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Nutrition and Health In Agriculturalists and Hunter-Gatherers

A Case Study of Two Prehistoric Populations

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Agriculture as a subsistence activity has long been viewed very positively because of the increases in population size and cultural complexity it is believed to have fostered (see, e.g., Childe, 1941; Cole, 1959; Braidwood, 1959; Harris, 1971). In contrast, hunting-gathering has been described as an inefficient and precarious means to wrest sustenance from the land.

However, recent ethnographic work has largely called into question past images of both hunter-gatherer and agricultural economies.[1] These studies have considered production, types of foods used, and some aspects of social structure, but have tended to omit detailed discussion of variables of health and food nutritional value. In this paper I consider the latter topics. My points will be illustrated with a case study of two prehistoric populations, one of which practiced hunting-gathering, and the other agriculture. This study indicates that the agriculturalists had poorer health and shorter life-spans than the hunter-gatherers, a difference apparently attributable to the inferior diet used by the agriculturalists. The argument is expanded to include other hunter-gatherer and simple agricultural populations, and, in the last section, I consider circumstances under which an inferior diet could become acceptable to a group.

According to the conventional view, agriculture is and was practiced by sedentary (settled) or at least seasonally-sedentary peoples. They are sedentary because care of their crops requires it. This is not a disadvantage, since crops can be depended upon to produce food that can be stored for gradual use. Agriculturalists thus have a stable food supply and often even have produced a surplus. The surplus is used to support population increases or to raise the caloric intake. It can be used to feed full-time artisans and other nonfarming specialists. The assurance of the daily availability of food reduces anxiety about food, and this, combined with the fact that the crops require tending for only a part of the year, produces leisure. Extra energy can be directed toward other goals—specifically, toward the building of complex societies. The existence of a stable food supply, accompanied by the production of surplus food, is considered the greatest strength of the agricultural method because it allows and supports the other changes.

The same model, in contrast, has hunter-gatherers living at the mercy of the environment, having none of the assurance that a stable food supply can give. They must be nomadic in order to take advantage of sparse wild food resources. They have little spare time, often go hungry, and live harried, short, simplified and rough lives (Cassidy, 1972 and Sahlins, 1972 review and discuss negative attitudes to the hunter-gatherer in more detail). The tendency to undervalue the way of life of the hunter-gatherer is so marked that Sahlins suggests:

> The traditional dismal view of the hunters' fix . . . was (probably) one of the first distinctly neolithic prejudices. (1972:3)

Much information now contradicts the above model. Ethnographic data on modern hunter-gatherers indicates that except in rare cases (e.g., Birhor of India, Netsilik Eskimos), these peoples have (more than) adequate food supplies of large variety and suffer malnutrition very much less often than do agriculturalists (see, e.g., discussions in Lee and DeVore, 1968; Sahlins, 1972). Some store food, but others, such as the Bushmen of the Kalahari desert in Africa, merely gather enough at one time to last for the next few days, and then go out again when necessary (Lee, 1968, 1969). There is actually more free time available than among agriculturalists. The food supply is not stable in the sense of being stored and instantly available, but it is relatively predictable to the hunter-gatherer (by season and location), and may be more stable in the face of drought, floods, or other natural disasters than are cultigens.

Little material is available that directly compares the health of hunter-gatherers and agriculturalists. The health of agriculturalists has usually been considered "good" in relation to what was perceived to be typical of hunter-gatherers. Hunter-gatherers were said to live short, tough lives, to be "forced" to eat foods the reporters considered unfit for normal human consumption, to starve frequently, to exhibit high infant mortality rates because of infection and malnourishment, and to need to practice population control by infanticide or gerontocide because food supplies were so limited. Again, ethnographic field data on hunter-gatherers contradicts this image. Some 10 percent of Bushmen live over sixty years (Lee, 1968); the health of the Hadza of Tanzania is considerably better than that of surrounding agricultural tribes (Woodburn, 1968; Scudder, 1971). Archaeological evidence shows that the introduction of corn agriculture to Illinois Woodland Indians led to a decrease in growth rate and size in childhood (Cook, 1972), while in Greece, people living in early Neolithic times had shorter life spans than those living either later (during industrialized periods) or earlier (pre-Neolithic; Angel, 1972).

From another point of view, (e.g., in Africa or Central America) studies of health in modern peasant villages indicate the people often have short life-spans, high rates of infectious and other diseases, high infant mortality rates, and much malnutrition. (Case studies can be found in, e.g., Burgess and Dean, 1962; Scrimshaw and Gordon, 1967; McCance and Widdowson, 1968; Patwardhan and Darby, 1972. Kryzwicki, 1934, provides much statistical comparative data on hunter-gatherers and agriculturalists.) Epidemiological reconstructions of the disease possibilities for peoples of the past (see, e.g., Polgar, 1964; Cockburn, 1971) indicate that hunter-gatherers suffered from a number of diseases derived from other animals (zoonoses), through contamination of foods, or wounds, or by vector routes. However, agriculturalists had all of these and had, in addition, a large number of so-called "crowd" diseases—diseases which require populations over a certain threshold size for propagation. Since hunter-gatherer groups tend to be small, the threshold is seldom if ever reached, and they are usually free of these diseases. Scourges such as plague, tuberculosis, typhoid fever, influenza, measles, and others probably were rare or nonexistent in human populations in pre-Neolithic (pre-agricultural) times. Further, there is growing evidence that specific nutritional disorders—beriberi, sprue, even kwashiorkor—did not appear until humans began living on diets consisting largely of grains. Several authors have speculated that some of the problems of malnutrition seen in modern agriculturalists result from an incomplete selective adjustment of the human organism to grain diets since the beginning of the Neolithic (Newman, 1962; Shatin, 1967).

Finally, the actual stability of food supply among agriculturalists can also be questioned. Famine is an ever-present threat if crops fail and the food supply cannot be replaced by trade or altruism. "Returning to the land" is an avenue closed to most agricultural groups—both because population sizes are too large to be supported by available wild foods, and because the people have forgotten how to hunt and gather successfully. Further, if when caloric supplies are adequate, a proper balance of nutrients cannot be maintained, malnutrition will occur in the population. This can happen because of poor soil, food preparation techniques that damage foods, or deleterious food habits. Scrimshaw and Gordon comment on these points:

> During the recent droughts in East Africa the semi-civilized tribes suffered greatly and some individuals survived by learning from the African Bushmen how to exploit long-forgotten food sources in the environment. The Bushmen themselves apparently do not suffer more malnutrition during droughts because they eat more low-preference foods and cover more ground to obtain food and water. (1967:109)

Thus, there is information to suggest that hunter-gatherers are not only better off than previously imagined, but also that living in a society dependent on agriculture is not an unmixed blessing. The conventional contrasting view of the hunter-gatherer and agriculturalist, which in so many ways gives the agriculturalist the advantages, needs to be reexamined. The following study examined health and nutrition in two pre-Columbian Amerindian groups, one pre-agricultural and the other agricultural, to determine the extent to which differences (if any) could be attributed to differences in diet.

The Research Populations

In order to study differences between hunter-gatherers and horticulturalists, it is necessary to limit the differences between the study populations as much as possible to those of subsistence method alone. Differences between the groups on other variables—as of race, natural environment, other cultural factors, and, in the case of Amerindians, amount of exposure to Europeans—must be minimal. Only under these circumstances can we be reasonably sure that the nutrition and health differences observed are primarily effected by the difference in subsistence methodology, and not by other factors. In addition, large skeletal populations in good condition are needed. These conditions were adequately met by the skeletal populations of two archaeological sites in Kentucky: *Hardin Village*, whose inhabitants practiced agriculture, and *Indian Knoll*, inhabited by hunter-gatherers.

Hardin Village is an archaeological site of the Fort Ancient Tradition,[2] located on the banks of the Ohio River in eastern Kentucky, across from the modern city of Portsmouth, Ohio. Fort Ancient villages are found abundantly in Ohio, Kentucky, and West Virginia, and have been dated from about AD 950 into the historic period (Prufer and Shane, 1970). Marquette and Joliet, the famous explorers, listed thirty-eight Shawnee villages in Ohio in the seventeenth century (Hanson, 1966). Work by Griffin (1943) indicates that in all probability Shawnee villages and Fort Ancient sites are the products of the same people.

There is general agreement that Fort Ancient peoples regularly practiced agriculture. According to Prufer and Shane, while early sites provide equivocal evidence on the degree of agricultural dependency, "for later Fort Ancient communities the evidence for intensive food production involving a developed corn-beans-squash complex is over-whelming" (1970:249).

Hanson's analysis of Hardin Village indicates that it was inhabited from approximately AD 1500 ± 50 years to AD 1675 ± 5 years (1966). The later date overlaps the historic period, but, although a few implements of brass were found in the highest levels of the village site, Hanson has concluded: "The European brass fragments and artifacts found at the Hardin Village site were probably the result of trade with other Indians, who acted as intermediaries, rather than directly with Europeans" (1966:175). Apparently, there was no significant contact with Europeans before site abandonment—a fact of importance in interpreting health data since it is well known that the arrival of Europeans usually usually signaled an abrupt increase in the frequency and types of diseases experienced by the Indians.

The village covered over eleven acres near the river bank, of which about one-tenth was excavated in 1939. It was surrounded by a stockade and contained an estimated ten to twenty dwellings that probably housed several nuclear families of the same kin group (Hanson, 1966). Population size can be reconstructed using house floor areas and assuming a minimum of $10m^2$ of floor space per individual (Naroll, 1962; Puleston, 1973). From this it appears that the size of the village nearly tripled in 150 years, from about 118 at settlement to as many as 359 just before abandonment (Table 1).

The Indian Knoll site consists of a large shell midden (refuse heap) of Archaic age, located on the Green river in western Kentucky. Culturally, it is classed with the Shell Mound Tradition of the Archaic[3] (other sites are found in Georgia, Tennessee, Kentucky, Indiana). There are numerous other Shell Mound sites in this valley and in neighboring river valleys. Archaic peoples were hunter-gatherers and are believed to have usually been nomadic. In the Shell Mound Tradition, in contradistinction to some other Archaic Traditions, river mussels and snails apparently provided stable food sources, allowing either sedentary or semisedentary occupation of sites and supporting relatively large populations. As the name implies, all these sites characteristically include large mounds of shells left over from the river harvest.

Nearly the whole of the Indian Knoll site—a midden heap with accumulations of up to eight feet in depth—was excavated between 1939 and 1941 (Webb, 1946). Carbon-14 dates give a maximum average age of 5,302 ± 300 radiocarbon years: B.C. 3352, and a minimum age of 3,963 ± 350 radiocarbon years: B.C. 2013 (Libby, 1955:94, 99). There is some argument as to whether the site was occupied on a permanent (Webb, 1946) or seasonal (Winters, 1969) basis. There is no evidence for substantial houses as at Hardin Village. Because of lack of agreement as to permanency of occupa-

TABLE 1. Estimation of population size at Hardin Village from house floor area.

House (listed in order of occupation)	Size in Feet	Size in Meters	Area in Meters	Number of Inhabitants	Estimated Village Population
1. House 6	24.5 x 51.0	7.5 x 15.7	117.8	11.8	118
2. House 4	27.0 x 66.0	8.3 x 20.3	168.5	16.9	169
3. House 1	27.5 x 57.0	8.4 x 17.5	147.0	14.7	147
4. House 5	30.0 x 70.5	9.2 x 21.7	199.6	20.0	359
House 7	29.5 x 57.0	9.1 x 17.5	159.2	15.9	

Method from Naroll, 1962; Puleston, 1973. House order of occupation and floor areas from Hanson, 1966. One more house was occupied during this time but Hanson was unable to decide to which occupation level it belonged since it contained no artifacts. Hanson considers the one-tenth of the site excavated to have been representative of the whole site (1966: 176); therefore the population estimate consists of house inhabitants times ten in each case.

tion of Indian Knoll, it is not possible to make a useful population estimate for the site.

Racially, the groups have been treated as similar since both are Amerindian and both lived for long periods in the same area of the continent. Current knowledge about population movements in Kentucky in prehistoric times does not permit any statement about the degree of genetic relationship between Hardin Villagers and Indian Knollers. However, the skeletal characteristics chosen for study were expressly picked because they are *known to vary primarily in response to nutritional stress.*

Available fauna and flora, water, and climate were so similar in the two areas (Table 2) that it may be assumed that whatever natural stresses existed at one site were probably existent at the other also, and therefore, in themselves, these should not affect health and nutrition differentially.

As mentioned earlier, population size and degree of sedentarism affect disease spread. In the cases of Hardin Village and Indian Knoll, since *both* are sedentary or semisedentary, this variable should be negligible in explaining differences in disease experience between the sites.

Archaeologically-reconstructable variability in material culture is also fairly small (though Indian Knollers used the spear-thrower and spear, while Hardin Villagers had pottery, permanent houses, and the bow and arrow). Thus in all probability the most significant difference between these two populations is in subsistence technique, with agriculture at the later site, and hunting-gathering at the earlier.

Diet in Hardin Village and Indian Knoll

The difference in subsistence technique also suggests a difference in diet. Though it is difficult in archaeological studies to determine the relative contributions of different foods to the diet, some data from these sites, taken in conjunction with faunal and floral data from nearby culturally-related site provide a general picture (Table 3). At Hardin Village, primary dependence was on corn, beans, and squash. Wild plants and animals (especially deer, elk, small mammals, wild turkey, box turtle) provided supplements to a largely agricultural diet. It is probable that deer was not a quantitatively important food source to Fort Ancient peoples. At Hardin Village,

TABLE 2. The natural environments of Indian Knoll and Hardin Village.

	Ohio County	Greenup County
Location:	Western Coalfields	Eastern Coalfields
Site of Interest:	Indian Knoll, on Green River	Hardin Village, on Ohio River
Geography:	Low hills intersected by broad alluvial valleys	Maturely dissected low mountains with steep slopes and narrow alluvial valleys
Mean Altitude:	370' above sea level on Green River at site	570' above sea level on Ohio River at site
Parent Rocks:	Sandstones and shales	Sandstones and shales
Soil Division:	Grey-brown podzolic	Grey-brown podzolic
Soil Types:	River: Waverly Elsewhere: Tilsit, Muskingum	River: Huntington Elsewhere: Muskingum
Minerals:	Bituminous coal, oil, asphaltic pitch, iron oxides as red ochre	Bituminous coal, cannel coal, oil, natural gas, iron oxides as red ochre
Former Climate at Occupation:	Atlantic IV--Sub-Boreal	Pacific II--Neo-Boreal
Modern Climate:		
Mean summer temperature	70-80°F	70-80°F
Mean winter temperature	30-40°F	30-40°F
Mean annual freeze period	180 days	180 days
Mean days w/snow cover	10-30 days	10-30 days
Normal annual total precipitation	40-48"	40-48"
Mean annual relative humidity	70-75%	70-75%
Potential natural vegetation:	Southern Hardwood Forest	Southern Hardwood Forest
Potential natural wildlife:	Black bear, bobcat, mountain lion, bison, wapiti, white-tailed deer, wolf, beaver, raccoon, opossum, cottontail rabbit, wild turkey, prairie chicken, Bob-white, passenger pigeon, dove, rattlesnake, box turtle, . . .	

Reference: Cassidy, 1972; with minor changes.

TABLE 3. Floral and faunal remains from selected Fort Ancient and Archaic sites.

(Date of Study)	1967 Blain	1902 Gartner	Fort Ancient 1901 Baum	Fort Ancient 1917 Feurt	1918 Fullerton	Shell Mound Archaic 1946 Indian Knoll	Shell Mound Archaic 1961-63 Riverton
FLORA--cultivated							
corn (<u>Zea mays</u>)	x	x	x	x	ND		
beans (<u>Phaseoius vulgaris</u>)	x	x	x	x			
pumpkin (<u>Cucurbita pepe</u>)	x						
FLORA--wild							
hickory nut	x	x	x	x		x	x
black walnut	x	x	x	x		x	x
acorn	x			x		x	x
butternut		x	x	x			x
chestnut			x				
hazelnut		x	x				x
pignut							x
wild grape	x		x				
wild red plum		x	x	x			
wild cherry	x			x			
elderberry							x
persimmon							x
pawpaw	x	x	x	x			
blackberry				x			
wild morning glory	x						
wild sunflower							x
smooth sumac	x						
Chenopod							x
Polygonum							x
bulb (lily or onion)							x

Key: ND--no data for category.
x--presence; blank space--absence.
Reference: Cassidy, 1972, Table 3.

TABLE 3. Floral and faunal remains from selected Fort Ancient and Archaic sites. (Continued)

(Date of Study)	1967 Blain	1902 Gartner	Fort Ancient 1901 Baum	Fort Ancient 1917 Feurt	1918 Fullerton	Shell Mound Archaic 1946 Indian Knoll	Shell Mound Archaic 1961-63 Riverton
MAMMALS							
white-tailed deer	x	x	x	x	x	x	x
wapiti (elk)	x	x	x	x	x		x
raccoon	x	x	x	x	x	x	x
beaver	x	x	x	x	x	x	x
squirrel	x	x	x	x	x	x	x
opossum	x	x	x	x		x	x
porcupine			x	x			x
bobcat (wildcat, lynx)	x	x	x	x		x	x
mountain lion (puma)	x	x	x	x	x		
cottontail rabbit	x	x	x	x		x	x
woodchuck (ground hog)	x	x	x	x		x	x
muskrat	x	x	x	x			x
fox	x	x	x	x		x	x
dog	x	x	x	x		x	x
wolf	x	x	x	x	x		x
coyote							x
skunk	x	x	x	x		x	x
mink		x	x	x		x	x
weasel			x				x
fisher			x	x			
otter		x	x	x			x
black bear	x	x	x	x	x	x	x
mole							x
pocket gopher							x
chipmunk						x	x

TABLE 3. Floral and faunal remains from selected Fort Ancient and Archaic sites. (Continued)

	Fort Ancient					Shell Mound Archaic	
(Date of Study)	1967 Blain	1902 Gartner	1901 Baum	1917 Feurt	1918 Fullerton	1946 Indian Knoll	1961-63 Riverton
BIRDS							
wild turkey	x	x	x	x	x	x	x
goose		x	x	x		x	x
duck			x				x
trumpeter swan		x	x	x			x
owl	x	x	x	x			x
turkey vulture						x	
crane						x	x
bald eagle		x	x	x			
great blue heron		x	x	x			
bittern		x					
prairie chicken							x
passenger pigeon	x						x
bobwhite	x						x
8 more species							x
TURTLES AND FISHES							
box turtle	x	ND	ND	ND	ND	x	x
snapping turtle						x	x
6 other turtles							x
drumfish	x	ND	ND	ND	ND	x	x
buffalofish	x					x	x
15 other fishes							x
6 other fishes	x						
MOLLUSCS							
Snails (Gastropods)	12 species	ND	ND	ND	ND	x	29 species
Mussels (Pelecypods)	26 species					x	37 species

Some of these plants and animals may not have been used for food (e.g., smallest mammals, some birds), see the reference for further discussion.

remains of deer were sparse. At the somewhat earlier Fort Ancient Blain site in Ohio, only remains of very young or aged deer were recovered (Prufer and Shane, 1970). These authors have interpreted this to indicate hunting by stalking—a relatively inefficient technique when contrasted to, for example, trapping or driving game animals. There was also little evidence for storage of wild plant foods at Hardin Village.

At Indian Knoll it is clear that very large quantities of river mussels and snails were consumed. Other meat was provided by deer, small mammals, wild turkey, box turtle, and fish; dog was sometimes eaten ceremonially. Deer remains were relatively very sparse—possibly the paucity of large mammal remains in the site reflects negatively on Indian Knoll technology, or it may be that the easy source of meat in mussels limited the appeal of hunting. The wild plant list is incomplete—more likely because of archaeological problems of preservation and collection than because of lack of utilization by the Indians themselves (Yarnell, 1964).

There are several other dietary differences. The Hardin Village diet was high in carbohydrates, while that at Indian Knoll was high in protein. In terms of quality, though Clark believes primitive agriculturalists got plenty of protein from grain diets (1963), most recent writers, such as Altschul (1962, 1965), emphasize that the proportion of essential amino-acids is the significant factor in determining protein-quality of the diet, rather than simply the numbers of grams of protein eaten. It is much more difficult to achieve a good balance of amino-acids on a corn-beans diet than when protein is derived from meat or eggs. The lack of protein at Hardin Village signaled by the archaeological data should prepare us for the possibility of finding evidence of protein deficiency in the skeletal material.

Health and Disease in Hardin Village and Indian Knoll

At Hardin Village 296 skeletons and at Indian Knoll 285 skeletons were studied. They were analyzed morphologically and by x-ray. (The techniques used are described below and in greater detail in Cassidy, 1972; only the most significant findings of the 1972 research are discussed here.)

Let us define malnutrition as a general term for physical states that result from lack or scarcity of food or deficiencies of specific nutrients. It may range from starvation with gross clinical states to mild subclinical states that affect individual functioning but are difficult to identify. Malnutrition and infections or other disease are closely interrelated:

a. Individuals who are ill are also typically malnourished because of loss of appetite or inability to take in or utilize nutrients. In such cases malnutrition may be acute—lasting just a few days—or prolonged if the disease is more chronic.

b. Persons who are malnourished, for whatever reason, are less resistant to infections and to some other diseases than are the well nourished. (See Scrimshaw, Taylor and Gordon, 1968, for a detailed discussion of nutrition-disease interrelationships.)

Modern peasant populations characterized by diets of limited variety and high carbohydrate content are also those in which infections of many kinds are commonest.

Malnutrition can be studied in skeletons in several ways. Mortality profiles, life expectancies, evidence for growth arrest, and frequency of nutritional and infectious disease will be discussed here (the following figures and statistical data are from Cassidy, 1972):

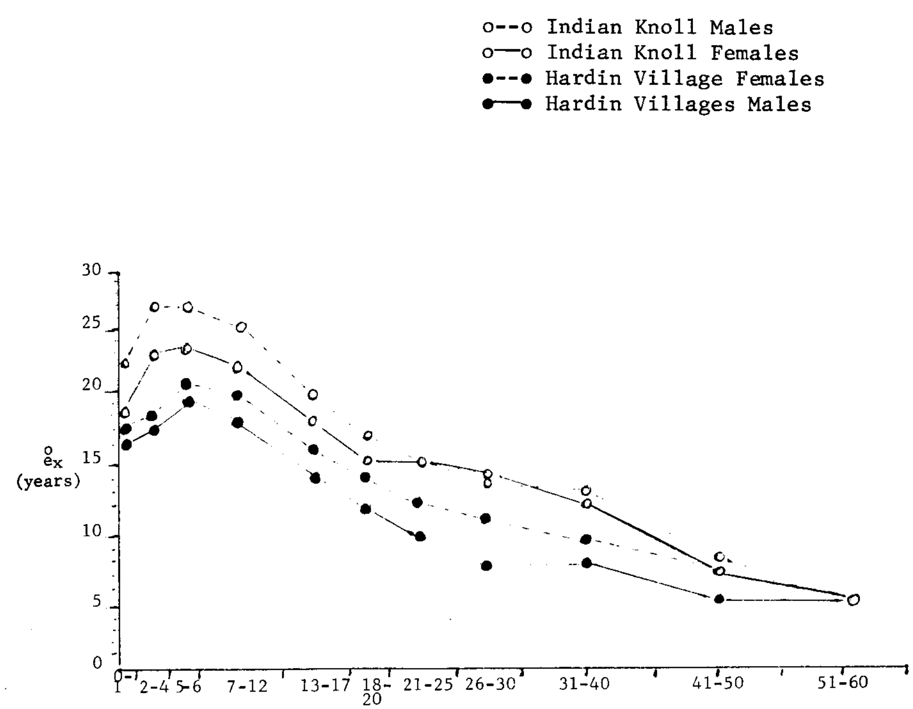
1. Figure 1 shows life expectancies for the sexes at different ages in the two groups.

These life expectancies have been derived using a composite life table, which does not require knowledge of the exact year of birth or death, as do conventional life tables (Swedlund and Armelagos, n.d.). This is important, since there are a number of good methods for aging skeletons, but they cannot give more than a close estimate of age. Therefore, skeletal material is grouped into age intervals. As can be seen in Figure 1, aging of children (based mainly on tooth eruption sequence and bone maturation) is more precise than aging of adults (based on pubic symphysis wear and tooth wear), and the age identification intervals grow from months to years as age advances. Similarly, the sex of a skeleton can be identified fairly reliably, but in this case, only in the adult. To derive sex ratios for death in childhood, I have assumed a ratio of 92 males: 100 females. This ratio is derived from karyotype (chromosome count) studies of aborted fetuses (McKusick, 1970).

Life expectancies for both male and female Indian Knollers exceeded those for Hardin Villagers at all ages. It is also interesting that the women at Hardin Village appear to have had a slight advantage over the men. A large loss of life between ages two to

four (12 months-47months)[4] at Hardin Village shows here in the failure of the life expectancy curve to rise sharply after infancy as it does for Indian Knoll.

Fig. 1. Life Expectancies at Succeeding Ages ($\overset{o}{e}_x$) for Indian Knoll and Hardin Village, by Sex.



2. Figure 2 shows the mortality profiles for the samples at each site. These are derived simply by adding males and females at each age interval, within population samples.

At Indian Knoll 44.6 percent of the children died before age 17, while at Hardin Village the corresponding figure is 53.7 percent. The difference is statistically significant ($p < 0.05$). The major difference in age at death occurs in the first four years. At Indian Knoll 70 percent of mortality under age four occurs in the first year (under 12 months), while 60 percent of Hardin Village infant and toddler mortality occurred in the next three years. The difference is highly significant ($p < 0.001$).

Fig. 2. Mortality Profiles for Hardin Village and Indian Knoll

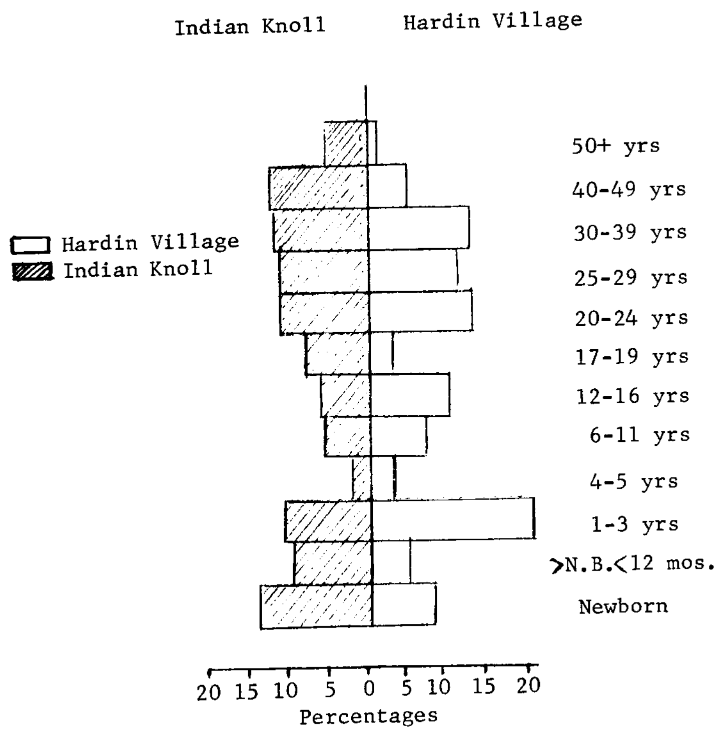
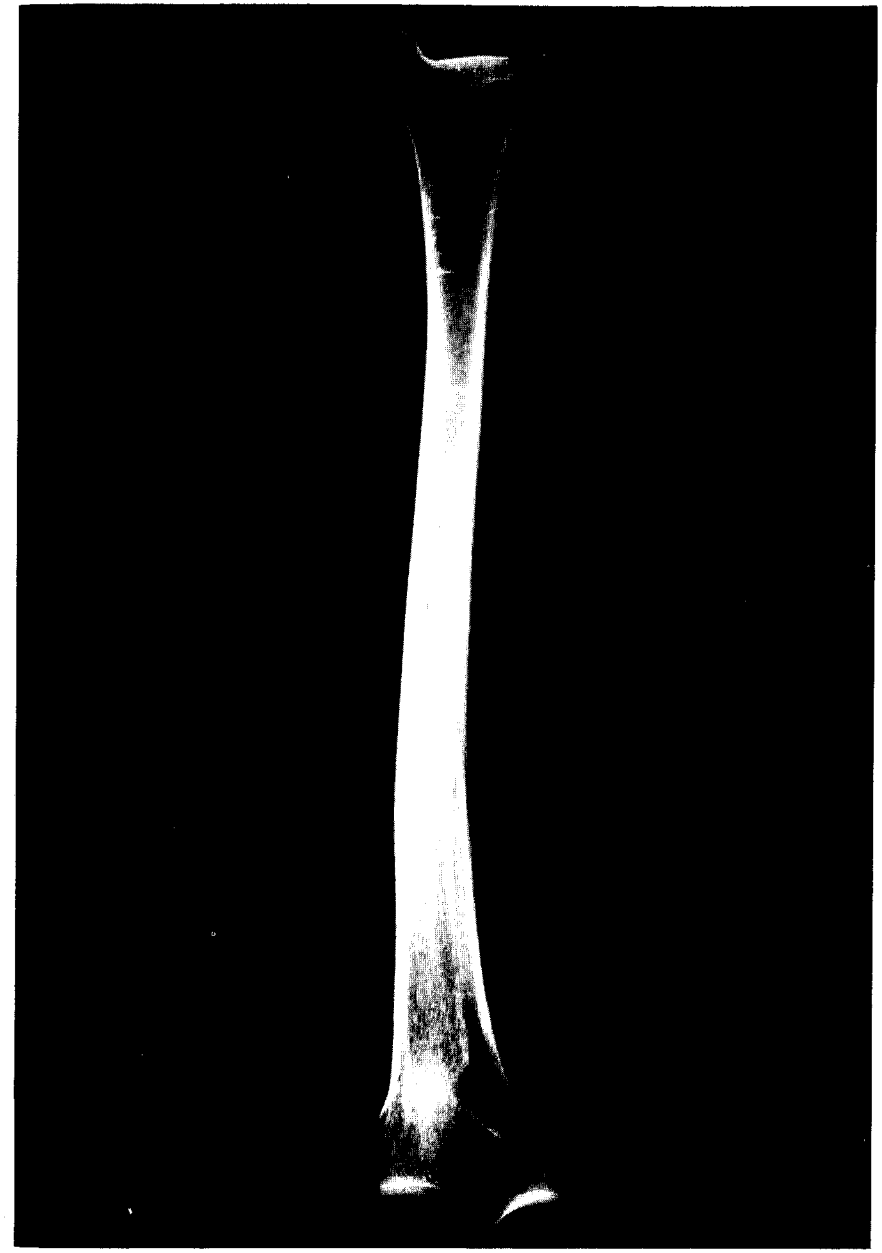


Fig. 3. X-ray photograph showing Harris Lines in a tibia.



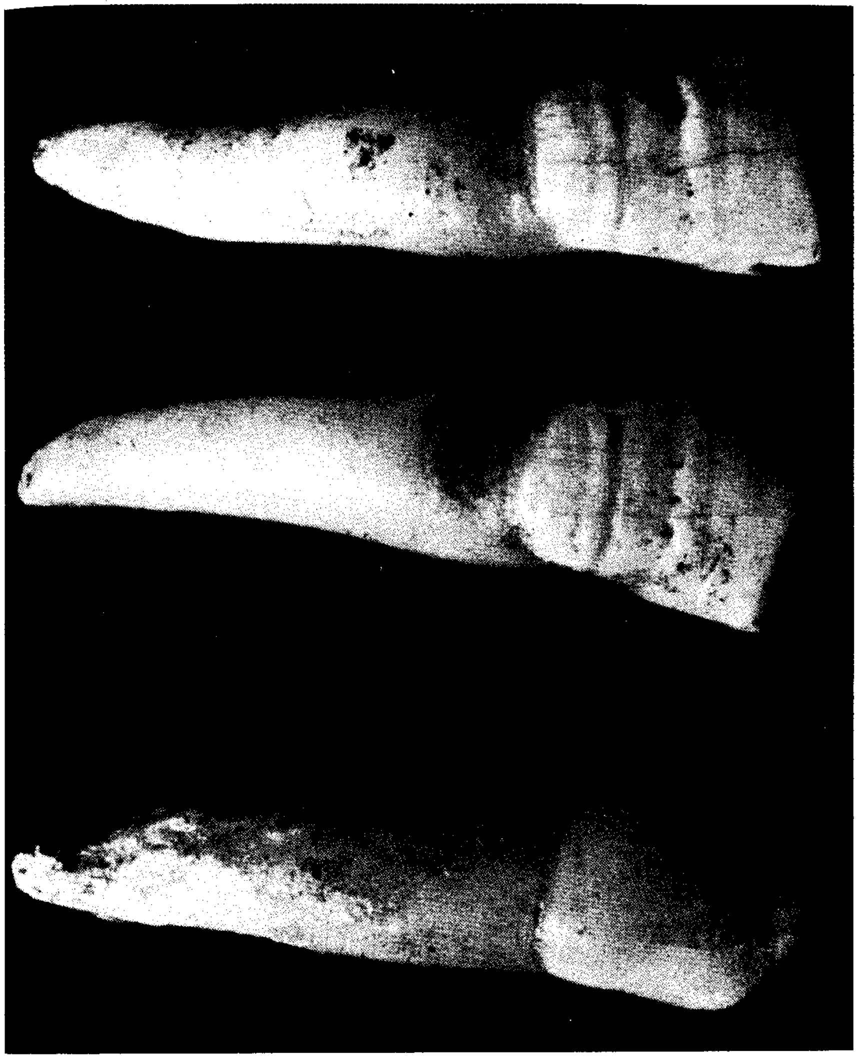
3. Iron-deficiency anemia is a true deficiency disease, often an accompaniment of low-meat diets, long-term infection, or chronic disease (Brown, 1971). It is also frequently found in cases of protein-energy malnutrition (especially in kwashiorkor). Chronic cases can be identified in skeletons from changes in the skull (Eng, 1958; Moseley, 1966). Iron-deficiency anemia chronic enough to alter the skull bones was identified in 8.2 percent of Hardin Villagers, but was absent from the Indian Knoll sample. Of the twenty-four cases at Hardin Village, twelve occurred in children under five years of age.

4. Growth arrest was analyzed by consideration of Harris' Lines (bone scars) in the tibias and of enamel hypoplasia in the teeth.

Harris' Lines (also called growth arrest lines or transverse lines) are lines of heavier deposition of calcified material which occur in long bones and are visible on x-rays as opacities spanning the marrow cavities (Figure 3). They appear in childhood following a bout of malnutrition (whether from infection or lack of food). Each line in the shaft and end of the bone indicates the person underwent one event of growth arrest lasting approximately ten days or more. Because the lines appear only *after* malnutrition is ended, they cannot provide information on the duration of the provoking event. Also, during bone remodeling, which continues throughout life, lines may disappear. Nevertheless, a summation of the lines in an individual gives at least a minimum figure on number of malnutrition events serious enough to have stopped growth temporarily during childhood. An average for a population, called the Index of Morbidity (Wells, 1967), allows interpopulation comparisons.

The deposition of the enamel of the teeth can also be interrupted during development by episodes of ill health or hunger. Such damage shows itself as horizontal lines, pits or grooves on the cheek or lip surfaces of the teeth (Figure 4. Mellanby, 1929; Wells, 1967). These defects, called enamel hypoplasia, are analogous to Harris' Lines in that they represent episodes of growth arrest in childhood. They have the advantage, though, of giving some impression, by the degree of their development, of the duration, and thus severity, of the growth arrest episode. Mellanby distinguishes three degrees of development—mild, moderate, and severe—which can be quantified to make possible intra- and inter-population comparisons.

Fig. 4. Lines of Enamel Hypoplasia, comparing a normal tooth (bottom) with two affected teeth.



An average of 11.3 bone scars were found in Indian Knoll shinbones, while the mean at Hardin Village was only 4.1. This means that in both groups growth ceased frequently but briefly during childhood. However, in contrast to the other data presented here, the higher rate at Indian Knoll might indicate more malnutrition there than at Hardin Village.

But two other pieces of information—one from the bones, and one from the teeth—alter this interpretation and bring it into line with other data indicating less good health among the Hardin Villagers: 1) The distribution pattern of scars in Indian Knoll tibias is extremely regular, indicating that malnutrition occurred at periodic intervals, perhaps as a "normal" part of life. At Hardin Village the intervals, perhaps as a "normal" part of life. At Hardin Village the lines occur randomly—a sign that intermittent malnutrition caused the growth arrest. 2) Equivalent numbers of jaws at Hardin Village and Indian Knoll had hypoplastic teeth, but the frequency of severe episodes of arrest was significantly higher at Hardin Village (p 0.05). Thus, when growth arrest occurred at Indian Knoll, it was temporary and soon made up; at Hardin Village severe and long-lasting states of malnutrition, such as might be caused by long illness, were not uncommon.

The most parsimonious interpretation of this information is that mild food shortages occurred at regular intervals at Indian Knoll; perhaps late winter was a time of danger. McHenry (1968), using growth arrest lines, and Winters (1969) using archaeological data, have similarly concluded that in the hunter-gatherer populations they studied, food shortages occurred regularly, probably on a yearly basis. At Hardin Village growth arrest was caused by illnesses or crop failures which resulted in long-lasting, but randomly-occurring, episodes of growth arrest.

5. Infections are identified in bones by the typical inflammatory changes that they provoke. Evidence for infections (other than those characteristic of the Syndrome of Periosteal Inflammation [below]) occurred with comparable frequency at the two sites ($p > 0.95$), but affected signficantly more children at Hardin Village than at Indian Knoll ($p < 0.02$). Though differences between the sexes in frequency of infection within sites was not statistically significant, there was a tendency for Hardin Village males to have more infections than Hardin Village females ($p < 0.10$); this is of interest since life expectancy for Hardin Village males was lower at all ages than for Hardin Village females.

6. A distinctive infectious disease, here identified as the Syndrome of Periosteal Inflammation, occurred at both sites but affected approximately thirteen times as many Hardin Villagers as Indian Knollers.

This syndrome is characterized by changes in the long bones, particularly those of the legs, consisting of thickening, and the development of either stripes of smooth billowed material or patches of rough porous material on the surfaces of the bones. Some diminution of the marrow spaces occurs in advanced cases by endosteal apposition. In very young children the bones, on x-ray, show layering, the so-called "onion-skin effect." This morphological picture, taken together with historical and medical data (Cassidy, 1972) suggests the identification of the disease as a treponematosis, similar to but not identical with contempoary treponematoses, which include pinta, yaws, endemic syphilis and venereal syphilis.

Part of the difference in incidence between the two sites may be explained on the basis of increase in possibilities for infection with population increase and sedentism among the Hardin Villagers. One might also propose that the infectious organism had become more common or contagious over time. But taken in conjunction with the other evidence presented above, it becomes probable that many of the cases owed their origin to lack of resistance in the host because of poor diet and general health.

7. Finally, teeth can provide information on type of diet by the kind of wear they exhibit and by their health. Unhealthy teeth are associated with poor-quality diets and are themselves often the cause of general ill health.

Tooth decay was rampant at Hardin Village, but uncommon at Indian Knoll. Adult males at Hardin Village had an average of 6.74 carious teeth/mouth, while at Indian Knoll the corresponding frequency was 0.73 per mouth. For women the rates were 8.51 and 0.91 per mouth, respectively. No Indian Knoll children under twelve years of age had caries, whereas some Hardin Village children already had developed caries in milk teeth in their second year of life. Tooth decay is closely associated with sugar content and consistency of food, occurring with higher frequency in sweet or high carbohydrate diets which are soft and sticky. Ethnographic data about methods of corn preparation among the Seneca (geographic, and in many ways, cultural neighbors of the Fort Ancient people) indicates that the typical food was indeed high in starch, sweet, and sticky (Harrington, 1908).

Tooth abscessing (infection of the pulp cavity which often drains into the tooth socket, producing characteristic damage) was frequent at both sites, and commoner at Indian Knoll than at Hardin Village in the older age group. Abscessing at Hardin Village occurred as a result of the development of massive caries which exposed the pulp cavities; this caused much tooth loss in early adulthood. At Indian Knoll, the gritty diet associated with eating river molluscs promoted rapid wear of the teeth. When enamel and dentine were worn away, and pulp cavities exposed, abscessing began. But this did not usually occur until the fourth decade of life or later; and until then tooth health was good.

To summarize the data on health derived from the skeletons:

1. Life expectancies for both sexes at all ages were lower at Hardin Village than at Indian Knoll.
2. Infant mortality was higher at Hardin Village.
3. Iron-deficiency anemia of sufficient duration to cause bone changes was absent at Indian Knoll, but present at Hardin Village, where 50 percent of cases occurred in children under age five.
4. Growth arrest episodes at Indian Knoll were periodic and more often of short duration and were possibly due to food shortage in late winter; those at Hardin Village occurred randomly and were more often of long duration, probably indicative of disease as a causative agent.
5. More children suffered infections at Hardin Village than at Indian Knoll.
6. The syndrome of periosteal inflammation was more common at Hardin Village than at Indian Knoll.
7. Tooth decay was rampant at Hardin Village and led to early abscessing and tooth loss; decay was unusual at Indian Knoll and abscessing occurred later in life because of severe wear to the teeth. The differences in tooth wear rate and caries rate are very likely attributable to dietary differences between the two groups.

Overall, the agricultural Hardin Villagers were clearly less healthy than the Indian Knollers, who lived by hunting and gathering.

Comparison of Archaeological and Contemporary Data

While the data are revealing in themselves, they become more useful if the characteristics of health and diet at these sites are compared with data on contemporary groups.

Modern hunter-gatherers usually live in marginal areas, yet, as mentioned above, they typically have adequate food supplies and enjoy balanced diets. Lee's study on the Bushmen (1968) showed many lived to old age, another parameter of good health; while

Jelliffe's medical survey of the Hadza showed high levels of health and good nutritional states in this group compared to surrounding agricultural peoples (Scudder, 1971). The picture at Indian Knoll is likewise characterized by good overall health and a good chance of living into middle or old age once past the first twelve months. This leads me to conclude that nutrition must also have been good; and the archaeological evidence on diet supports such a conclusion. Furthermore, it is quite likely that at least some of the infant mortality is attributable to infanticide; Birdsell (1968) and Washburn (1968) believe that some 15 to 50 percent of hunter-gatherer infant mortality was voluntary.

The health and nutrition situation at Hardin Village may profitably be compared with that in modern peasant villages. In many of these, children are typically fairly healthy until weaned. At this time they are introduced to a soft diet consisting largely of carbohydrates (in much of Africa and Central America, a pap is made of sugar, water, and maize flour; in Jamaica green bananas replace maize). In many cases, within a few weeks or months these children develop diarrhea, lose weight, suffer multiple infections, and may eventually develop the form of protein-energy malnutrition called kwashiorkor. In this disorder caloric intake is usually adequate, but protein and other nutrient intakes are extremely limited; without modern hospital care many victims die. The first description of this disease, in 1933, correlated its occurrence with children weaned onto maize diets (Williams, 1935). Kwashiorkor is frequently accompanied by iron-deficiency anemia.

At Hardin Village the highest rate of death occurs between the second and fourth years of life. This is typical for a population experiencing weaning problems. Considering the softness of the adult diet and the high caries rate of both children and adults, it is not unlikely that the children were weaned onto a corn pap of some type. Perhaps it was much the same as that given to children in some Central American villages today. The high prevalence of childhood infection, severity of growth arrest in the first few years of life, and the existence of iron-deficiency anemia all point to a situation at Hardin Village analogous to those in modern peasant villages. In other words the evidence supports a hypothesis that malnutrition began with weaning at Hardin Village, sometimes resulted in kwashiorkor, and continued at a low level—just enough to reduce the resistance of the population to infectious disease—throughout the life of the individual.

Since the groups were chosen in such a way as to minimize input from other sources, most of these health differences can be attributed to subsistence technique as it is expressed in dietary quality. The health data provides convincing evidence that the diet of the agriculturalists was the inferior of the two. The archaeological dietary data support this conclusion. As far as the skeletal and archaeological data will take us at this time, the inferiority of the agricultural diet lies in the lack of adequate supplies of high-quality protein.

Cultural Complexity and Health

The data from Indian Knoll and Hardin Village provide us with an interesting question to ponder and point up the need for more research on the comparative advantages of being a hunter-gatherer or being an agriculturalist: How could such an inferior diet become acceptable to a group?

The population at Hardin Village increased over the 150 years of its occupation from just over 100 people to over 300. Further, it was just one of many such villages dotting the major river valleys of Ohio and northern and eastern Kentucky. The increases in population size called for increases in hunted foods as well as in cultivated foods. At the time Hardin Village was being settled, Fort Ancient peoples had already been exploiting surrounding lands for some 600 to 700 years. Under these circumstances there must have been pressures on both wild and cultivated food sources from several directions.

As human population densities rise, many species of animals, including large game animals, leave the area (Naumov, 1972). Overhunting must have occurred in the neighborhood of the village. As time passed Hardin Villagers must have had to travel farther and farther to bag a single deer or elk; at some point the reward must rarely have been worth the effort. Warfare could have removed so many young men from the work force that hunting was to all intents and purposes out of the question. Hanson's occupational reconstruction of the Hardin Village site indicates an increase in evidence for violence just before abandonment (1966). Historical data show that the Iroquois and Shawnee were at war in the seventeenth century, the time when Hardin Village was still inhabited. Eventually the Shawnee moved south to the Cumberland River Valley, and the Iroquois extended their warfare west to the lands of the Illinois. Finally, we must also wonder if people didn't begin to prefer corn and beans to meats? There is some evidence that carbohydrates can become so palatable to humans that they eat them in preference to other foods (Shatin, 1967); such a situation may have further limited the appeal of hunting.

Thus population expansion, inefficient hunting techniques, loss of game from the area by migration and overkill, and warfare, all may have contributed to force the Hardin Villagers to become more and more dependent on a small number of high-carbohydrate agricultural foods of limited quality, and *this may have been so even were they aware of an increase in physical ill-health in the group.*

Further, at the same time that wild foods, especially meats, were becoming harder to procure, there may have been pressures on farm land that also reduced the quantity and quality of cultivated foods. Possibilities include natural or man-made disasters (the result of warfare or poor land management, for example) which could have destroyed a year's crops; loss of soil fertility on intensively cultivated lands such as those nearest the village, which would lead to a decline in nutritional quality of foods produced on that land; and the use of food processing techniques which damaged food quality.

To expand this argument: Population increase and overkill/migration of game are typical experiences and may in large part explain the overdependence of many simple agricultural groups (not practicing animal husbandry) on certain food crops even when they are well aware of the dangers of undependable climate and poor soil in producing poor quality foods. Food production, it appears, forces its practitioners into a vicious circle. Once population expansion occurs, the group cannot return to the land. Techniques of hunting-gathering are forgotten, and population size may exceed the ability of wild lands to supply adequate amounts of food. Large animals often desert the area. Gradually the agriculturalists come to depend more and more on their crops. Then, vicissitudes in weather and soil quality become more and more significant in determining the quality of life. In this situation, should an inadequate diet develop, they can do very little about it.

In the past, anthropologists gave major credit for the social changes accompanying the development of agriculture to the existence of a stable food supply. I have presented some evidence that indicates not only that the food supplies of simple agriculturalists may not be so stable as was formerly assumed, but also that even if stable, these food supplies may be of such low quality as to lead to malnutrition and other forms of ill-health. In view of current data, we should seriously consider the possibility that agriculturalists experienced population growth and increased cultural complexity *in spite of* unpredictable food supplies and supplies of low nutritional value and *despite* increased rates of ill-health. It is a curious and bitter paradox that humans, in the transitional periods to food production, exchanged many components of good physical health for opportunities to increase cultural complexity. The development must have been so slow as to blind experiencers to its occurrence. Indeed, we are only now, as we come out on the other side of what might be called "agricultural-superiority ethnocentrism," in a position to realize the fatal bargain we, as agriculturalists, seem to have made.

Notes

1. Throughout this paper, agriculturalist or agricultural economy should be taken to mean simple, early, or primitive agriculturalist or agricultural economy including contemporary peasant farmers who practice slash-and-burn techniques. Since the discussion centers on two New World groups, pastoralists are also excluded.

With slash-and-burn technique, future farm land is first cut over, fallen plant-life is allowed to dry somewhat, and then the land is fired. The resultant ashes provide fertilizer for subsequent crops. Such fields are used for two to three years and then allowed to revert to brush for a longer period, after which they may be reclaimed once again. Slash-and-burn farming has been practiced in both temperate and tropical climates, and remains common in many parts of the world.

2. Archaeologists use a taxonomy to organize sites into groups sharing spatial, temporal and/or cultural configurations. See Willey and Phillips (1958) for detailed exposition of this subject. A *tradition* is a "temporal continuity represented by persistent configurations in single technologies or other systems of related forms" (Willey and Phillips, 1958:37). A *stage* is a large division designating a major level of cultural development.

The Fort Ancient Tradition belongs to the Formative Stage, a stage in which agriculture was certainly practiced and people lived in settled villages. Peoples of the Fort Ancient Tradition lived over much of the Ohio River Valley, built their villages on the banks of large streams or rivers, and used shell-tempered pottery and small triangular projectile points (more details in Griffin, 1943).

3. The Shell Mound Tradition belongs to the Archaic Stage, which is a developmental stage characterized by nomadic but increasingly seasonally sedentary populations, practicing hunting and gathering with an emphasis on gathering, and lacking pottery and the bow and arrow. In the Shell Mound Tradition (broadly spread over Indiana, Illinois, Kentucky, Tennessee, Alabama, and Georgia) settlement occurred along streams capable of supplying large quantities of molluscs.

4. The demographer counts the first year of life as "age 1," while in the vernacular this would be counted in months. Thus the demographer's "age 2-4" corresponds to the vernacular "age 1-3." In either case the interval refers to months 12-47, roughly the age of weaning.

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