarzians, who followed, possessed a more complex suite of microlithic artifacts, they also relied primarily on game animals. The occurrence of obsidian artifacts at several Zarzian sites indicates travel to the Lake Van area 200 kilometers across the mountains in eastern Turkey, the nearest source of obsidian, a valuable raw material for microlithic tools. The importance of these movements in post-Zarzian times cannot be overemphasized, for they may have been a prime factor in the development of seasonal migrations and in transfer of early plant domesticates within the region and beyond it—true marks of domestication that survive today in the region (*6*).

Most of the Zarzian and earlier sites are in caves, although certainly the hunters must have lived in the open air much of the time. During the subsequent stage of incipient food production, however, open living sites are characteristic (*7*). At Zawi Chemi Shanidar the large number of grinding tools indicates extensive use of plant foods, but there is no positive evidence of plant domestication or, in fact, of plant-collecting. Sheep was a more important food source than goat, and the relatively high proportion of immature specimens has implied to Perkins that sheep was domesticated (*5, 8*).

The next stage, termed the stage of established food production, had permanent open sites with house architecture, domesticated wheat and barley, domesticated goat, sheep, pig, and dog, artifacts for cutting and grinding grain, ground-stone artifacts, well-formed figurines, and other amenities of a stable agricultural village. Most of the sites of this stage are in the modern "natural area" of cereal grains and of domesticable animals, although at Ali Kosh on the Mesopotamian piedmont steppe neither the terrain nor the climate is suitable for wild forms of these plants and animals (except barley), which implies that they had been introduced into the areas as domesticates, unless climatic conditions differed at that time (*9*).

Thus, the cultural sequence indicates a hunting economy of people living primarily in caves and rock shelters until about 11,000 years ago, and then a trend toward open settlements with incipient food production until about 9000 years ago, when permanent villages and a variety of domestic plants and animals had been established. How does this chronology compare with the climatic and paleoecologic sequence?

Table 1. Summary of cultural and vegetational sequences in the mountains north of Mesopotamia. Intermediate cultural stages may occur.

Representative sites	Cultural stages	Radiocarbon years ago		Zeribar pollen zones	Vegetation
			5,500	C	Oak woodland
Jarmo, Sarab, basal Ali Kosh, Cayönü	Earliest established food production	9,000		B	Oak-pistachio savanna
Karim, Shair, Asiab, Zawi Chemi Shandar, Shanidar B-1, Ganj-i-Dareh	Incipient food production	11,000	11,000		
Zarzi, Palegawri, Shanidar B-2, Warawasi Ghar-i-kar	Terminal food-collecting (Zarzian)	12,000	14,000	A-2	Steppe
Shanidar C	Food-collecting (Baradostian)	26,500 to > 34,000		A-1	
Shanidar D	Food-gathering (Moustenian)	> 40,000	> 40,000		

Environmental Sequence

In general, paleoclimatic materials of importance in the region fall into three categories — glacial fluctuations, zoological evidence, and paleolimnology—and each tells a different type of story about the environmental history for the time range in question.

Glaciers occupied the high parts of the Zagros Mountains in the Pleistocene. In fact, moraines and cirques occur at such low levels that the snowline must have been as low as 1500 to 2100 meters, or 1200 to 1800 meters lower than today. The climate therefore was much colder (*10*). Unfortunately the lack of organic material in glacial deposits means that the sequence of ice recession in the Zagros cannot be dated by radiocarbon analysis, but if analogy is made with the glaciers of the European Alps, which may have started their retreat by 18,000 years ago, the Kurdish glaciers were probably well up in the mountains by 11,000 years ago. If this correlation is correct, the climate of the Zagros Mountains was already warm by 11,000 years ago, and thus environmental change could not have been the major cause for plant and animal domestication (*11*). It was also argued that even if climatic change were still in progress 11,000 years ago it would result merely in shifting of the vegetation belts up the mountains, so that man could easily follow these belts to retain the natural environment he preferred.

The zoological evidence comes entirely from bones of game animals recovered from archeological sites. Although these provide valuable information about diet and the progress of domestication, they have proven less useful for climatic and environmental interpretations.

First of all, the distribution and habitat preferences of wild game in the region today, to the extent that they are known, may not accurately reflect the conditions of the recent past, because of severe hunting pressures with firearms in modern times and the virtual removal of natural predators. In any case, the distribution of Zagros wild game depends more on the varied habitats provided by diverse topography and landforms than on the general climate or vegetation (*12*). Finally, some of the bones found at these archeological sites may be of animals hunted high in the mountains or far away in the lowlands, so their presence at particular sites may not indicate the nature of the past local environment.

Presumably because of these factors, the faunas recovered from the Pleistocene levels (Mousterian and Baradostian) at Shanidar are essentially the same as those for the Zarzian and subsequent levels, including the modern (*5, 13*). The Zarzian fauna at Palegawra is also similar (*14*).

An explanation for this similarity may come from the possibility that the Baradostian there predates 26,500 years ago and the Zarzian postdates

12,000 years ago, with a stratigraphic hiatus between, marking a time when the cave was unoccupied. This hiatus, if it exists, spans the time of maximum glaciation, at least in western Europe. Perhaps the preceding millennia had a milder climate, like today's, so that the fauna was the same. Archeological finds, however, suggest that in most localities no cultural hiatus existed between Baradostian and Zarzian. Furthermore, paleolimnological evidence indicates no major climatic and environmental changes between 40,000 and 12,000 years ago.

Lake sediments provide a record of climatic change that has the advantage of continuity, good chronologic control, and freedom from direct cultural interference. Its most informative component is the pollen sequence, which reveals the history of the regional vegetation. The Zagros Mountains today have a simple altitudinal zonation of vegetation belts. Below about 600 meters is a warm steppe. Between 600 and 2000 meters is oak woodland, now much modified by cutting and grazing, covering a belt about 50 to 100 kilometers broad (Fig. 1). At higher elevations, and to the north on the Iranian and Anatolian Plateaus, is a cool steppe characterized by *Artemisia* (sage).

Pollen sequences are known from three localities in the Zagros Mountains. In the Kermanshah Valley (elevation, 1300 meters), at the inner (northern) edge of the oak woodland, are two spring-marsh sites with sediments from 28,000 to more than 40,000 years old, with a pollen assemblage marked by high values of *Artemisia* and chenopods and less than 2 percent oak (*15*). The same assemblage occurs in pollen zone A-1 (Fig. 2), dated 23,000 to 14,000 years ago, at Lake Zeribar (elevation, 1400 meters) in the middle of the oak woodland (*16, 17*). This assemblage is similar to those of modern surface samples collected from the steppe of the Iranian and Anatolian Plateaus (*18*). These and other surface samples, taken from a transect from the plateau across the Zagros Mountains to the Mesopotamian steppe, show that oak-pollen values as low as 2 percent are found only in areas more than 75 kilometers from the oak woodland (*18*). Because the mountains of the Zeribar-Kermanshah area are only about 75 kilometers broad, oak must have been absent from the mountains in this region between 40,000 and 14,000 years ago. A cool steppe similar to that of the higher parts of the Iranian Plateau must have prevailed during this interval in the region of the present oak woodland. This evidence vitiates the hypothesis from the Shanidar fauna that the climate for the Baradostians 26,500 to 12,000 years ago was similar to today's.

It might be postulated that the oak woodland was depressed at this time to the Mesopotamian piedmont or even to the lowland. But a third site, Lake Mirabad, at an elevation of 800 meters near the base of the mountains and the oak woodland, shows pollen curves (Fig. 3) essentially similar to those for Lake Zeribar, at least down to the base of the sediments 10,400 years old (*17*). Because of this similarity, the piedmont was probably also treeless before 14,000 years ago. The oak may have had its main Pleistocene distribution as far away as the Mediterranean littoral. The dominance of *Artemisia* pollen in Pleistocene sediments even in Macedonia as late as 12,600 years ago supports the view that much of the eastern Mediterranean had a late-Pleistocene

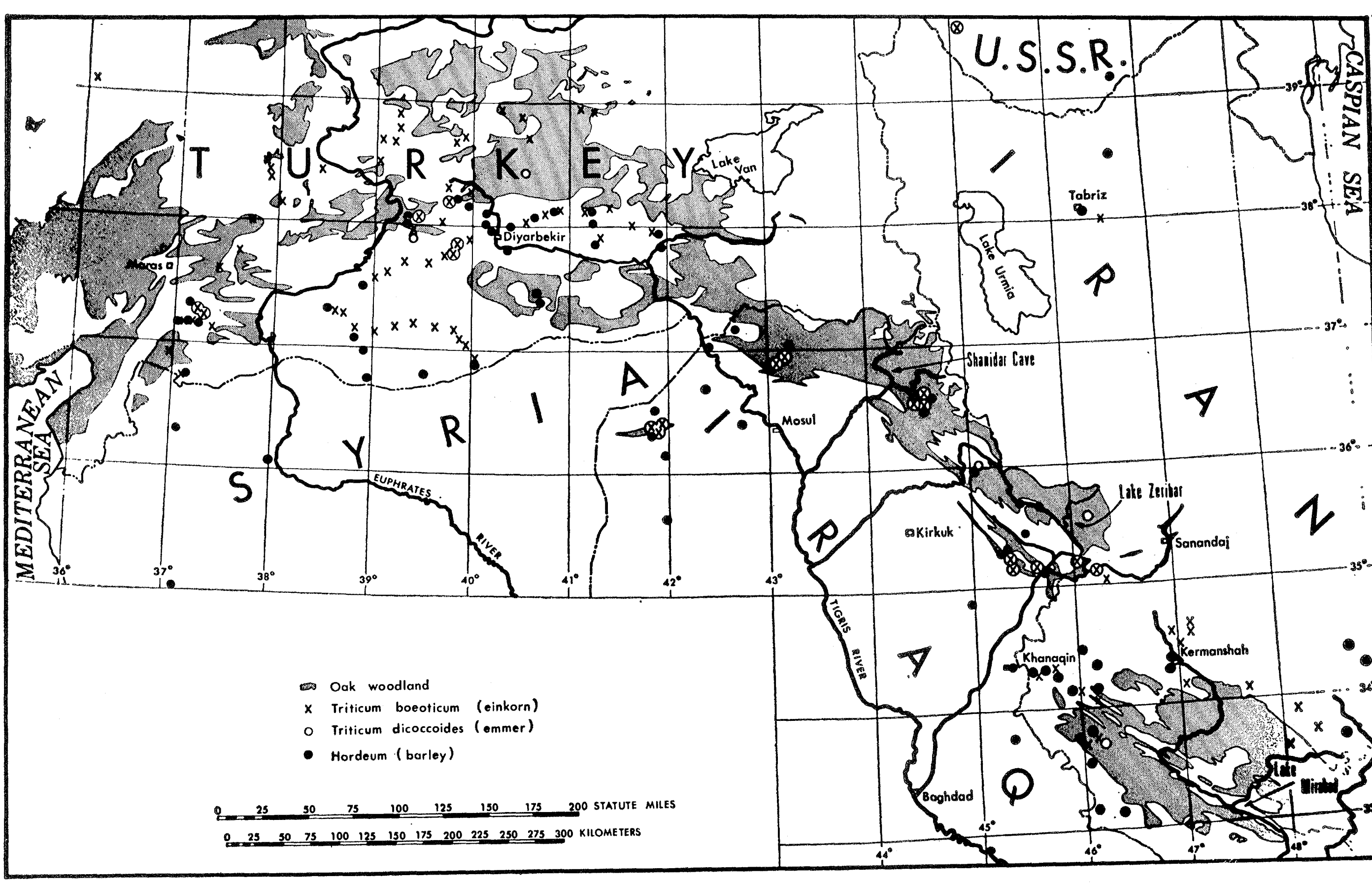


Fig. 1. Localities of modern collections of wild einkorn, emmer, and barley in the Zagros-Taurus Mountains and adjacent areas, in relation to the oak woodland. Modified from Harlan and Zohary (*27*) with additions supplied by J. R. Harlan in 1967.

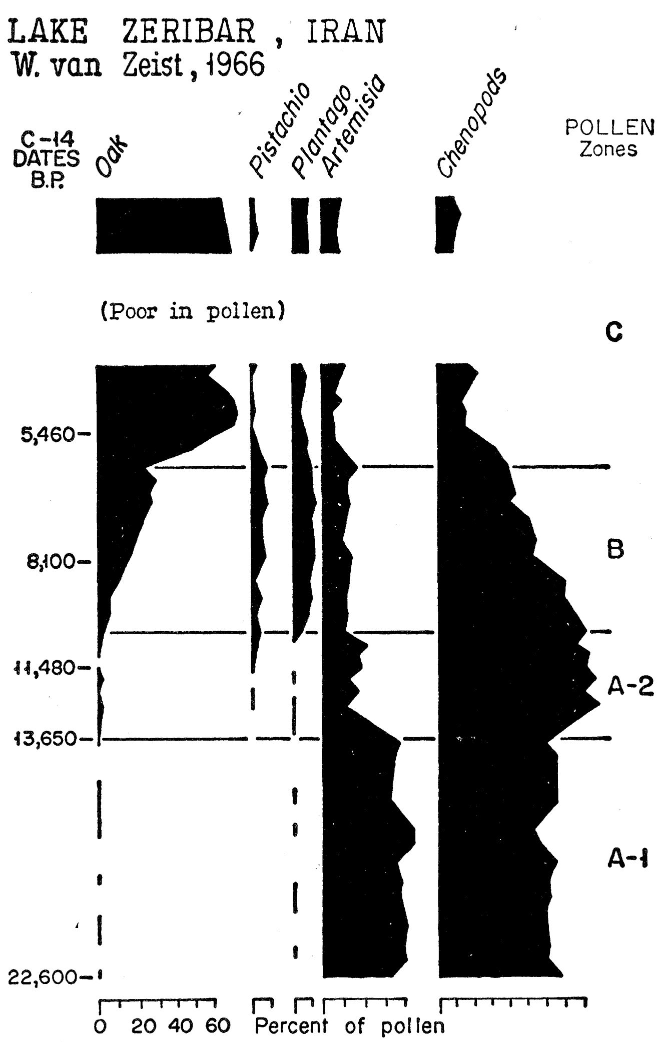
vegetation markedly different from that of the present (*19*).

From about 14,000 to 11,000 years ago (zone A-2), the pollen sequence at Lake Zeribar shows the first continuous curves for oak and pistachio pollen (but only 1 to 2 percent), together with a decrease in the percentage of *Artemisia* pollen (*17*). The region still contained few trees, which were confined to local habitats. The occurrence of charcoal of oak and probably juniper at the Zarzian cave of Palegawra (*14*) indicates that some trees were available to the inhabitants. The faunal list at Palegawra includes red deer (*Cervus elephas*) and other types that today are found in forests. But one might properly ask, How many charcoal fragments make a forest? Or better, How many *Cervus* bones make a forest? Red deer is a grazer, not a browser, so it prefers the open landscape for food. Woodland, where available, is used for protection from predators or weather, but irregular topography can provide the same protection. Darling (*20*) reports that the red deer in Scotland favors open land, to which it is better adapted than to forest. Its American ecologic (and perhaps taxonomic) equivalent, the elk (*Cervus canadensis*), was abundant throughout the treeless Great Plains until the latter part of the 19th century (*21*). Disturbance of its habitat as well as indiscriminate hunting (or even slaughter) decimated the herds, which are now restricted to the western mountains, where they are associated with woodlands as well as openings.

Considering our poor knowledge of the natural habitat of the red deer in the Near East, perhaps we could compromise by supposing that red deer could thrive with enough trees to supply the charcoal fragments at Palegawra but not enough to be recorded by more than 2 percent in the pollen rain at Lake Zeribar.

After 11,000 years ago, the tree-pollen percentages rise steadily (pollen zone B), and for several thousand years the vegetation was probably an oak-pistachio savanna such as can be found today on south-facing slopes near the lower tree line of the Mesopotamian foothills. About 11,000 years ago there was also a sharp increase in *Plantago* (plantain), which today is more common in the pollen rain of the lower steppe than at higher elevations. These trends indicate a climate warmer and drier than that of today at Lake Zeribar.

After 8000 years ago, the percentages of oak pollen increased more steeply, both in the Zeribar and the Mirabad sequences, and by 5500 years ago they reached the high pollen values of 50 to 70 percent that have since been maintained (zone C). The precipita-



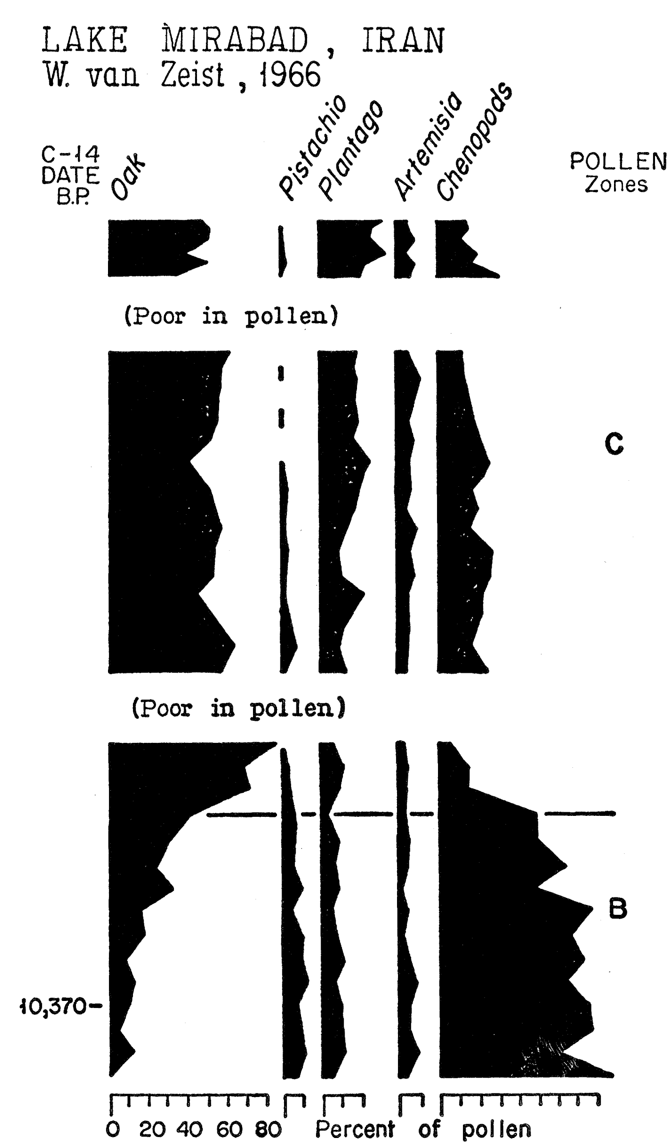


Fig. 2. (left). Selected pollen curves from Lake Zeribar, western Iran (*17*). For location, see Fig. 1. Fig. 3. (right). Selected pollen curves from Lake Mirabad, southwestern Iran (*17*). For location, see Fig. 1.

tion had apparently gradually increased from 11,000 years ago, although possibly the slowness of rise in oak-pollen percentage during this interval may reflect slowness of migration of oak trees from distant Pleistocene refuges.

The pollen sequence at Lake Zeribar is supported by other sediment analyses. Seeds and fruits and other plant fragments indicate that the climate before 14,000 years ago was not really cold but rather only cool-temperate — no colder than southern Scandinavia today (*22*). Cool-temperate species of Cladocera—the small crustaceans so abundant in lakes—are common at these levels (*23*). In younger sediments the aquatic flowering plants and the diatoms (*22, 24*) indicate intermittently low water levels and thus probably a warmer or drier climate than before. Warm-temperate species of Cladocera became common 11,000 years ago, and the cool-temperate types left soon after (*23*).

No other pollen studies have been completed in the Zagros Mountains or Mesopotamia to check the regional variations in Pleistocene vegetation. The preliminary pollen counts reporting palm and fir at Shanidar (*25*), never elaborated, confirmed, or published in any detail, unfortunately continue to be quoted seriously (*26*). Sediments with well-preserved and abundant pollen are so rare in the region that additional reliable information on vegetational history may be very difficult to obtain.

Climatic Determinism

Because the glacial evidence is not precisely datable and the vertebrate evidence is relatively undiagnostic in many respects, paleoclimatic reconstructions must depend largely on the paleolimnological evidence, particularly pollen, which is based on a continuous, well-dated fossil record that is well supported by modern analogs. The evidence from glaciation indicates a Pleistocene climate colder than the present; the pollen sequence not only confirms this conclusion but also provides the detailed chronological framework for comparison with the cultural sequence. It now appears that the environmental change, from a cool steppe to a warm oak-pistachio savanna, occurred about 11,000 years ago, at approximately the same time as the first manifestations of domestication of plants and animals.

We therefore can no longer say that the environmental change was completed long before the cultural change, and therefore that the two were not related. Furthermore, the environmental change did not simply involve a vertical movement of the principal vegetation belts up the mountains from Pleistocene refuges. Woodland may have been completely absent from mountain and piedmont during the Pleistocene, except for riverine habitats. Although evidence from fossils indicates that the domesticable fauna (sheep, goat, ox, pig) remained much the same, perhaps the domesticable plants had a different distribution. Recent work on the wild grains provides some clues.

Harlan and Zohary's (*27*) maps of the modern distribution of wild wheats and barley indicate that wild emmer (*Triticum dicoccoides*) is largely confined to the oak woodlands of the Zagros-Taurus Mountains and to the Palestinian area (Fig. 1); perhaps if the oak did not occur in the Zagros region before 11,000 years ago, neither did emmer. Consistent with this possible history is the fact that modern domesticated emmer wheat is more closely related genetically to the Palestinian race of wild emmer than to the Zagros race and may therefore have developed from a domestication that took place in or near Palestine (*27*).

Wild einkorn (*Triticum boeoticum*), by contrast, has its major modern distribution on the interior plateaus and in the mountains as high as 2000 meters (Fig. 1); before 11,000 years ago, when the *Artemisia* steppe covered the mountains, wild einkorn may have been more common in the Zagros foothills and the Mesopotamian piedmont than today.

Wild barley (*Hordeum spontaneum*) occurs in undisturbed sites primarily in the steppe below the mountains, and in the oak woodland of the foothills, rarely as high as 1500 meters (Fig. 1). Before 11,000 years ago it may have been confined to even lower elevations in Mesopotamia, or to the now-desert Arabian Peninsula.

All this implies that prehistoric man in the Zagros Highlands before 11,000 years ago was familiar only with einkorn among the wild grains, and that emmer and barley immigrated or expanded subsequently. Emmer may have been domesticated first in Palestine, according to the genetic evidence, and then imported to the Zagros region; or it may have been domesticated independently in the Zagros area at a later date after the wild form had spread into the region as a component of the oak woodland. Barley likewise may have been a late-comer to the Zagros, following the climatic change of 11,000 years ago.

If we then assume that game animals before 11,000 years ago were more abundant in the mountains than in the plains, because of the greater diversity of topography and habitats (despite the relative cold and the lack of trees), and that man the hunter also lived mostly in the mountains because of the availability of wild game for food and of caves for shelter, then with the change to a warmer climate and the immigration of wild grains we had available the combination of circumstances most favorable for domestication of animals as well as of emmer and barley, accompanied by shift from caves in the mountains to open living sites in the foothills, where ground was more favorable for cultivation.

Although I have always felt that cultural evolution—gradual refinement of tools and techniques for controlling the environment—is a stronger force than climatic determinism in the development of early cultures, the chronological coincidence of important environmental and cultural change in this area during initial phases of domestication is now well enough documented that it cannot be ignored. A much greater problem, of course, will be to prove that the environmental change was the cause of the cultural revolution. This hypothesis needs severe testing from many approaches. Only with more extensive and more detailed paleoecologic and archeologic studies of the critical period from 12,000 to 9000 years ago, closely controlled by radiocarbon dating, can we obtain more insight into this problem which has interested the student of early man for two generations.

References and Notes

1. P. J. Watson, in *Chronologies in Old World History*, R. W. Ehrich, Ed. (Univ. of Chicago Press, Chicago, 1966).
2. R. J. Braidwood, *6th Congr. Internaz. Sci. Preist. Protoist. Atti* **1**, 115 (1960); R. J. Braidwood *et al.*, entire volume of yearly publication *Stud. Ancient Orient. Civil.* **31** (1960).
3. R. S. Solecki, *Smithsonian Institution Report (1954)* (U.S. Government Printing Office, Washington, D.C., 1955), p. 389.
4. R. J. Braidwood, B. Howe, C. A. Reed, *Science* **133**, 2008 (1961); T. C. Young, Jr., and P. E. L. Smith, *ibid.* **153**, 386 (1966).
5. D. Perkins, Jr., *ibid.* **144**, 1565 (1964).
6. The case is well put by K. V. Flannery, *ibid.* **147**, 1247 (1965), who follows earlier suggestions on the matter.
7. Few large areas of mountains and plains have been adequately surveyed to test the correlation of cultural stage with caves as compared with open sites. In the Zagros Mountains and foothills, however, Braidwood and Howe (*2*) conclude that "the Zarzian appears to be the last horizon in which the cave was a primary focus of human settlement." The few open-site concentrations of Zarzian or

earlier artifacts can generally be attributed to seasonal occupation—no structures have been found that imply permanent shelters of any kind. Most open sites are younger, and they usually are low mounds of earth that contain pits, rows of fieldstones, remains of mud walls, or other indications of houses of some kind. Caves, by contrast, rarely have more than very shallow accumulations of the younger material. Surface erosion of older sites has not been sufficient to alter this picture; nor has pfromiscuous trenching or robbing of caves.

8. R. L. Solecki, *Intern. Congr. Quaternary 6th (Warsaw 1961) Rep.* **4**, 405 (1964).
9. F. Hole and K. V. Flannery, *Iranica Antiqua* **2**, 97. Wild barley, however, has been collected in the Ali Kosh area, so it provides an exception to this statement, according to J. R. Harlan, personal communication (1967).
10. H. E. Wright, Jr., *Eiszeitalter Gegenwart* **12**, 131 (1961).
11. ———, *Intern. Congr. Quaternary 6th (Warsaw 1961) Rep.* **2**, 341 (1964).
12. R. J. Braidwood, in *Courses Toward Urban Life*, R. J. Braidwood and G. Willey, Eds. (Aldine, Chicago, 1962); K. V. Flannery, *Science* **147**, 1247 (1965).
13. C. A. Reed and R. J. Braidwood, *Stud. Ancient Orient. Civil.* **31**, 163 (1960).
14. P. Turnbull and C. A. Reed, unpublished manuscript.
15. K. Wasylikowa, unpublished manuscript.
16. W. van Zeist and H. E. Wright, Jr., *Science* **140**, 67 (1963).
17. W. van Zeist, *Rev. Paleobot. Palynol.* **2**, 301 (1967).
18. H. E. Wright, Jr., J. H. McAndrews, W. van Zeist, *J. Ecol.* **55**, 415 (1967).
19. T. van der Hammen, T. A. Wijmstra, W. H. van der Molen. *Geol. Mijnbouw* **44**, 37 (1965).
20. F. F. Darling, *A Herd of Red Deer* (Oxford, London, 1937).
21. O. Murie, *The Elk of North America* (Stackpole, Harrisburg, Pa., 1951).
22. K. Wasylikowa, *Rev. Paleobot. Palynol.* **2**, 313 (1967).
23. R. O. Megard, *Ecology* **48**, 179 (1967).
24. K. Wasylik, unpublished analyses.
25. R. S. Solecki and A. Leroi-Gourhan, *Ann. N.Y. Acad. Sci.* **95**(1), 729 (1961).
26. K. W. Butzer, *Environment and Archaeology* (Aldine, Chicago, 1964); K. V. Flannery, *Science* **147**, 1247 (1965).
27. J. H. Harlan and D. Zohary, *Science* **153**, 1074 (1966).

28. I thank for helpful discussions: R. J. and L. Braidwood, J. Harlan, B. Howe, R. O. Megard, C. A. Reed, K. Wasylikowa, P. J. Watson, R. A. Watson, W. van Zeist, and other colleagues on various Near Eastern projects of the Oriental Institute, University of Chicago, which has supported (through grants from the National Science Foundation) many of the paleobotanical and geological field studies that provided the background for this paper. A contract between the Office of Naval Research and the University of Minnesota also furnished funds for the investigation of climatic change in the eastern Mediterranean region. The manuscript was read by C. T. Shay.

NEWS AND COMMENT

UFO Project: Trouble on the Ground

Boulder, Colorado. The Air Force–sponsored investigation that was intended to still the controversy over unidentified flying objects (UFO's) has become mired in controversy itself.

The project, conducted at the University of Colorado under the direction of the eminent physicist Edward U. Condon, has been plagued with troubles almost as bizarre as the phenomena it is investigating. It has been criticized by reputable scientists who are interested in UFO phenomena, embarrassed by publication of an indiscreet internal memorandum, attacked by a mass-circulation magazine, disowned by a national group of UFO enthusiasts, threatened with libel suits and a congressional investigation, and depleted in staff strength by two firings, a heated resignation, and a narcotics arrest—all before the project has even had a chance to publish its final report. And still more controversy lies ahead, for one of the ousted scientists is preparing a popularized dissenting report which is scheduled to be published at the time the Condon group's final report is made public.

The full story of the Condon group's internal troubles is not known at this time, for Condon has refused to discuss the matter in any detail and has ordered his staff not to talk to reporters. Condon discussed the controversy briefly in preliminary telephone conversations with *Science*, agreed to hold an interview with *Science*, then changed his mind, partly on the ground that his project should be judged by its final report rather than by its administrative problems, and partly because he felt the situation was too "complex and emotion-laden" for accurate reportorial treatment.

The University of Colorado undertook the UFO project in late 1966 at the request of the U.S. Air Force, which has been under mounting criticism for its handling of the "flying saucer" problem over the past two decades. Critics claim the Air Force has consistently refused to take UFO's seriously, and some even charge that the Air Force has deliberately suppressed evidence that UFO's are vehicles from another world. In an effort to still the clamor, the Air Force decided to commission an independent study by respected civilian scientists whose word might carry weight with a skeptical public.

But finding topflight scientists willing to tackle the somewhat "messy" UFO problem, where observations are difficult, professional recognition is slight, and the field is cluttered with crackpots, was not easy. Various scientists were approached informally and turned the Air Force down. Finally, the Air Force came up with a seemingly perfect choice in Condon, a distinguished theoretical physicist, former head of the National Bureau of Standards, and former president of the American Physical Society and the American Association for the Advancement of Science. Moreover, Condon, a tough, fearless man, known for speaking out on vital national issues and for his battles with the House Un-American Activities Committee, seemed ideally suited to handle the controversial assignment. But even Condon's arm had to be twisted a bit. "He was not at all eager," says an Air Force UFO specialist. "He took the job out of a sense of duty."

The university's contract with the Air Force (ultimately for about $500,000) became effective on 1 November 1966 and originally called for research to be completed by 31 January 1968, but difficulty in mapping out a methodology necessitated extending the project until 30 September 1968. The Condon group has now essentially completed its field investigations and is preparing its final report, which will be reviewed by the National Academy of Sciences; the report is then expected to be made public. But already critics are charging that the Colorado scientists have conducted a biased and less-than-diligent investigation and that any report the group produces will be suspect. The chief targets of criticism have been Condon, who is professor of physics and astrophysics at Colorado, and the project coordinator, Robert J. Low, who was previously an assistant dean at the university's graduate school and who has recently been appointed a special assistant to Colorado's vice president for academic affairs, though he still retains some