Disease and Death at Dr. Dickson's Mounds

The skeletal remains of prehistoric Native Americans show that agricultural revolutions can be hazardous to your health

by Alan H. Goodman and George J. Armelagos

Clustered in west-central Illinois, atop a bluff near the confluence of the Illinois and Spoon rivers, are twelve to thirteen poorly defined earthen mounds. The mounds, which overlap each other to some extent, cover a crescent-shaped area of about an acre. Since at least the middle of the nineteenth century, local residents have known that prehistoric Native Americans built these mounds to bury their dead. But it was not until the late 1920s that Don Dickson, a chiropractor, undertook the first systematic excavation of the mounds, located on farmland owned by his father. Barely into his thirties at the time, Dickson became so involved in the venture that he never returned to his chiropractic practice. Apparently, he was intrigued by the novel undertaking of unearthing skeletons and trying to diagnose the maladies of long-dead individuals. Later on, he became more concerned with the patterns of disease and death in this extinct group in order to understand how these people lived and why they often died at an early age.

The "Dickson Mounds" (the site also includes two early, unmounded burial grounds) quickly attracted the attention of professional anthropologists. In the early 1930s, a team of University of Chicago archeologists exposed about 200 of the estimated 3,000 burials and identified a number of settlement sites in a 100-square-mile area. A second phase of excavation at Dickson began in the 1960s under the direction of Alan Harn, an archeologist working for the state of Illinois, whose crew excavated many of the local living sites and more than 800 additional burials. The archeological research revealed that these prehistoric people had taken part in an important transition, from hunting and gathering to an agricultural way of life.

About A.D. 950, hunter-gatherers lived along the Illinois River valley area near Dickson, subsisting on a wide range of local plants and animals, including grasses and seeds, fruits and berries, roots and tubers, vines, herbs, large and small mammals, migratory waterfowl and riverine birds, and fish. The moderate climate, copious water supply, and rich soil made this a bountiful and attractive area for hunter-gatherers. Groups occupied campsites that consisted of a few small structures, and the debris scattered around these sites suggests seasonal use. The population density was low, perhaps on the order of two to three persons per square mile. Then, about 1050, broken hoes and other agricultural tools, as well as maize, began to form part of village refuse, evidence of the introduction of maize agriculture. At the same time, the population grew. By 1200 the population density may have increased by a factor of ten, to about twenty-five persons per square mile. Living sites became larger and more permanent. The largest settlement in the area, Larson, was a residential and ceremonial center where some 1,000 inhabitants lived, many behind a palisaded wall.

Trade also flourished. Dickson became part of what archeologists call the Mississippian tradition, a network of maize-growing, mound-building societies that spread throughout most of the eastern United States. More and more, items used at the village sites or deposited as grave offerings were not of local origin. Some, such as marine shell necklaces, came from as far away as the Gulf of Mexico and Florida, one thousand miles to the south. Everyday objects such as spoons and jars were received from peoples of the eastern plains and the western prairies, while luxury items of ceremonial or decorative value arrived in trade from the south, probably coming upriver to Dickson through Cahokia, a Mississippian center some 110 miles away. Cahokia is a massive site that includes some 120 mounds within a six-square-mile area. As many as 30,000 persons lived at Cahokia and in the surrounding villages.

What we know about Dickson might have ended at this point, but continues because the skeletal remains that Harn excavated have been used to evaluate how the

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health of these prehistoric people fared following the adoption of agriculture and other changes in their life style. Interest in this issue stems from the writings of the eminent British archeologist V. Gordon Childe (1892 1957), who believed that the development of agriculture prompted the first great revolution in human technology, ushering in fundamental changes in economy, social organization, and ideology. Archeologists continue to debate the causes of agricultural revolutions. For example, some believe that in various regions of the world, increased population pressure, leading to food shortages and declining health, spurred the switch to agricultural food production. Others believe population increase was one of the consequences of agricultural revolutions. More important to us are the effects of an agricultural revolution on the health of people who lived at the time of such change.

Three circumstances have made it possible to test the effects agriculture had upon health at Dickson. First, Harn and those working with him valued the potential information to be gained from skeletons and therefore paid close attention to their excavation. Ultimately, the skeletal remains were sent to the University of Massachusetts at Amherst for analysis by George Armelagos and many of his graduate students (this is how we became involved). Second, the recovered remains include both individuals who lived before the development of maize agriculture (Late Woodland, or pre-Mississippian) and after (Mississippian). The two groups of individuals could be distinguished according to the mounds they were buried in, their placement within each mound, and their burial position (in earlier burials the bodies tend to be in a flexed or semiflexed position; in later burials they tend to be extended). The third enabling condition was provided by Janice Cohen, one of Armelagos's graduate students. Her analysis of highly heritable dental traits showed that although Dickson was in contact with persons from outside the central Illinois River valley area during the period of rapid cultural change, outside groups did not replace or significantly merge with the local groups. It is therefore possible to follow the health over time of a single population that, for all intents and purposes, was genetically stable.

As a doctoral student working under Armelagos in the early 1970s, John Lallo, now at Cleveland State University, set out to test whether health at Dickson improved, got worse, or remained the same with the advent of agriculture and its accompanying changes. Lallo argued that intensification of maize agriculture most likely resulted in a poorer diet. Although a common assumption is that the adoption of agriculture should have provided a prehistoric people with a better diet, there are good reasons to predict just the opposite. Heavy reliance on a single crop may lead to nutritional problems. Maize, for example, is deficient in lysine, an essential amino acid. Furthermore, agricultural societies that subsist on a few foodstuffs are more vulnerable to famines brought about by drought and other disasters. Finally, increased population density, a more sedentary life style, and greater trade, all of which are associated with agriculture, provide conditions for the spread and maintenance of infectious diseases.

The skeletons of individuals who lived before and after the introduction of maize agriculture were examined for a number of different health indicators, in order to provide a balanced picture of the pattern of stress, disease, and death that affected the Dickson population. The indicators that proved most sensitive to health differences were: bone lesions (scars) due to infection, nutritional deficiencies, trauma, and degenerative conditions; long bone growth; dental developmental defects; and age at death. To avoid unconscious bias, we and the other researchers involved measured these seven traits without knowing in advance which skeletons came from each of the two cultural periods.

Persistent bacterial infection leaves its mark on the outer, or periosteal, layer of bone. Tibias (shinbones) are the most frequently affected bones because they have relatively poor circulation and therefore tend to accumulate bacteria. Toxins produced by bacteria kill some of the bone cells; as new bone is produced, the periosteal bone becomes roughened and layered. Lallo and his co-workers found that following the introduction of agriculture there was a threefold increase in the percentage of individuals with such lesions. Eighty-four percent of the Mississippian tibias had these "periosteal reactions," as compared with only 26 percent of pre-Mississippian tibias. The lesions also tended to be more severe and to show up in younger individuals in the Mississippian population.

A second type of lesion, more easily seen in the thinner bones of the body (such as those of the skull), is a sign of anemia. In response to anemia, the body steps up its production of red blood cells, which are formed in the bone marrow. To accomplish this the marrow must expand at the expense of the outer layer of bone. In severe cases, this expansion may cause the outer layer of bone to disappear, exposing the porous, sievelike inner bone. This lesion, called porotic hyperostosis, can occur with any kind of anemia. In the Dickson Mounds populations, the lesions are not severe, are restricted to the eye sockets and crania, and occur mainly in children and young adult females. This pattern suggests anemia resulting from a nutritional deficiency, specifically an iron deficiency. (A hereditary anemia, such as sickle-cell anemia, would have been more severe in its manifestation and would have affected all ages and both sexes in the population.)

There is a significant increase in the frequency of porotic hyperostosis during the Mississippian period. Half the Mississippian infants and children had porotic hyperostosis, twice the rate found for pre-Mississippian infants and children. Individuals with both periosteal reactions and porotic hyperostosis tend to have suffered more severely from each condition. This may be evidence of a deadly synergism of malnutrition and infection, like that often reported among contemporary populations.

Traumatic lesions were measured by diagnosis of healed fractures of the long bones of the legs and arms. Adult males had the highest frequency of such fractures. Approximately one out of three Mississippian males had at least one fracture, twice the frequency of their predecessors. These fractures often occurred at the midshaft of the ulna and radius, the bones of the lower arm. Fractures at this location are called parry fractures because they are typically the result of efforts to ward off a blow.

The frequency of degenerative pathologies, including arthritic conditions found on joints and the contacting surfaces of the vertebral column, also increased through time. One or more degenerative conditions were diagnosed in 40 percent of pre-Mississippian adults but in more than 70 percent of Mississippian adults.

In addition to the studies of the changing pattern of disease and trauma, we, along with Lallo and Jerome Rose, now at the University of Arkansas, assessed differences in skeletal growth and developmental timing. Skeletal growth and development are susceptible to a wide variety of stressful conditions and therefore reflect overall health. We found that in comparison to pre-Mississippians of the same age, Mississippian children between the ages of five and ten had significantly shorter and narrower tibias and femurs (the major long bones of the legs). This difference may be explained by a decreased rate of growth before the age of five. The Mississippians apparently were able to catch up in growth after age ten, however, since

adult Mississippians are only slightly smaller than pre-Mississippians.

A more detailed exploration of developmental changes came from studying defects in enamel, the hard white coating of the crowns of teeth. Ameloblasts, the enamel-forming cells, secrete enamel matrix in ringlike fashion, starting at the biting surface and ending at the bottom of the crown. A deficiency in enamel thickness, called a hypoplasia, may result if the individual suffers a systemic physiological stress during enamel formation. Since the timing of enamel secretion is well known and relatively stable, the position of such a lesion on a tooth corresponds to an individual's age at the time of stress.

We examined the permanent teeth—teeth that form between birth and age seven. For skeletons with nearly complete sets of permanent teeth, 55 percent of pre-Mississippians had hypoplasias, while among Mississippians the figure rose to 80 percent. In both groups, hypoplasias were most frequently laid down between the ages of one and one-half and four. However, the hypoplasias in the Mississippian group peak at age two and one-half, approximately one-half year earlier than the pre-Mississippian peak. The peak is also more pronounced. This pattern of defects may indicate both an earlier age at weaning and the use of cereal products as weanling foods.

The repeated occurrence of hypoplasias within individuals revealed an annual cycle of stress. Most likely there was a seasonal food shortage. This seems to have worsened in the period just before the population becomes completely "Mississippianized," suggesting that it provided a rationale for intensifying agriculture.

All the above six indicators point toward a decrease in health associated with cultural change at Dickson. However, they are not meaningful apart from an analysis of the pattern of death in these populations. Healthy-looking skeletons, for example, may be the remains of young individuals who died outright because their bodies were too weak to cope in the face of disease, injury, and other forms of stress. Conversely, skeletons that show wear and tear may be those of individuals who survived during stressful times and lived to a ripe old age.

At Dickson, however, the trend is unambiguous. Individuals whose skeletons showed more signs of stress and disease (for example, enamel hypoplasias) also lived shorter lives, on average, than individuals with fewer such indications. For the population as a whole, life expectancy at birth decreased from twenty-six years in the pre-Mississippian to nineteen years in the Mississippian. The contrast in mortality is especially pronounced during the infant and childhood years. For example, 22 percent of Mississippians died during their first year as compared to 13 percent of the pre-Mississippians. Even for those who passed through the dangerous early years of childhood, there is a differential life expectancy. At fifteen years of age, pre-Mississippians could expect to live for an average of twenty-three more years, while Mississippians could expect to live for only eighteen more years.

What caused this decline in health? A number of possibilities have been proposed. Lallo and others have emphasized the effect of agriculture on diet. Most of the health trends may be explained by a decline in diet quality. These include the trends in growth, development, mortality, and nutritional disease, all four of which have obvious links to nutrition. The same explanation may be offered for the increase in infectious diseases, since increased susceptibility may be due to poor nutrition. Furthermore, a population subject to considerable infectious disease would be likely to suffer from other conditions, including increased rates of anemia and mortality and decreased growth rates.

The link between diet and infectious disease is bolstered by an analysis of trace elements from tibial bone cores. Robert Gilbert found that the Mississippian bones contain less zinc, an element that is limited in maize. Building on this research, Wadia Bahou, now a physician in Ann Arbor, Michigan, showed that the skeletons with the lowest levels of zinc had the highest frequency of infectious lesions. This is strong evidence that a diet of maize was relied on to a point where health was affected.

The population increase associated with the changeover to agriculture probably also contributed to the decline in health. We do not believe that the population ever threatened to exceed the carrying capacity of the bountiful Dickson area (and there are no signs of the environmental degradation one would expect to find if resources were overexploited). However, increased population density and sedentariness, coupled with intensification of contact with outsiders, create opportunities for the spread of infectious disease. George Milner of the University of Kentucky, while still a graduate student at Northwestern University, argued this point in comparing Dickson with the Kane Mounds populations. Kane is located near Cahokia, the major center south of Dickson. Despite Kane's proximity to this large center, its population density was much lower than at Larson, the major agricultural village of the Dickson population. Of the two, Kane had the lower rate of infectious diseases.

While the "agricultural hypothesis," including the effects of population pressure, offers an explanation for much of the health data, it doesn't automatically account for the two remaining measures: degenerative and traumatic pathologies. Poor nutrition and infectious disease may make people more susceptible to degenerative disease. However, the arthritic conditions found in the Dickson skeletons, involving movable joints, were probably caused by strenuous physical activity. The link, then, is not with the consumption of an agricultural diet but, if anything, with the physically taxing work of agricultural production. An explanation for the increase in traumatic injuries is harder to imagine. Possibly, the increased population density caused social tension and strife to arise within communities, but why should this have happened?

A curious fact makes us think that explanations based only on agricultural intensification and population increase are missing an important contributing factor. Recent archeological research at Dickson suggests that hunting and gathering remained productive enterprises and were never completely abandoned. Many of the local Mississippian sites have a great concentration of animal bones and projectile points used for hunting. A balanced diet apparently was available. The health and trace element data, however, suggest that the Mississippian diet was deficient. There is a disparity between what was available and what was eaten.

At present our search for an explanation for this paradox centers on the relationship between Dickson and the Cahokia population. The builders of the Dickson Mounds received many items of symbolic worth from the Cahokia region, such as copper-covered ear spools and marine shell necklaces. Much of the health data would be explained if Dickson had been trading perishable foodstuffs for these luxury items. In particular, the diversion of meat or fish to Cahokia would explain the apparent discrepancy between diet and resources.

To have a food surplus to trade, individuals from the Dickson area may have intensified their agricultural production while continuing to hunt and gather. The increase in degenerative conditions could have resulted from such a heavy workload. The system may also have put social strain on the community, leading to internal strife. And the accumulation of wealth in terms of ceremonial or other luxury

items may have necessitated protection from outside groups. This would explain why the Larson site was palisaded. Both internal and external strain may have led to the increase in traumatic pathologies.

To test the validity of this scenario, we are hoping to gather additional evidence, concentrating on an analysis of trade. The flow of perishable goods such as meat is hard to trace, but we can study the sets of animal bones found at Cahokia and at Dickson village and butchering sites. The distribution of animal bones at the archeological sites can then be compared with examples of bone distributions in areas where trading has been ethnographically recorded. Further evidence is provided by data such as Milner's, which showed that health at Kane—a community that shared in Cahokia's power—was better than at Dickson.

The trading of needed food for items of symbolic value, to the point where health is threatened, may not seem to make sense from an objective, outsider's perspective. But it is a situation that has been observed in historic and modern times. An indigenous group learns that it can trade something it has access to (sugar cane, alpacas, turtles) for something it greatly admires but can only obtain from outside groups (metal products, radios, alcohol). The group's members do not perceive that the long-term health and economic results of such trade are usually unfavorable. Nor are all such arrangements a result of voluntary agreement. The pattern of health observed at Dickson is seen in most situations where there is a decline in access to, and control over, resources. For example, lower classes in stratified societies live shorter lives and suffer more from nearly all major diseases.

Agriculture is not invariably associated with declining health. A recent volume edited by Mark N. Cohen and George J. Armelagos, *Paleopathology and the Origins of Agriculture*, analyzed health changes in twenty-three regions of the world where agriculture developed. In many of these regions there was a clear, concurrent decline in health, while in others there was little or no change or slight improvements in health. Perhaps a decline is more likely to occur when agriculture is intensified in the hinterland of a political system. Groups living far away from the centers of trade and power are apt to be at a disadvantage. They may send the best fruits of their labors to market and receive little in return. And during times of economic hardship or political turmoil, they may be the ones to suffer the most, as resources are concentrated on maintaining the central parts of the system. □

Additional Reading

Dickson Mounds (p. 12)

Paleopathology and the Origins of Agriculture, edited by Mark N. Cohen and George J. Armelagos (New York: Academic Press, 1984), compares the health of prehistoric farmers with their hunter-gatherer forebears. A chapter by Alan H. Goodman et al., "Health Changes at Dickson Mounds, Illinois (A.D. 950–1300)," chronicles the effects of economic and cultural change on the health of prehistoric populations in this area. Robert Gilbert, Jr., and James Mielke edited *Analysis of Prehistoric Diets* (New York: Academic Press, 1985), a report on the methods used to interpret prehistoric nutritional stress. For a review of mankind's first three million years, see Robert J. Wenke's *Patterns in Prehistory* (New York: Oxford University Press, 1980).