New discovery sheds light on the deep roots of the Agricultural Revolution

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It has long been understood that the transition from economies based on hunting and gathering, in which humans are dependent on the inherent productivity of nature to provide food and organic raw materials, to ones based on agriculture, the systematic cultivation of domesticated plants and rearing of domesticated animals, was one of the most critical steps in human cultural evolution. Generally termed the Agricultural Revolution, this development laid the basis for an expandable food supply, surplus production, growing populations, an increasingly complex division of labor, and, eventually class society and civilization.

Although archaeologists and other researchers have devoted much effort to understanding the origins of agriculture, key questions remain unanswered. Early evidence of agriculture—domesticated (i.e., genetically modified) plants and animals and the technology for their cultivation, husbandry, storage and processing—generally dates to the period following the end of the Pleistocene epoch, roughly 12,000 years ago.

When compared to the time frame for the existence of anatomically modern humans (*Homo sapiens*), about 200,000 years, the development of agriculture and all that followed occurred in a relative blink of an eye. This raises the question of why humans, with effectively the same mental and physical capabilities as at present, took so long to make this development.

A recently reported discovery of 23,000-year-old stone tools used to harvest cereal grains suggests that the kinds of subsistence adaptations that ultimately lead to full-fledged agriculture were being developed thousands of years earlier than had previously been documented.

The discovery, reported in the journal PLOS ONE, by authors Iris Groman-Yaroslavski, Ehud Weiss, and Dani Nadel, was made at the Ohalo II archaeological site located on the shore of the Sea of Galilee in northern Israel. The find consists of five flint blades that bear a gloss on their edges characteristic of use in cutting grasses. This gloss, also called “sickle sheen,” is found on tools from later sites definitely associated with agriculture, where cereal grains (which are grasses) such as wheat were cultivated and harvested. Sickle sheen is the result of silica crystals in plants, particularly cereals, rubbing off on a tool’s working edge.

Other wear patterns indicate that the tools were used in two modes—hand-held and hafted into a handle. In later times, compound sickles were made by embedding a series of flint blades into the edge of a long wooden or bone tool, resembling the form of later metal sickles, resulting in a more efficient harvesting implement.

Comparison via microscopic examination with the results from experimentally replicated tools indicates that these blades were used to harvest plants in which the seeds had not yet fully ripened, indicating that the users knew that fully ripened seeds would be fragile and thus fall to the ground, making effective harvesting impossible. These were wild plants. Domesticated plants are bred to prevent the seeds from falling.

The significance of the discovery at the Ohalo II site is twofold. First, the age of the site demonstrates that cereal harvesting, at some level of intensity, was occurring at least 8,000 years earlier than the previous known evidence of such activity on a consistent basis, in a culture called the Natufian, and 12,000 years before evidence of Early Neolithic sedentary farming communities in places such as modern day Iraq.

Second, other evidence from the Ohalo II site indicates that, aside from an apparently limited amount of wild cereal harvesting, the economy of this community was based on hunting, fishing, and gathering of a range of wild plant foods. Cereal harvesting would, therefore, appear to have been but one component of the group’s overall subsistence economy. Other reports of early sites with blades bearing sickle sheen have previously been made, but these artifacts are few and widely scattered, and the use damage on the tools generally slight, indicated limited use. The data from Ohalo II is the strongest evidence yet found of this activity at such an early date.

In addition to the sickle sheen on blades, the Ohalo II site also yielded grinding tools used to process cereal grains, including traces of wheat, barley, and oats, all of which were later domesticated.

Collectively, the finds at Ohalo II plus the trace indications from other sites, pose the key question—how and why, over the subsequent 8,000 years, did a radical shift occur in which this one component of the overall subsistence strategy gained such significance in the economies of this region? This is the same question that is posed in all the other centers of early

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agriculture—Southeast Asia (rice) and Mesoamerica (maize).

As the authors of the PLOS ONE article point out, evidence of the use of cereal grains as food substantially predates that from Ohalo II. Indications of their consumption have been found at a Middle Paleolithic site in Israel and at an Upper Paleolithic site in Europe. Therefore, humans had known about this food source for a very long time and their agricultural use did not represent a sudden discovery.

The development of agriculture was not the overnight adoption of radically new food sources, but rather a shift from the use of a range of resources to the increasing emphasis on a few plant and/or animal species already "on the menu," on which humans focused greater amounts of time, energy, and technological innovation. This focus would have initially included various kinds of "tending" to encourage the proliferation of the favored species (such as the setting of fires to clear brush and promote the growth of grasses), and the development of new technologies to enhance the efficiency of harvesting, processing, and storage. This also involved selective breeding, intentional or unintentional, that, over time, resulted in genetic changes making the target species more productive and easily manipulated (e.g., seeds not falling when ripe so they can be harvested).

The critical question is, in reality, not so much how but why did this occur. After many tens of thousands of years of existence based on a hunting and gathering economy, why did humans independently in a number of different areas around the world and using a variety of plant and animal species, shift, over the course of only a few thousand years, to an agriculturally based economy?

The apparent correlation between the development of agriculture and the end of the Pleistocene (the Ice Age), roughly 12,000 years ago, suggests that one key factor may have been climate change. The presence of massive continental ice sheets tended to stabilize climate, a phenomenon known as Pleistocene Equability. Under such conditions, wild food resources on which humans relied would have tended to be relatively reliable and predictable, both seasonally and year to year, promoting stability in human adaptations.

The end of the Pleistocene was marked by rapid global warming and abrupt climatic fluctuations, including a sharp, temporary reversion to colder conditions known as the Younger Dryas (approximately 12,900 to 11,700 years ago). This increased variability and greater seasonality persisted into the new geologic period, the Holocene, in which we are still living. Under such conditions, the reliability of naturally occurring food resources would have been markedly reduced. As one apparent consequence, many large mammal species which had existed for millions of years, like mammoths and giant ground sloths, some of which were hunted by humans, suddenly became extinct.

In areas where such climatic instability was pronounced, humans too would have been under stress. Instead of relying solely on "nature's bounty," one coping strategy would have been to focus on food species whose abundance and reliability could be rendered more stable by human intervention (i.e., the expenditure of labor and the development of new or enhanced technology). Mammals such as sheep, goats, and pigs, birds such as chickens, and cereal grains, such as wheat, maize, and rice, as well as a variety of other species became the focus of human attention.

As humans became more reliant on these targeted species, they made increasing investments of labor in improving technology and infrastructure to promote the success of this new economic system. Increased sedentism (larger and more permanent villages), larger population sizes, increased territoriality and social divisions based on economic class were among the consequences. This process, once begun, was self-re-enforcing. The larger populations that could be supported by agriculture as opposed to hunting and gathering meant that there was no going back without severe consequences.

The newly reported discovery from the Ohalo II enriches our understanding of the development of agriculture, and supports the view that it does not represent a "eureka moment," a flash of discovery, but rather was the culmination of a long process of material adaptations and the dialectical interaction of a variety of natural and cultural factors, which ultimately led to a qualitative change in the ways in which humans interacted with the environment and each other, resulting in a whole range of revolutionary consequences. It also demonstrates the wealth of information that can be obtained through the use of sophisticated techniques such as microscopic use-wear analysis.

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