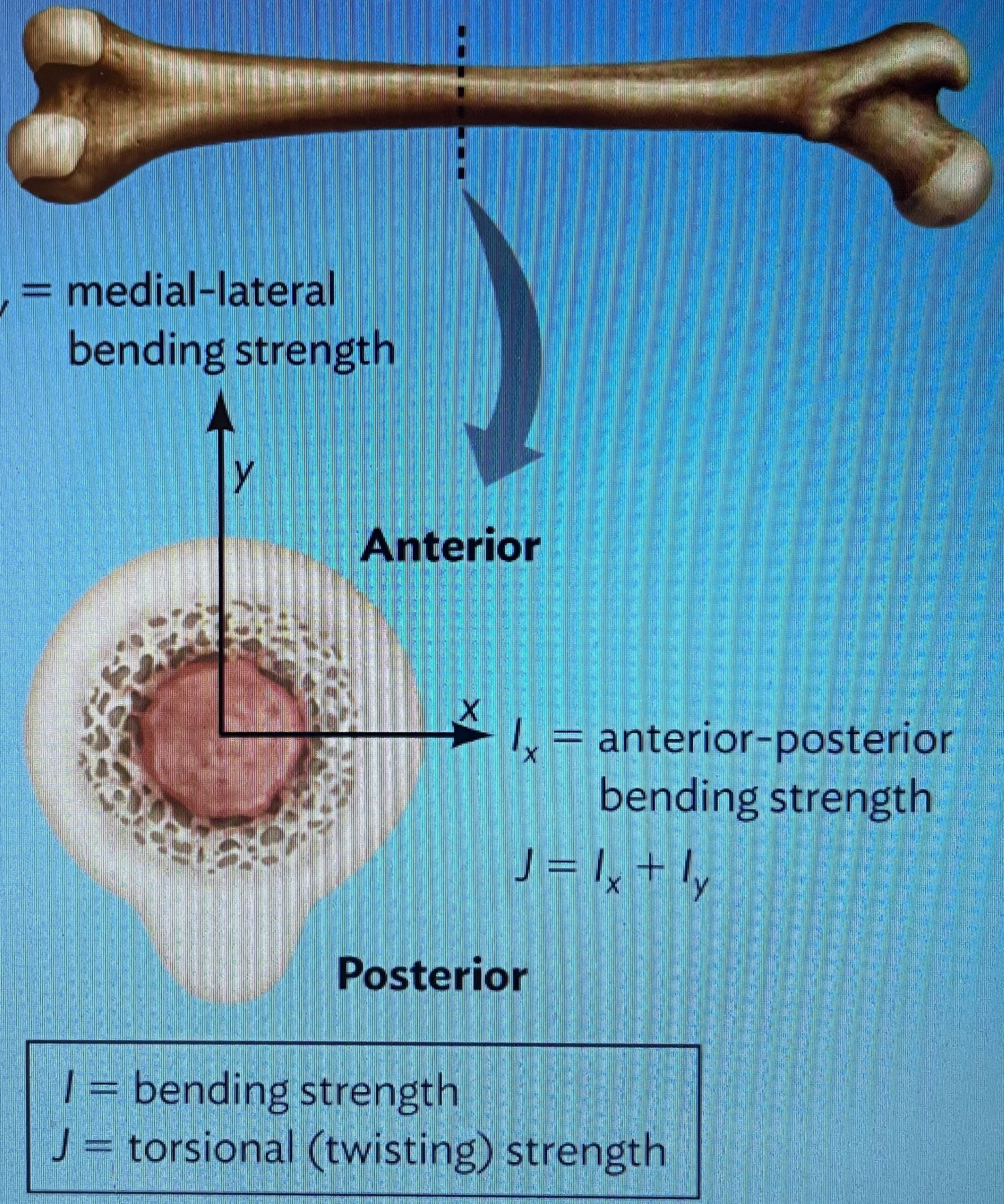
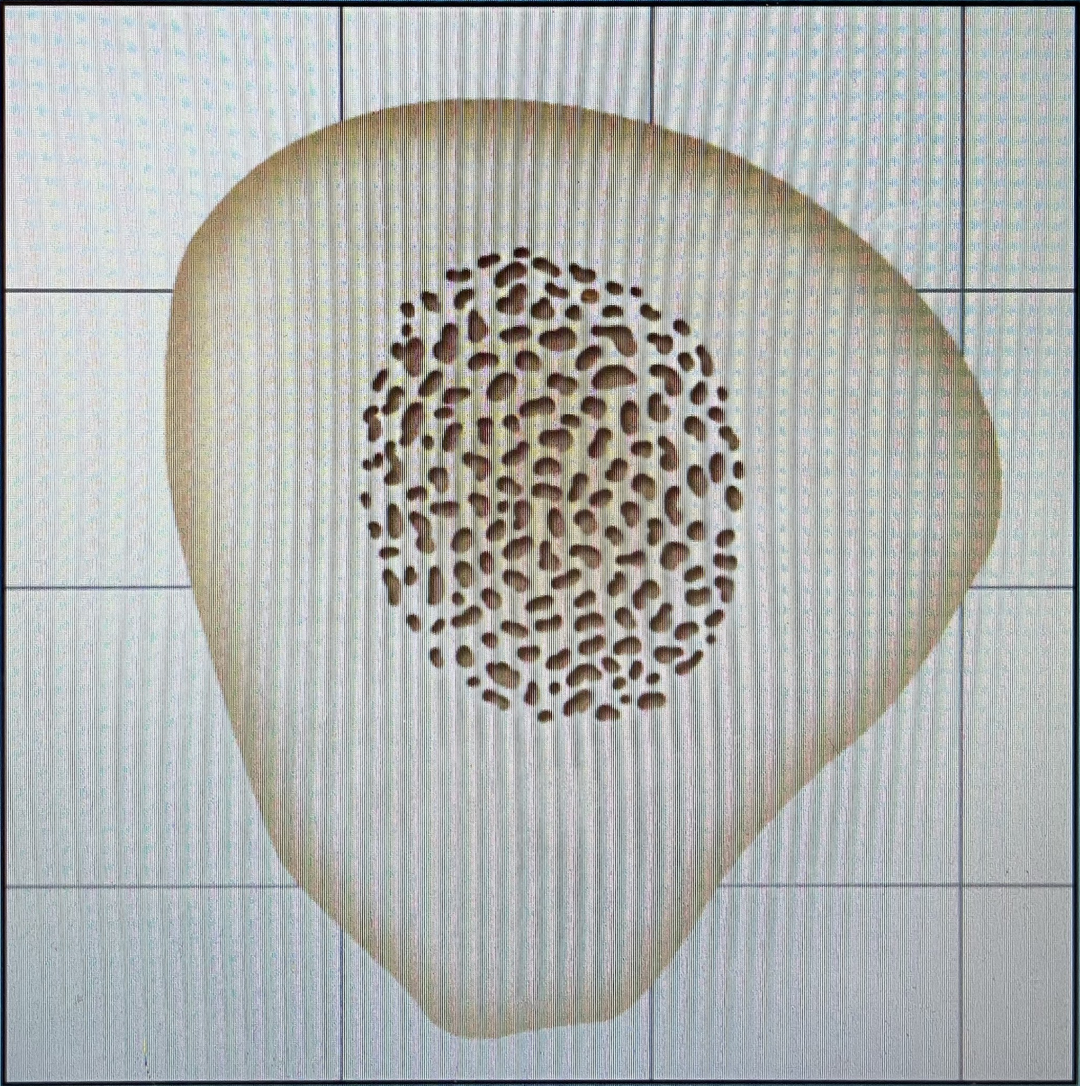


C This cross section illustrates two second moments of area: I, which reflects

C This cross section illustrates two second moments of area: I, which reflects bending strength in one of two dimensions, and J, which reflects torsional strength. The relative strength of any second moment of area (SMA) reflects the individual's activity patterns.



D This cross section is taken at the midpoint of an adult femur diaphysis from

D This cross section is taken at the midpoint of an adult femur diaphysis from a prehistoric site in Nevada. That this cross section is especially elongated from top to bottom (front and back of the bone) indicates high bending strength in that direction. The bone came from a population that was likely both physically active and engaged in long-distance movement.

American biological anthropologist Christopher Ruff has pioneered this method of assessing bone strength to document and interpret major (and very minor) trends in populations' physical activity and in adaptions to that activity. He has found one very clear trend in human evolution: bone strength in *Homo* has declined dramatically, but especially in the past 10,000 years. However, comparisons between earlier North American hunter-gatherers and the prehistoric farmers who descended from them reveal that bone strength increased in some settings and decreased in others. This variation pattern reflects the highly localized nature of the shift from foraging to farming. The study of bone biomechanics reveals that, whatever the change may have been for a particular region, the transition had a major impact on physical activity and lifestyle generally.

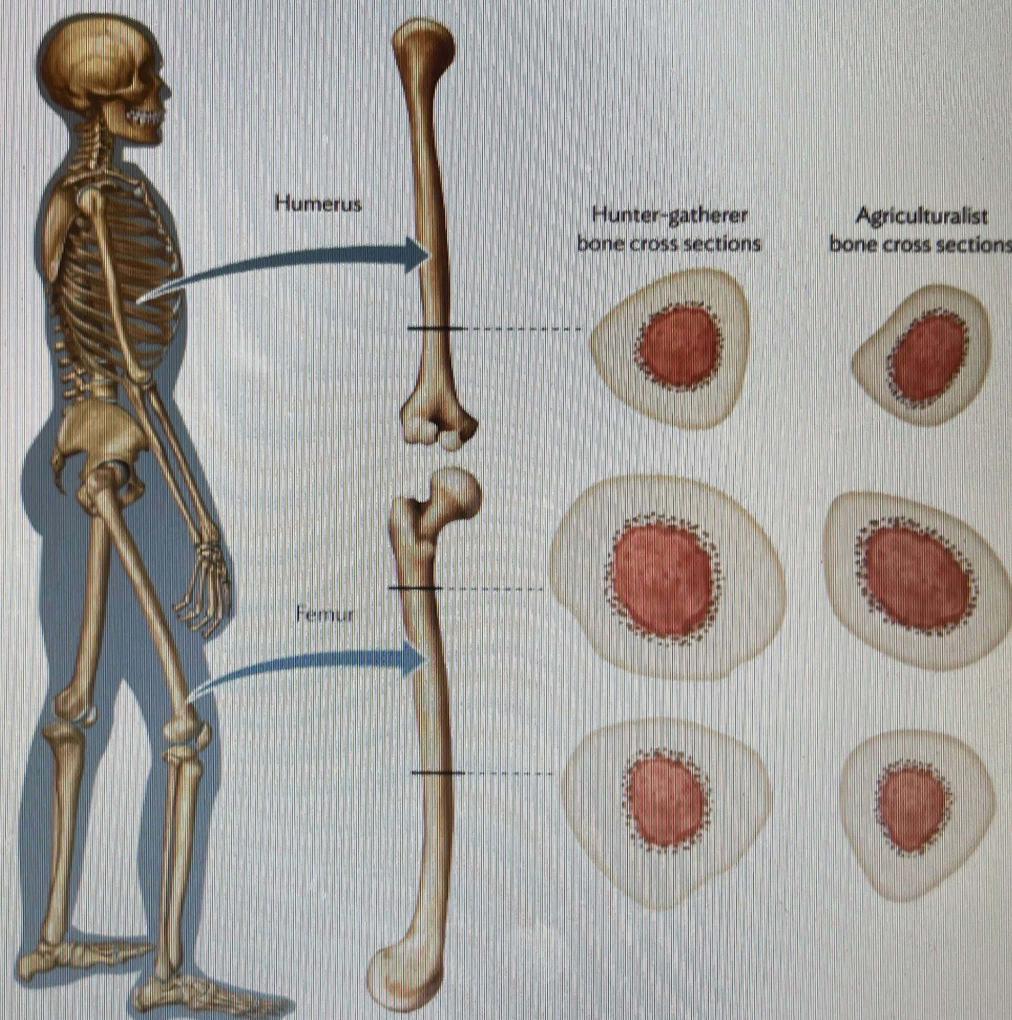


FIGURE 13.16

Activity Pattern Comparison Biological anthropologists compared cross sections of the femurs and humeri from prehistoric hunter–gatherers and agriculturalists living on the southeastern US Atlantic coast (modern states of Georgia and Florida; see the opening paragraphs of chapter 1) to determine whether significant changes in the native populations' activity patterns had agriculturalists living on the southeastern US Atlantic coast (modern states of Georgia and Florida; see the opening paragraphs of chapter 1) to determine whether significant changes in the native populations' activity patterns had occurred with the shift to farming. The larger sections in the hunter-gatherers indicate greater bone strength than in their agricultural descendants. The reduced bone strength in the Mission-era Indians reflects less mechanical stress in the prehistoric farmers in this setting.

Biological anthropologists' studies have shown that populations respond differently to the adoption of an agricultural lifestyle. For example, in our research on skeletons from the Atlantic coasts of Georgia and Florida, Christopher Ruff and I have found that agricultural populations' bones became smaller, which we interpret to mean that those populations worked less hard than their hunter-gatherer ancestors (**Figure 13.16**). We have also found a decrease in **osteoarthritis,** a disorder of the skeletal joints that results from excessive stresses on places where the bones articulate (**Figure 13.17**). In contrast, the American biological anthropologist Patricia Bridges has discovered a clear increase in bone size in Alabama populations. Which is correct? Did workload increase or decrease? Actually, both are correct. Coastal settings involved very different means of food production compared to those of noncoastal settings, reflecting the regions' differences in terrain and in other kinds of nonagricultural foods. On the Georgia coast, people collected seafood in addition to practicing agriculture. In noncoastal Alabama, people supplemented agriculture with terrestrial foods, such as deer.

In general, the reduction in human bone

In general, the reduction in human bone size represents an overall evolutionary trend in the past 20,000 years. Thanks to the increasing tool complexity and greater cultural sophistication, the biological changes came about as physical strength was replaced with technology. Ruff's studies of human remains from around the world indicate that the reduced bone mass reflects about a 10% decrease in body weight during this period. Simply, a decrease in mechanical demand on the body and its skeletal elements has resulted in increasing gracility, especially in modern humans.

FIGURE 13.17
Osteoarthritis Degenerative joint disease, or osteoarthritis, can occur in a variety of sites throughout the body, commonly in the vertebrae, hips, knees, and hands.

Health and the Agricultural Revolution

POPULATION CROWDING AND INFECTIOUS DISEASE The population increase during the Holocene, discussed extensively earlier in the chapter, was linked with agriculture and increased food production. As the population increased, communities grew more committed to raising crops and became more sedentary, living in one place the entire year. Before then, the smaller number of people had moved around at least on a seasonal basis. The increase in extensively earlier in the chapter, was linked with agriculture and increased food production. As the population increased, communities grew more committed to raising crops and became more sedentary, living in one place the entire year. Before then, the smaller number of people had moved around at least on a seasonal basis. The increase in size and density of the population, especially when the population remained in place, had enormous, negative effects on people's health. In short, humans began to live in conditions crowded and unsanitary enough to support pathogens.

CONCEPT CHECK

Labor, Lifestyle, and Adaptation in the Skeleton

The human skeleton responds to activity, reflecting the person's lifestyle. Hunter-gatherers' skeletons and agriculturalists' skeletons vary in patterns that reveal different levels of activity, including that of workload; but hunter-gatherers' skeletons tend to show higher levels of responses resulting from higher or more strenuous activity.

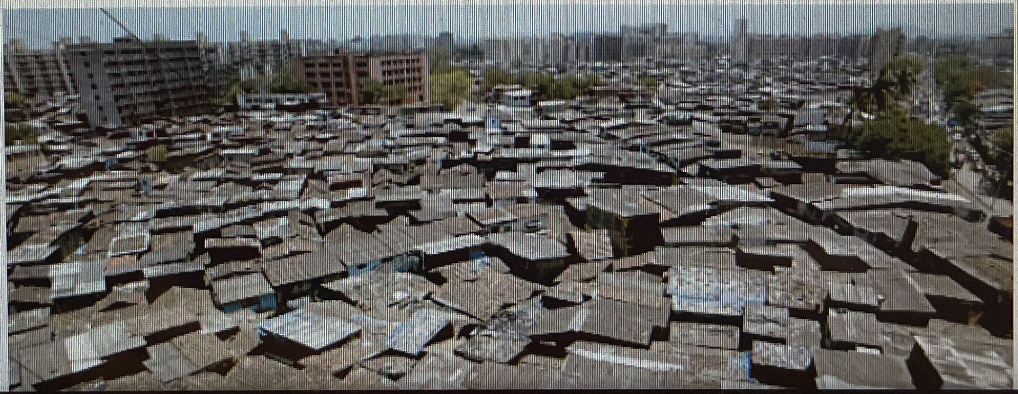
Hunter-Gatherers	Agriculturalists
Bones with higher robusticity	Bones with lower robusticity

strenuous activity.

Hunter-Gatherers	Agriculturalists
Bones with higher robusticity and size	Bones with lower robusticity and size
Larger, more robust bones	Smaller, less robust bones
More osteoarthritis	Less osteoarthritis

age 476

Consider the overcrowded cities around the globe today. In the urban slums of Bombay, India, or Rio de Janeiro, Brazil, or La Paz, Bolivia, or even within developed nations where sanitation is carefully regulated and monitored, the crowding sets up conditions for increased interpersonal contact and the spread of infectious microorganisms and viruses (**Figure 13.18**).



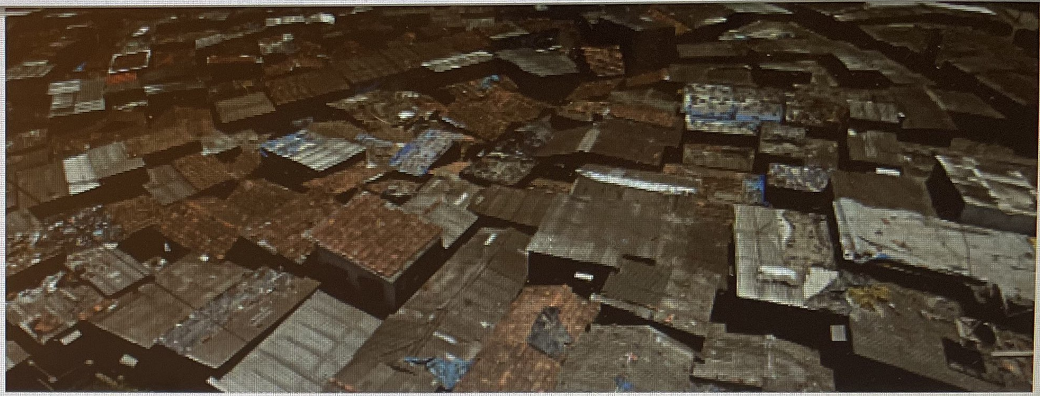


FIGURE 13.18

Overcrowding One negative effect of agriculture and the resulting increase in sedentism is overcrowding. In overcrowded slums, such as this one in Bombay, India, unsanitary conditions help increase the levels of infectious microorganisms and thus lead to disease outbreaks.

During the Holocene, especially in agricultural settings, crowding seems to have produced illnesses and injuries. Any kind of injury to the outer surface of bone can cause a **periosteal reaction**, or bone buildup, which is sometimes combined with an abnormal expansion of a bone's diameter. The reaction is often caused by localized infection, such as from the so-called staph bacteria, *Staphylococcus aureus*. The infection essentially stimulates new bone growth, hence the swollen appearance. Most periosteal reactions are nonspecific, so anthropologists cannot tell exactly what caused them. Anthropologists find, however, a general increase in periosteal reactions on the limb bones of skeletons from crowded settings in the Holocene. Such reactions are practically nonexistent in human groups pre-dating that time.

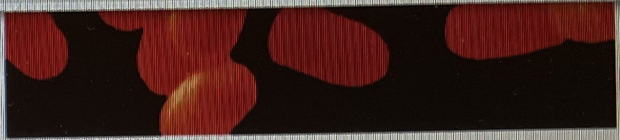
Some infections identified on bones from Holocene populations have a specific pattern that suggests the diseases that caused them. In the American Midwest and Southeast, for example, tibias are swollen and bowed, while crania have distinctive uneven, pitted texture. Both kinds of bone deformation are caused by a group of diseases called **treponematoses,** which include venereal syphilis, nonvenereal (also called *endemic*) syphilis, and yaws. Anthropologists, historians, and others debate the origin of venereal syphilis, some blaming native populations, some blaming Christopher Columbus and his ship crews, and some arguing for the appearance of a wholly new disease sometime after the initial European explorations of the New World. However, the pattern of bone changes in the New World prior to the late 1400s suggests a nonvenereal syphilis, one passed not by sexual contact but by casual contact, such as by a mother holding her child.

Many other infectious diseases likely affected Holocene populations worldwide. The skeletal indicators of tuberculosis, for example, are widespread in parts of the New World, of the Old World, and of Australia, well before the time of European exploration. For much of the mid-twentieth century, many medical practitioners thought this microbial infection had been conquered; but today, 2–3 million people die annually from the disease. Other modern diseases made possible by overcrowding include, but are not limited to, measles, mumps, cholera, smallpox, and influenza. Some of these diseases have an Old World origin, but the New World was hardly a disease-free paradise before their introduction. Bioarchaeologists have documented many poor health conditions and evidence of documented many poor health conditions and evidence of physiological stress before the Europeans' arrival in North and South America.

THE CONSEQUENCES OF DECLINING NUTRITION: TOOTH DECAY All domesticated plants have nutritional drawbacks. Because they are carbohydrates, they promote dental caries, commonly known as tooth decay or "cavities" (**Figure 13.19**). Caries is a process in which the natural bacteria in your mouth—common culprits are *Streptococcus mutans* and *Lactobacillus acidophilus* —digest the carbohydrates there. One end product of this digestive process is lactic acid, which literally dissolves tooth enamel. In industrial societies today, dentists stabilize caries by removing diseased parts of teeth and filling the cavities with composite material to stop the spread of decay. In the ancient world, dentistry was mostly nonexistent, and cavities grew until the teeth fell out or, in some instances, people with cavities died from secondary infections.

(a)

Different domesticated plants promote tooth decay at varying rates. Rice does not tooth decay at varying rates. Rice does not seem to cause it to the same extent as other domesticated plants do. Corn causes it considerably. Once post–AD 800 populations in eastern North America had adopted corn agriculture, the frequency of their dental caries rose dramatically (**Figure 13.20**).



(b)

FIGURE 13.19
Dental Caries Cavities are more common in individuals with carbohydrate-rich diets. As a result of the digestion of carbohydrates, carious lesions form as the enamel of the teeth deteriorates. In extreme cases, the pulp of the teeth can be affected. **(a)** This cross section of a tooth affected by dental caries shows two common locations of cavities: the occlusal, or chewing, surface (black arrows) and between successive teeth (white arrow). **(b)** *Lactobacillus* is one of the two main bacteria that cause dental caries.

NUTRITIONAL CONSEQUENCES DUE TO MISSING NUTRIENTS: REDUCED GROWTH AND ABNORMAL DEVELOPMENT The popular and the academic literatures suggest that agriculture has improved humans' nutrition. This conclusion makes sense given the huge worldwide investment in agriculture, even today. However, the assessment of superfoods' nutritional content argues otherwise.

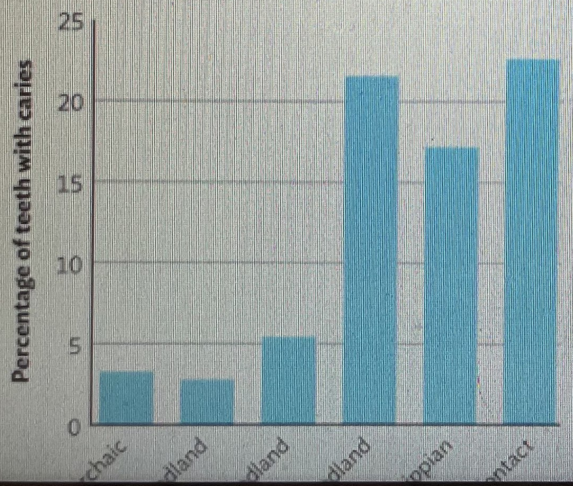
In most places where early populations relied on agriculture, there existed the potential for abnormal growth and development because of the nutritional limitations of domesticated plants. Dietary reconstructions of past societies by archaeologists and studies of living agrarian populations in different settings indicate that agriculturalists' diets tend to overemphasize one plant or a couple of them, such as rice in Asia, wheat in Europe and temperate Asia, corn in the Americas, and millet or sorghum in Africa. Thus, many groups, rice in Asia, wheat in Europe and temperate Asia, corn in the Americas, and millet or sorghum in Africa. Thus, many groups, especially in the later Holocene, received poor nutrition from an increasingly narrow range of foods. A well-balanced diet, as your parents and teachers have told you time and again, involves variety from all the food groups.

Domesticated plants have nutritional value, of course, but they also present a range of negative nutritional consequences. For example, corn is deficient in the amino acids lysine, isoleucine, and tryptophan, and a person who does not receive the right amount of even one amino acid will neither grow normally nor develop properly. In addition, vitamin B_3 (niacin) in corn is bound chemically, therefore making this essential nutrient unavailable to the body. Corn also contains phytate, a chemical that binds with iron and hampers the body's iron absorption. Also, grains such as millet and wheat contain very little iron. Rice is deficient in protein and thus inhibits vitamin A activity.

Numerous societies worldwide have developed strategies for improving these foods' nutritional content. For example, corn-dependent populations commonly treat corn with alkali, a weak solution of lye. This treatment increases availability of niacin and improves the quality of the protein. Such treatments cannot, however, entirely make up for the negative consequences of dietary overreliance on these plants.

One of the most obvious ways of assessing the impact of nutritional change in the Holocene is by looking at the growth of bones and of change in the Holocene is by looking at the growth of bones and of teeth. Like any other body tissues, bones and teeth grow to their full genetic potential only if they receive proper nutrition. Anthropologists are able to identify a few indicators of growth stress in skeletal and dental records from fossils, but these indicators are generally nonspecific; that is, they are not linked to a precise cause (for example, a particular vitamin that the person was deficient in). These stress indicators are also related to multiple factors that may or may not

include nutrition. Nonnutritional factors often include infection or infectious disease. Yet, as studies of living populations have shown, nutrition and infection have a synergistic relationship: poor nutrition worsens the infection, and vice versa; essential nutrition is used to fight the infection and is taken away from the growth process. Despite such complications, anthropologists have found these indicators to be very informative about the history of stress both in individuals and in populations.



Deficiencies in dental enamel are one of the most important nonspecific stress indicators. Typically, the deficiencies appear as lines, pits, or grooves, any of which occur when the cells responsible for enamel production (called **ameloblasts**) are disrupted. Consequently, when the disturbance ends (the illness or the infection is over), a defect, or hypoplasia, is left (**Figure 13.21**). Defects of this kind are commonplace in earlier humans' teeth—indeed, researchers have found them in

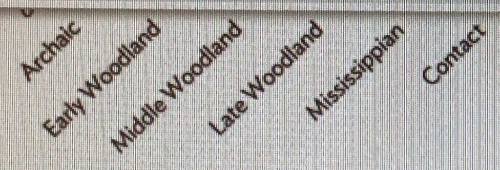


FIGURE 13.20
Changes in Oral Health This chart shows temporal changes in dental caries in eastern North America. During the Archaic, Early Woodland, and Middle Woodland periods, which predate AD 800, the region's native inhabitants were hunter-gatherers. During the Late Woodland, Mississippian, and Contact periods, which postdate AD 1000, the adoption of agriculture caused a large increase in dental caries.

indeed, researchers have found them in australopithecines—but they are rare through most of human evolution. Some hunter-gatherer populations have high frequencies, but hypoplasias became relatively common in Holocene populations. The high frequency in agriculturalists around the world was caused by two factors: decline in nutritional quality and increase in infectious disease. (Other dental defects, visible in teeth only with a microscope, reflect very short-term stress episodes, lasting several hours to several days. Virtually everyone has microscopic defects in the deciduous teeth, created as a result of birth stress.)

NUTRITIONAL CONSEQUENCES OF IRON DEFICIENCY Other markers of stress and of deprivation in agricultural populations can be linked to specific causes. Iron deficiency anemia, a problem that plagues many millions of people around the globe, results when the body receives limited iron. Iron is necessary for many body functions and is an essential element in hemoglobin, serving in the transport of oxygen to the body tissues. Iron—specifically, heme iron—enters the body easily through meat eating because the amino acids from the digestion of meat promote iron absorption. Iron from plants—nonheme iron—is not as readily available because various substances in plants inhibit iron absorption (see the earlier discussion on corn in plants inhibit iron absorption (see the earlier discussion on corn and its iron content). Citric acid found in various fruits, however, may promote iron absorption.

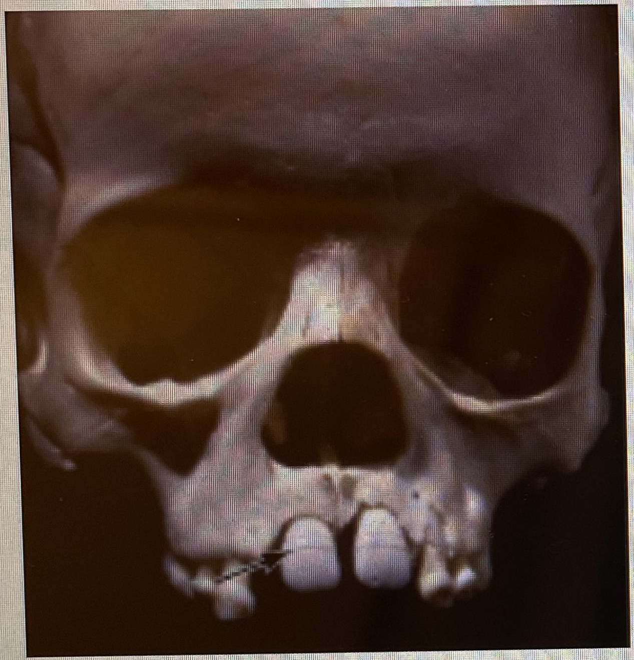


FIGURE 13.21
Enamel Hypoplasias These defects reflect stress episodes that occurred during tooth development. Individuals with multiple hypoplasias on each tooth underwent several stress episodes.

Some authorities believe that iron deficiency is rarely caused by dietary stress and is more often related to nondietary factors. Parasitic infections, for example, are a primary cause of iron deficiency anemia in many regions of the globe. One such infection, hookworm disease, is caused when someone inhales or ingests hookworm larvae. The worm (*Ancylostoma duodenale, Necator americanus*) extracts blood from its human host by using the sharp teethlike structures in its head to latch itself to the intestinal wall (**Figure 13.22**). When several hundred or more of these worms are present, severe blood loss—and therefore anemia—can result.

Abundant evidence of anemia exists among skeletons in numerous settings worldwide. In response to anemia, red blood cells increase in production, potentially leading to **porotic hyperostosis** in skulls and **cribra orbitalia** in eye orbits, in which these areas gain a porous appearance. These abnormalities were quite rare before the Holocene but then suddenly appeared, especially in agricultural groups.

NUTRITIONAL CONSEQUENCES: HEIGHTS ON THE DECLINE

In many regions where farming was adopted, adult heights declined appreciably. That people simply stopped growing as tall has been documented in western Europe, the eastern Mediterranean, Nubia, southern Asia, the Ohio River valley, and central Illinois. The Peruvian biological anthropologist Lourdes Márquez and Mexican biological anthropologist Andrés del Ángel have found a general decline in height among the Maya of the first millennium AD, a time in which this ancient civilization experienced a deterioration in environment and in living circumstances. Thus, for some groups shorter height might have been the biological result of adopting agriculture, but for other groups it might have been an adaptation to reduced resources, as smaller bodies require less food. However, all the human populations whose height decreased because of stress also experienced elevated infectious disease loads, anemia, malnutrition, and other factors indicating that a smaller body does not confer an adaptive advantage. These people were smaller but not healthier.

page 479

FIGURE 13.22
Hookworm Parasites, such as this hookworm, can cause iron deficiency. Today, hookworms are commonly found in subtropical regions of North Africa, India, and elsewhere.