A Revolution of Ideas in Agricultural Origins

Ideas about the origin of sedentism and agriculture have been changing in recent years, with a greater emphasis on examining the details of sites case by case

TELL Abu Hureyra, a large archeological site in northern Syria, contained the remains of one of the earliest known village settlements in the world. First occupied in 9500 B.C. and going through to about 5000 B.C. with one major break, the site witnessed a key transition in human prehistory: the shift from nomadic hunting and gathering to a sedentary, village existence.

Unfortunately, Abu Hureyra disappeared under the waters of the Euphrates in 1974, the result of the Tabqa Dam project. Before the mound was submerged, however, Andrew Moore of Yale University led a salvage archeological expedition to chart and recover evidence of the crucial slice of prehistory entombed in the mound.

Analysis and reanalysis of the data and material from the excavation is now producing something of a coherent picture of preagricultural and early agricultural village life, one that will add important impetus to the current intellectual shift concerning the origins of sedentism and domestication. The latest results of the Abu Hureyra project have been presented at three separate symposia within the last month, including one at the annual meeting of the Society for American Archeology, held in Phoenix, Arizona.

"What we see at Abu Hureyra is a step-by-step introduction of domesticated plants and animals," Moore told *Science*. "The origin of agriculture was not a single event, not a sudden revolution, but something more complicated than that. Nevertheless, each step within this process seems to have occurred very rapidly. This is a pattern I see across southwestern Asia."

The conclusions that Moore and his colleagues draw about life in ancient Abu Hureyra are based on a sample of less than 1% of the surface area of the site: of the 11 hectares of the mound, the salvage operation managed to excavate just 300 square meters. Although a sample of this size might sound impossibly small, it is actually rather typical of many excavations of large sites, even those not pressured by the imminent rise of flood waters.

"It is salutary to realize that, until recently, our models were based on tiny pieces of evidence," says Mary Voigt of the University of Pennsylvania Museum of Archeology and Anthropology. More and more evidence is coming together now, including Voigt's own site of Gritille in Turkey, the site of 'Ain Ghazal in Jordan that was recently described in *Science* by Gary Rollefson and his colleagues, and, of course, Abu Hureyra. "The result is that the old models don't fit anymore," says Voigt. "They were very compelling and it is difficult to give them up."

Principal among the "old models" was the notion of a revolution: agriculture was invented, and previously nomadic hunters and gatherers settled down in villages to reap the benefits of domesticated food resources; eventually, these simple, egalitarian settlements enlarged as agricultural production intensified, and social, political, and cultural institutions became more and more sophisticated. In other words, the agricultural (or Neolithic) revolution was envisioned as the transition from a simple form of socioeconomic subsistence to a much more complicated form.

"The new evidence is forcing us to accept the reality that there was no simple transition," says Voigt, "that it wasn't a case of *either* hunting and gathering *or* farming. And it wasn't a case of a uniform shift from simple, egalitarian farming villages to large, culturally sophisticated settlements." It is now clear that sometimes villages became established in the absence of plant or animal domestication; domestication sometimes occurred in the absence of village formation; and the elaboration of cultural complexity did not depend absolutely upon the expansion of small villages into substantial towns. "The process was obviously more complicated that our models allowed," says Voigt.

When the archeological data were sparse, the few key sites tended to dazzle, sometimes spectacularly so. Such was the case with Catal Huyuk, a seventh millennium farming community in Turkey. Excavated in the 1960s, this 6500 B.C. to 5800 B.C. town contained elaborate animal carvings, wall paintings, and substantial architecture: an "archeological supernova," notes Voigt. Bursting upon an otherwise void backdrop, Catal Huyuk appeared to encapsulate the very notion of economic and social revolution. "But," says Voigt, "the discovery of other large sites, some contemporary with Catal Huyuk, some earlier, means that it is a supernova no more."

The first settlement at Abu Hureyra was some three millennia earlier than Catal Huyuk, but was smaller and simpler. Known as Abu Hureyra I, it lasted from 9500 B.C. until 8100 B.C., when it was abandoned for about 500 years. The second, much larger, settlement ranged from 7600 B.C. until about 5000 B.C., when once again the community was deserted. This second abandonment coincided with similar events at other major settlements in the Levant, and is thought to be related to climatic change that became less and less conducive to agriculture. The reason why Abu Hureyra I collapsed is, however, less certain, but may have been the result of exhaustion of environmental resources, which seems to have been a common pattern in early settlements.

Tell Abu Hureyra Excavation

Tell Abu Hureyra. *The prehistoric site seen from the southwest, with trenches on the north-south ridge.*

The preliminary analysis of the Abu Hureyra I material seemed to indicate that the community subsisted by a mixture of hunting, gathering, and plant domestication. "There was circumstantial evidence for thinking that farming was getting under way at this time," says Moore. "For instance, cereal plants like einkorn, a primitive wheat, were found at the site. Second, the site was favorably placed for farming, being located near the Euphrates. And third, mixed in with the wild einkorn, wild rye, wild legumes, and so on were seeds of plants that would now be considered as weeds of cultivation."

This interpretation was interesting, because it appeared to show that agriculture was emerging rather earlier than had been imagined. "Now we see that we probably got that wrong," says Moore. But being wrong has now produced an answer that is even more interesting. Abu Hureyra I, it seems, was a settled, year-round village of substantial size whose economic base was solely hunting and gathering.

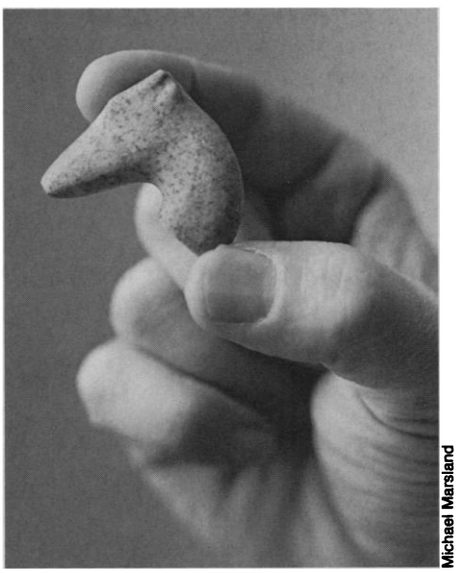
"It turns out that the steppe flora was much richer than we thought," Moore told *Science*. "At the time of Abu Hureyra I, the edge of the Mediterranean forest, which is the source of wild cereals, pulses, legumes, and so on, came very close to the village." Although these plant species appear to thin out toward the end of the first settlement, the people of Abu Hureyra I clearly had access to rich plant food resources. According to Gordon Hillman of the University of London, these species would have grown together so densely that they could have been scythed in great sweeps. He calls this the lawnmower hypothesis.

In addition to an abundance of plant foods, the people of Abu Hureyra I also had access to a large and reliable source of meat, in the form of the annual migration of Persian gazelle, which arrived from the south every spring. Anthony Legge of the University of London and Peter Rowley-Conwy of the University of Cambridge have analyzed bones from the excavation, and conclude that the animals were killed en masse each migration, thus providing huge quantities of meat, supposing it could be stored.

"The site was therefore extraordinarily favorably located," says Moore. "So we can see why it was possible for hunting and gathering people to settle there, and why they stayed." The classic view of hunters and gatherers is that they were nomads, living in small, socially and culturally simple groups. Although this pattern might well have held for many such peoples, it is becoming clear that, for at least some substantial proportion of groups, socioeconomic life was anything but simple. (A Research News article will further explore this topic next week.)

The hunters and gatherers of Abu Hureyra I appear to have been an example of a people exploiting rich resources in the absence of agriculture and in the presence of a settled village. The population of Abu Hureyra I gradually increased through time, ultimately reaching perhaps 300 or 400 inhabitants. Though living in simple dwellings, these people must therefore have experienced a higher degree of social organization than normally operates in small nomadic bands.

During the 700-year span of Abu Hureyra I the climate gradually became less favorable for supporting the rich steppe flora, and eventually the people left. Perhaps the cause was a combination of climate change and constant high level exploitation of resources, including resources for fuel.



Michael Marsland

Tell Abu Hureyra Excavation

Excavations. *At top, a small gazelle head carved in granite. At botton, Syrian workers recover plant remains, including wheat and barley, during the 1973 excavation.*

In any case, after a hiatus of half a millennium the site was once again populated, this time with farmers. "Domesticated cereals and pulses came in right from the beginning," explains Moore. "But for meat the people continued hunting wild gazelle on their migration round." The economic base of Abu Hureyra II, which expanded tenfold in area and population over the previous settlement, was therefore a combination of plant domestication and hunting.

Domestic architecture was now mud brick houses, presumably single-family dwellings, of substantial size. "Specialized crafts became established, such as the manufacture of stone vessels, stone jewelry, and gypsum plaster," says Moore. "And the hints of long-distance exchange we noted in Abu Hureyra I now expand substantially."

Gazelle hunting continued for almost a millennium, when there was a sudden change to domestication of sheep and goats. Legge and Rowley-Conwy interpret this shift as a response to overkill, with settlements in the south joining in the regular mass culling. It is only at this point, therefore, that Abu Hureyra became a fully agricultural community: it was a step by step process, as Moore noted earlier.

"Once they took on agriculture," says Moore, "there is no doubt that it took them over." Population expansion continued further and occupational disease developed. For instance, Theya Molleson of the British Museum (Natural History), London, identifies deformations in the legs, feet, and vertebrae that indicate the carrying of heavy loads and the relentless hand-milling of grain. Other signs of pathology indicate that life became more and more arduous and less prosperous than in earlier times, perhaps revealing that resources were becoming stretched to some degree. Finally, the town was abandoned.

In many ways Abu Hureyra is a special case: rich plant and animal resources allowed hunters and gathers to subsist from a settled community, and then provided a foundation for a mix of hunting and gathering and domestication. "We are learning that what we have to look at are the special cases," says Moore.

One long-standing and, to some scholars, persuasive explanation of the origin of agriculture has been population pressure: increasing population numbers forced people to intensify food production. Although Moore accepts that "the population pressure idea still carries weight," he says that when you look at the documented cases of early sedentism "you become more impressed by the local circumstances."

Bruce Smith, of the Smithsonian Institution in Washington, agrees with Moore on

this point. "Simple models work well when the data are limited," says Smith, a specialist on sedentism in North America. "As the information base gets larger you get a detailed, information-rich, historical sequence through time. This is showing that the general causal models often don't fit particular sequences in the archeological record."

The search for single causal factors has seemed very reasonable, not least because sedentism and agriculture emerged, on a prehistoric scale at least, virtually simultaneously throughout the world: about 10,000 years ago in the Old World, and a few thousand years later in the New World. "When systems converge in a parallel manner we should expect to be able to come up with a general explanation," says Mark Nathan Cohen of the State University College, Plattsburgh, New York. Cohen has been the principal proponent of the population pressure hypothesis in recent years.

Unfortunately, the prehistoric record is often too incomplete to allow a separation of the cause/effect relationship between population numbers and intensification of food production. However, Cohen has been collating physical anthropological data that appear to show increasingly poor nutritional status coincident with the beginnings of agriculture, indicating, he says, food stress as an engine of the change.

Many other researchers fail to find any support for Cohen's case. For instance Kent Flannery of the University of Michigan states: "I don't see any evidence anywhere in the New World that suggests population pressure was responsible for the beginnings of agriculture. Population was not high enough to force anyone to do anything."

Climatic change has formed the focus of a rival single-cause hypothesis, and is clearly attractive in that the advent of sedentism tracks closely the end of the Pleistocene glaciation and the onset of the Holocene interglacial. Moore sees climatic change in the Levant being crucial in setting propitious environmental conditions for the establishment of Abu Hureyra. "It may be an unpopular idea, but it's true," he says. "I'd stake my reputation on that."

Although it is true that climate change was dramatic at the end of the Pleistocene, 10,000 years ago, it must also be true that conditions favorable to sedentism must have existed somewhere in the Old World in the last 75,000 years of the Pleistocene. And if anatomically modern humans have been around for at least this length of time, as recent anatomical and genetic data indicate, why did sedentism not develop earlier? Is it possible that low population levels through this period is the only answer? ■

ROGER LEWIN

Pluto's Orbital Motion Looks Chaotic

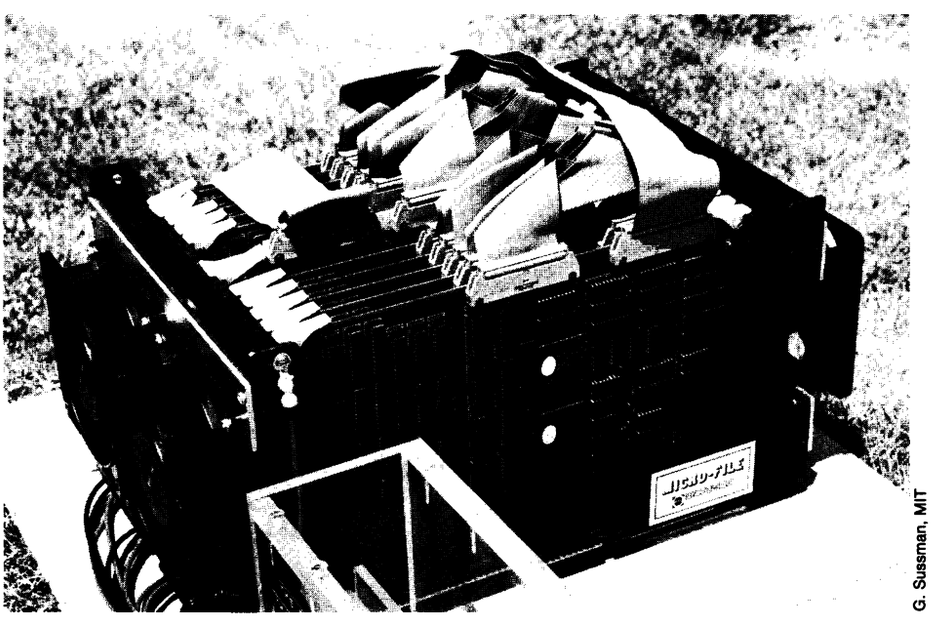
The oddest planet seems to have a new distinction: its motion around the sun is irregular to the point of unpredictability

PLUTO seems to have locked up its status as the oddball planet of the solar system. A near billion-year computer simulation of the motions of the planets provides strong evidence that over millions of years Pluto's motion about the sun cannot be predicted. Even the clocklike workings of the planets would thus seem to have their little glitches. The discovery adds another peculiarity to a planet that is probably a leftover from the early days of the solar system, a lucky, lone survivor of the swarm of small bodies that were either thrown from the solar system or pulled into one of the planets.

Chaos in the solar system has been becoming more obvious of late, at least among its minor bodies. None of the Newtonian laws of physics is being violated, it is just that the future motions of some bodies are so sensitive to their present conditions that their behavior cannot be predicted. An infinitesimal difference in their positions or motions now can lead to wildly different behavior in the future. Largely through the work of Jack Wisdom of Massachusetts Institute of Technology, it has become apparent that Jupiter's gravitational influence can send rock in the asteroid belt into chaotic, highly elliptical orbits that deliver meteorites to Earth. Saturn's tiny satellite Hyperion tumbles chaotically instead of locking one face toward Saturn. And the slight inclination of the orbit of Miranda, the innermost major satellite of Uranus, may also reflect chaotic behavior.

Of all the planets, Pluto has seemed the most likely to behave chaotically. In addition to its having a cockeyed orbit, which is tilted 16° to Earth's orbital plane and so elongated that Pluto is now temporarily inside the orbit of its neighbor Neptune, it is enmeshed in more periodic gravitational interactions with its neighbor, called resonances, than any other planet. The more resonances, the more likely chaotic behavior.

The best way to see if the solar system is stable and predictable is to have a computer simulate the motion of the four massive outer planets and Pluto long enough to see



G. Sussman, MIT

The new and the old orreries. *The mechanical calculation of the positions of the planets began in the 17th century with the original form of the orrery (right), named after the Earl of Orrery for whom it was first made. The Digital Orrery (above), a one of a kind parallel computer, is less stylish but much faster. Designed solely for simulating the motions of the solar system, it runs at one-third the speed of a Cray 1 supercomputer.*