ANTHROPOLOGY

The Roots of Cultivation in Southwestern Asia

Evidence of early cultivation of crops in the Zagros mountains in Iran helps to elucidate where and when humans first started to cultivate wild cereals.

George Willcox

The origins of agriculture have been the source of much speculation, but recent discoveries are enabling archaeologists to piece together a more accurate picture. Fifty years ago, the earliest known farming village was Jericho in the southern Levant, dated to about 11,000 years ago (*1*). Since then, a series of sites dated hundreds of years earlier has been found in an arc extending to northern Iraq. Discoveries in Iran at Chogha Golan and Sheikh-e Abad (*2*), dated to 11,700 years ago, extend the arc to Iran, allowing five clusters of sites to be defined (see the figure, panel A). Archaeological excavations in the foothills of the Zagros Mountains of Iran reported by Riehl *et al*. on page xxx of this issue (*3*) provide evidence that wild cereal cultivation in the eastern cluster occurred almost as early as in the clusters further west.

The emerging evidence shows that cultivation began at more or less the same time in all five clusters, but that the crops were different from one cluster to another. This pattern has been established at 11 sites dated to between 11,500 and 11,000 years ago, including Chogha Golan in the Zagros Mountains, where charred cereals were recovered in association with arable weeds (*4*). At this time, the inhabitants of these sites were not yet herders but continued to hunt large game, aurochs, gazelle, sheep, goat, and equids.

At some sites, cultivation of wild cereals occurred on a large scale, as demonstrated by discoveries of storage structures (*5*), installations with multiple querns (see the figure, panels C and D), and massive quantities of cereal chaff used to temper daub for construction (*6*). Imposing architecture has been unearthed, sometimes consisting of spectacular communal buildings, but with different styles in each cluster (*7*). Long-distance transportation of rare raw materials took place; obsidian, marine shells, bitumen, ochre, and chlorite (a stone used for carving) have been found on sites far from their sources, indicating contact between clusters.

Cultural and agricultural developments during the early Holocene differed strongly from one cluster to another, as recent finds from the Zagros Mountains, Cyprus (*8*, *9*), central Anatolia, and the southern Levant (*10*) demonstrate. At Chogha Golan, wild cereals began to lose the ability to disperse their seeds after 9800 years ago. This evolutionary adaptation, called morphological domestication, occurred earlier in western clusters, between 10,500 and 10,000 years ago. Goat herding in the Zagros Mountains is also dated to around 9800 years ago (*11*), again later than in the west. Genetic studies point to independent local domestication of barley in the Zagros cluster (*12*). However, more data are required to distinguish and date local domestications, as opposed to introductions between clusters.

How did cultivation originate in the Zagros foothills? Late Pleistocene sites in the Zagros Mountains have querns, but no cereal remains have been found. Cereals were in use nearly 12,000 years ago in northern Iraq and 13,000 years ago in northern Syria. In the

Early cultivation. (**A**) Archeological finds from Iran reported by Riehl *et al*. allow definition of an eastern cluster of sites in the Zagros foothills where wild cereals were cultivated almost as early as in clusters further west. Dates in blue denote early cultivation of wild cereals; dates in green are for earlier finds of cereals without evidence for cultivation. These dates may be revised as new sites are discovered. Ongoing excavations in central Anatolia and Cyprus are pushing dates back in these areas. Isolated sites without cereals are not included. (**B**) Mortar and pestle from Wadi Hammeh in the southern Levant, dated to 14,000 years ago (*14*). (**C**) Bases of three aligned querns in a room at Jerf el Ahmar, northern Syria (*7*). (**D**) Large quern from Tell 'Abr, northern Syria. The finds in (C) and (D) have been dated to 11,300 years ago.

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southern Levant they are attested at 23,000 years ago, but by 14,000 years ago, houses comparable to those of the early Holocene contained mortars and pestles that were probably used for cereal processing (see the figure, panel B). These late Pleistocene remains do not allow differentiation between gathering and cultivation (*13*), but it is probable that these societies had knowledge of cultivation.

Ethnographic literature shows that hunter-gatherer groups in many parts of the world propagated plants, although they had little or no contact with farmers. The discovery of early cultivation in the Zagros Mountains by Riehl *et al*. and the series of dates pointing back to the Late Pleistocene in the southern Levant suggest, but do not prove, that the roots of cultivation may lie there. It remains to be seen, however, whether ideas, crops, or migration were responsible for disseminating cultivation as far as the Zagros Mountains.

References and Notes

1. This and all other dates are calibrated ^{14}C dates before the present.
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10.1126/science.1240496

ASTRONOMY

Radio Bursts, Origin Unknown

Observations of radio bursts that appear to originate from outside the Milky Way may suggest the existence of a large and exotic source population.

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Analyzing the transient electromagnetic signals pervading the cosmos has led to the identification of a plethora of exotic astrophysical objects. On page XXX of this issue, Thornton *et al*. (*1*) report on the discovery of several short radio bursts, only a few milliseconds in duration, from four widely spaced directions during a survey of the sky using the Parkes radio telescope in Australia. The bursts are not unlike individual pulses seen from pulsars, neutron stars whose spins regularly sweep a lighthouse-like beam into Earth's direction. Because of their weak emission, the majority of known pulsars reside within the Milky Way or in one of its satellite dwarf galaxies, the Large and Small Magellanic Clouds. By contrast, the new bursts appear to originate from large distances, outside the Milky Way. Truly remarkable is that a burst rate of about 10^4 bursts per day over the entire sky has been deduced. It is still early days for identifying the astrophysical origins of such common but (so far) rarely detected events.

The sources of the bursts are undoubtedly exotic by normal standards. The usual suspects include emissions from evaporating black holes (*2*) or from gamma-ray burst (GRB) sources that include supernovae, mergers of neutron stars, and magnetars (neutron stars with hyperstrong magnetic fields). They could originate in the centers of galaxies where compact stars interact with and plunge into supermassive black holes. Or they could represent an entirely new class of source. Another possibility is that they are bursts much brighter than the giant pulses seen from some pulsars (*3*).

The measured properties of the new bursts allow the range of possible explanations to be narrowed. The pulses are distinguished from terrestrial interference by the characteristic plasma dispersion effect that causes radio waves to travel more slowly at lower radio frequencies (see the figure). The pulse shape encodes the amount of plasma that the pulse propagates through. The measured plasma dispersion is too high to be explained by interstellar gas in the Milky Way for the particular source directions. Where does the "extra" plasma come from? One possibility is the intergalactic medium.

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Remote sensing. The observed radio bursts sample ionized gas along the entire path length and therefore provide the means for sampling any host galaxy, intervening galaxies, and the intergalactic medium.

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