bridge *History of the Native Peoples of the Americas.* Vol 1, *North America,* pt 1, 1–59. Cambridge: Cambridge University Press.

Powell JW. 1891. Indian linguistic families of America north of Mexico. In: *Seventh Annual Report of the Bureau of Ethnology for the Years 1885–1886,* 1–142. Washington, D.C.: Government Printing Office.

Rogers RA, Rogers LA, Martin LD. 1992. How the door opened: The peopling of the New World. *Hum Biol* 64:281–302.

Sapir E. 1949. Central and North American languages. In: Mandelbaum DG, ed. *Selected Writings of Edward Sapir in Language, Culture, and Personality,* 169–78. Berkeley and Los Angeles: University of California Press.

Schurr TG, Ballinger SW, Gan YY, et al. 1990. American mitochondrial DNAs have rare Asian mutations at high frequencies, suggesting they derived from four primary maternal lineages. *Am J Hum Genet* 46:613–23.

Sievers ML, Fisher JR. 1981. Diseases of North American Indians. In: Rothschild HR, ed. *Biocultural Aspects of Disease,* 191–252. New York: Academic Press.

Snow DR. 1996. The first Americans and the differentiation of hunter-gatherer cultures. In: Trigger BG, Washburn W, eds. *The Cambridge History of the Native Peoples of the Americas.* Vol 1, *North America,* pt 1, 25–200. Cambridge: Cambridge University Press.

Spencer RF, Jennings JD, et al. 1977. *The Native Americans: Ethnology and Backgrounds of the North American Indians.* 2d ed. New York: Harper & Row.

Steele DG, Powell JF. 1992. Peopling of the Americas: Paleobiological evidence. *Hum Biol* 64:303–36.

Stone AC, Stoneking M. 1993. Ancient DNA from a pre-Columbian Amerindian population. *Am J Phys Anthropol* 92:463–71.

Szathmary EJE. 1993. Application of our understanding of genetic variation in North America. In: Sing CF, Hanis CL, eds. *Genetics of Cellular, Individual, Family, and Population Variability,* 215 ff. Oxford: Oxford University Press.

Torroni A, Schurr TG, Cabell MF, et al. 1994. Asian affinities and continental radiation of the four founding Native American mtDNAs. *Am J Hum Genet* 53:563–90.

Turner CG II. 1987. Telltale teeth. *Nat History* 96:6–10.

Voegelin CF, Voegelin FM. 1965. Languages of the world: Native America, fascicle 2. *Anthropol Linguistics* 7(1):1–150.

Weiss KM. 1994. American origins. *Proc Natl Acad Sci USA* 91:833–35.

Williams RC, Steinberg AG, Gershowitz H, et al. 1985. GM allotypes in Native Americans: Evidence for three distinct migrations across the Bering land bridge. *Am J Phys Anthropol* 66:1–19.

Williams TM, Wu J, Foutz T, et al. 1994. A new DRB1 allele (DRB1*0811) identified in Native Americans. *Immunogenetics* 40:314.

Wissler C. 1917. *The American Indian: An Introduction to the Anthropology of the New World.* New York: Douglas C. McMurtrie.

Young TK. 1994. *The Health of Native Americans: Toward a Biocultural Epidemiology.* New York: Oxford University Press.

2000 DL Martin and AH Goodman. Health Conditions Before Columbus. In E R Rhoades (ed.), *American Indian Health.* Johns Hopkins University Press, pp 19-40.

2

Debra L. Martin, Ph.D., and
Alan H. Goodman, Ph.D.

Health Conditions before Columbus

The Paleopathology of Native North Americans

Information about the health status of the earliest inhabitants of North America provides a chronology of health problems that spans more than a thousand years. Studies of disease in ancient times add an important dimension to our understanding of the life struggles of a largely unknown past. This chapter provides a brief overview of health conditions and quality of life in North America before contact and colonization. Data on health in ancient societies are inferred from the analysis of a wide range of archaeologic materials, but human bones and teeth form by far the largest body of evidence. Although physicians and anatomists began publishing observations on unusual cases of pathology in the mid-1800s (Matthews, Wortman, and Billings 1893), more technical and anthropological analyses began in the 1960s (Wells 1964; Jarcho 1966; Brothwell and Sandison 1967). Employing a more integrated approach, a generation of paleopathologists developed approaches to disease in the past that emphasized population-level analyses and transformed paleopathology into paleoepidemiology (Armelagos 1969; Buikstra and Cook 1980).

New techniques for analysis of ancient human remains employ a wide range of diagnostic methods (Ortner and Putschar 1981), atlases (Mann and Murphy 1990), and procedures derived from forensics (Iscan and Kennedy 1989). For several regions in the United States, there are health chronologies spanning hundreds of years. For example, Walker (1989, 1996), using a multimethodology approach involving analysis of a number of skeletal lesions and detailed reconstruction of the environment, demonstrated that Indians of southern California who lived in marginal island environments (ca. 800 B.C. to A.D. 1150) show greater evidence of health problems than those who lived on the mainland, where food was more abundant and diverse. He also showed that there were changes over time, with increases in infectious disease from 20 percent to 30 percent.

Other regions of the United States for which large skeletal series have been studied include the Georgia coast (Larsen 1987); the Illinois River Valley (Milner, Anderson, and Smith 1991); Ottowa County, Ohio (Lovejoy 1985); and Dickson Mound, Illinois (Goodman et al. 1984). The southeastern United States has yielded abundant skeletal material (Powell 1988; Powell, Bridges, and Wagner-Mires 1991), as has the Southwest (Merbs and Miller 1985; Martin 1994; Martin et al. 1991). Human skeletal remains are relatively less abundant or nonexistent in other areas because of environmental conditions that prohibit preservation (Alaska, Canada, the Northwest, the Northeast, and Hawaii). There has been a shift toward conducting population-level analyses that shed light on epidemiologic characteristics of the health of ancient societies by providing frequencies and patterning of disease within and between populations (Cohen and Armelagos 1984; Goodman et al. 1984). The volume *Human Paleopathology and Related Subjects: An International Bibliography* (Ortner and Tyson 1997) provides a comprehensive, cross-cultural listing of publications dealing with the health status of earlier peoples. Studies of the relatively few mummified remains from North America have provided relatively little medical information, often focusing on mortuary behavior and grave offerings (Cockburn 1980; El-Najjar and Mulinski 1980). Cancers, tumors, skin diseases, and other soft-tissue diseases are relatively rare, although not absent, in the archaeologic record. For example, Ortner and Putschar (1981) listed a broad range of tumors and types of cancers that have been diagnosed in ancient material.

Much of the recent paleopathological literature emphasizes temporal and spatial variability in patterns of disease and the shift in many parts of North America at different times from an economy based on gathering and hunting to agriculture (Cohen 1989). Although not all groups in North America adopted full-blown maize agriculture, many did, and it has been the focus of intense debate and disciplinary convergence (Cohen and Armelagos 1984).

The study of North American archaeologic remains has been under protest by Native groups because historically they have had little say over the excavation and curation of their ancestors' remains (Echo-Hawk 1993). These protests led to legislation passed in 1990 entitled the Native American Graves Protection and Repatriation Act (U.S. Public Law 101-601) (see Rose, Green, and Green 1996). This law ensures that Native Americans have final say regarding the nature of studies that rely on ancestral and historic human remains (Coughlin 1994). In many ways, this legislation has redefined the nature of archaeologic research in the United States and has opened new venues of study as Native Americans and anthropologists have begun working together to reconstruct the past (Barrios 1993).

An Analysis of Pathology in Ancient Populations

Because skeletal tissue typically responds in nonspecific ways to disease, the diagnosis of a specific etiology is often difficult (Ortner and Putschar 1981). Fortunately, what does have greatest explanatory power is not the specific agent, but rather the severity, duration, and temporal course of generalized physiologic perturbations. These general stressors, as they may be read and deciphered from skeletal lesions, can provide a means for assessing the health status and degree of functional impairment that an individual experienced (Goodman et al. 1988).

To elucidate this general health/stress perspective, we developed a model to apply to studies of health in the past (Goodman et al. 1984; Martin et al. 1991). With its focus on relationships between environment, culture, and biological conditions, this model has proven useful in considering past adaptive struggles and the centrality of health (Figure 2.1). Analysis of past health begins with understanding the environmental context within which people lived. The environment greatly influences how successful groups are at procuring food, as

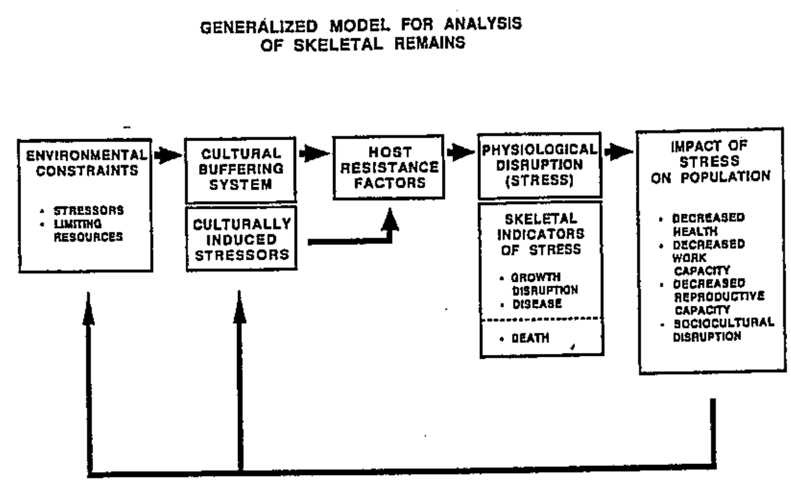

Figure 2.1. Variables that delineate adaptation of prehistoric groups. The feedback loop can be used only when the archaeologic context of the human remains is well documented.

TABLE 2.1
Summary of certain skeletal and dental indicators of disease and mortality

Indicator	Requirements	Subgroups at risk	Comments
Age/sex composition	Well-represented skeletal population	All	Age-at-death represents one of the better overall indicators of adaptation; indicates patterns of mortality.
Porotic hyperostosis	Cranium	Subadults, females	Related to iron deficiency anemia; can provide indication of severity and timing, indicates patterns of morbidity.
Periosteal reaction	Long bones	All	Related to nonspecific infectious diseases; can distinguish localized from systemic infection and provides indication of timing and severity; indicates patterns of morbidity.
Enamel defects	Any teeth	0.5 in utero to age 7	Related to acute or chronic physiologic disruption; can specify age of occurrence and peak occurrence of morbidity.
Subadult size	Subadults with dental age	Subadults	Represents the summation of factors that may affect growth and development; can indicate the timing of greatest stress.
Adult stature	Adult long bones	Subadults	Summation of preadult factors; short stature is often a response to undernutrition or chronic illness.
Osteoarthritis	Vertebrae and joints	Adults	Indication of occupational and biomechanical wear and tear on joint system and the vertebral column.
Trauma	All bones	All	Indication of accidents and violence.
Dental caries	Any teeth	All	Indication of refined carbohydrate diet; can lead to infection and tooth loss.

well as what the constraints may be in terms of providing food, clothing, and shelter. Climate, excess heat or cold, high altitude, parasites, and predators all present challenges in the environment to which successful adaptations must be made if groups are to thrive.

In terms of ancient health, it is important to understand as much about the cultural patterns as possible in order to understand which cultural customs buffered against poor health and which customs may have promoted disease.

For example, enclosed rock shelters in Colorado offered protection from the elements and predators, but they also facilitated the exchange of communicable diseases (Kunitz and Euler 1972). The development of agriculture in North America allowed greater production of calories relative to human expenditure (Wetterstrom 1986) and, thus, would seem to have provided a buffer against undernutrition. However, the resulting increased population density, along with other ecological and demographic changes associated with intensified farming, had a profound influence on health, with statistically significant increases in infectious diseases and iron deficiency anemia (Cohen and Armelagos 1984).

The response to disease stress is often a stereotypic physiologic change that results from the effort to adjust and overcome the stress, and this is frequently manifest in relatively permanent osteologic indicators (Table 2.1). Although the paleopathologist may be limited by the amount of information that can be gleaned from archaeologic remains, a multidisciplinary approach has allowed the integration of forensic, medical, and epidemiologic methods to reconstruct health conditions.

Prevalent Health Problems in Pre-Columbian Times

Paleodemography and Infant-Childhood Mortality

Paleodemography remains one of the primary and crucial sets of data for analysis of general health (Swedlund 1994). Angel (1969) argued that relatively simple statistical procedures, such as calculation of the relative proportion of deaths in infancy and childhood, are informative of the general health of populations. New World pre-Columbian groups (ca. A.D. 800–1300) in general demonstrate ranges of 10–41 percent for deaths under the age of one year (Table 2.2). The wide range of variation in percentage of infant deaths suggests that certain communities were better equipped to buffer infants from early death. The site with the highest infant mortality rate (Tlajinga) is the densely settled

TABLE 2.2
Age composition for pre-Columbian burial populations

Skeletal collection	N	% dying at age (years): <1	1–9	10–18	>18
Black Mesa, Arizona	165	10	24	14	51
Casas Grandes, Mexico	612	10	22	14	54
Pecos Pueblo, New Mexico	1,722	19	14	8	60
Tlajinga, Mexico	166	41	10	10	39
Arikara, Plains	1,487	31	24	10	26
Libben, Ohio	1,239	18	22	14	46

agrarian city of Teotihaocan near present-day Mexico City, and Storey (1992) attributes this to common communicable infectious diseases and to a general undernutrition of many of the people living there. She bases this on a detailed analysis of the infant long bones for signs of periosteal inflammation and porotic hyperostosis, a sign of iron deficiency. Sites with low infant mortality, such as the ancestral Pueblo communities of Black Mesa, Mesa Verde, and La Plata in the American Southwest, suggest that health conditions were relatively improved for infants (Martin et al. 1991).

Lifetable analysis has been used by many paleopathologists to assess the mean age at death or the life expectancy of pre-Columbian groups (Weiss and Smouse 1976; Buikstra and Mielke 1985). Life expectancy for a wide range of North American native populations in general falls between the ages of 15 and 25 (Cohen and Armelagos 1984; Buikstra, Konigsberg, and Bullington 1986; Nelson et al. 1994). What these data reveal most strikingly is not that most people died in young adulthood, but that there was generally high infant mortality combined with an ultimate life expectation of approximately 45 to 50 years (Martin et al. 1991).

Nutrition, Growth, and Development

Variation in size among contemporary groups, at least to the age of 10, depends almost completely on the environment (Habicht et al. 1974). Several aspects of growth and development provide insights into the general level of nutrition. Key among these are measures of subadult long bone lengths relative to age (based on dental development) and signs of growth disruption in teeth (Goodman and Rose 1991). Because chronological age is unknown for archaeologic samples, dental age is used as a proxy, and because sex of subadults cannot presently be reliably evaluated, males and females are averaged.

Several studies examining pre-Columbian growth patterns in children have demonstrated that changes in growth are consistent with changes in environmental conditions (Cohen and Armelagos 1984). Lallo (1973) observed a decrease in growth velocity around the time of weaning in the agricultural groups from Dickson Mounds, Illinois (ca. A.D. 900–1200). Others, such as Cook (1984), Jantz and Owsley (1984), and Mensforth (1985), have also looked closely at patterns of pre-Columbian growth in North America, and all have found evidence for growth dampening around the ages of two to five years. That seems to be a period of increased vulnerability for the growing child in prehistoric communities.

In comparing ancient with contemporary children, variability suggests a role for local conditions in growth and development. Ancestral Plains children appear to be rather close to the modern Anglo standard (Owsley and Jantz 1985),

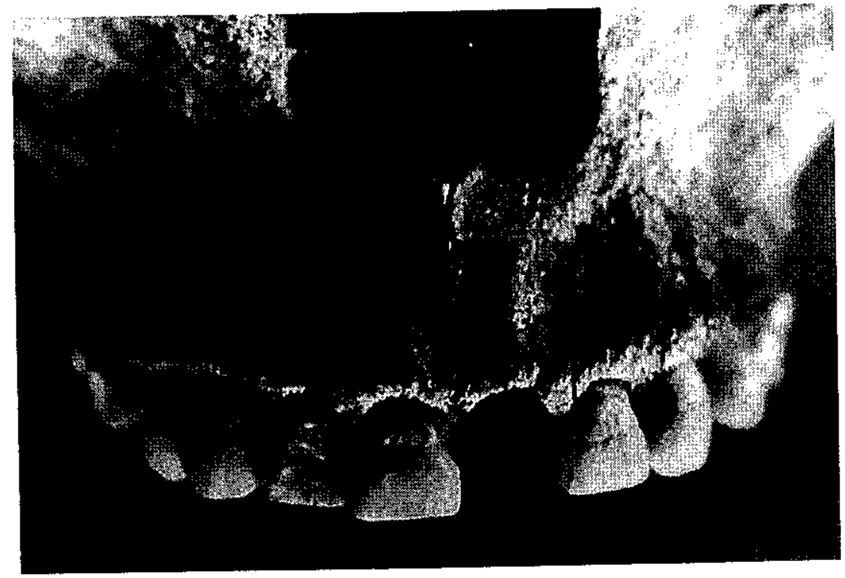

Figure 2.2. Single linear enamel hypoplasias on the upper incisors and canines. These defects formed while the individual was approximately 3 years old. The individual is a 25–30-year-old woman from northeastern Arizona (ca. A.D. 900–1150).

whereas ancestral Pueblo children are smaller (Martin et al. 1991). This most likely corresponds to the more diverse meat and wild plants diet of the Plains children (Merchant and Ubelaker 1977) versus the largely maize diet of the Pueblo children. Goodman and colleagues (1984) compared subadult growth for the Mississippian cultures in Illinois from the earliest hunting and gathering period (A.D. 950–1050) to that from the later intensive agricultural period (A.D. 1200–1300). They demonstrated that the rate of growth, especially in long bone circumferences of individuals at age two years, seemed to decrease in the agricultural group relative to the hunter and gatherer group. By five years of age, the achieved lengths and circumferences of long bones were significantly less in the agricultural groups.

Linear enamel hypoplasias (LEHs) are among the most widely studied indicators of life conditions of past populations (Goodman and Rose 1990). LEHs are caused by a temporary disruption to enamel matrix secretion, resulting in a transverse line or band of decreased enamel thickness (Figure 2.2). Once formed, these hypoplastic areas are relatively indelible because enamel does not remodel (it can be obliterated only by attrition or external forces). Furthermore, the location of LEHs is informative of the time of disruption (Goodman and Rose 1991).

TABLE 2.3
Comparative prevalence of linear enamel hypoplasias

Sample/population	Individuals affected (%)
Homo s. Neanderthalensis (1)	57
Illinois Woodland period (2)[a]	45
Pueblo I period sites (3)[a]	94
Illinois Mississippian period (2)[a]	80
Pueblo II period sites (2)[a]	94
Pueblo III period sites (2)[a]	86
Nineteenth-century poorhouse (4)	72
Highland Mexican children, 1985 (4)	57

SOURCE: Data from (1) Ogilvie and Hilton 1993; (2) Goodman et al. 1984; (3) Malville 1997; and (4) Goodman et al. 1992.
NOTE: Comparative prevalence of linear enamel hypoplasias in the permanent dentition of select samples. Earlier groups are at the top. The North American rates range from relatively low to relatively high.
[a]North American Indian groups.

Epidemiologic studies of these defects in contemporary Native Americans have been reported. In a study of Nahuatl adolescents from highland Mexico, Goodman and colleagues (1992) found that nearly 75 percent had one or more LEHs on permanent teeth and that the peak age for LEH formation was about 2–2.5 years. Infante (1974) found that 19.4 percent of White Mountain Apache children had LEHs on deciduous central incisors that formed about the time of birth, suggesting a peak period of physiologic stress for children in that group.

Hypoplastic defects are common on teeth of ancestral Indian children before colonization. LEHs on permanent teeth have been reported to occur in 50–100 percent of subjects studied (Skinner and Hung 1989). For a sense of the kinds of stress levels in different groups, Table 2.3 provides comparative data for Neanderthals, early transitional agricultural groups, intensive agriculturists, nineteenth-century poor, and contemporary Mexican children. Unlike the data on health derived from long bone growth and stature, these data are highly variable across regions and temporal units, suggesting that LEHs are more sensitive indicators of childhood physiologic disruption and illness.

Iron Deficiency Anemia

Porotic hyperostosis is an additional skeletal indicator of nutritional stress that has been extensively studied in archaeologic populations (Mensforth et al. 1978). Nearly all cases of porotic hyperostosis in North America seem to be due to iron deficiency, and the presence of low iron stores is likely to co-occur with other health problems and nutritional deficiencies (Scrimshaw 1991). Although these lesions can also be caused by hereditary hemolytic anemia as well as other disorders (Ortner and Putschar 1981), iron deficiency is accepted as the primary

cause of porotic hyperostosis for the vast majority of documented prehistoric cases (Stuart-Macadam 1987; Walker 1985).

Porotic hyperostosis is a descriptive term for lesions primarily found on the parietal and orbital bones of the cranium, produced by bone marrow proliferation diagnostic of anemia. The lesion generally takes the form of a raised, porous area that develops when the trabecular portion of the cranial bone (diplöe) expands and the outer table of bone becomes thinner, exposing the inner diplöe. Anemias can potentially affect any bone of the skeleton that is involved in the production of red blood cells, but the most frequently affected bones are those of the cranium (Figure 2.3).

Iron deficiency anemia appears to have been widespread and ubiquitous in most ancient populations in the New World (Mensforth et al. 1978; Lallo, Armelagos, and Rose 1977). The general distribution of the lesion corresponds with increasing reliance on agricultural products such as maize, which are low in bioavailable iron. For example, Lallo and co-workers (1977) evaluated changes in rates of porotic hyperostosis for ancient Mississippians in Illinois living in the twelfth century and found that it increased dramatically in the transition from hunting and gathering to agriculture. They suggested that this was due to an overreliance on maize, with its low iron bioavailability, and that the lesions were

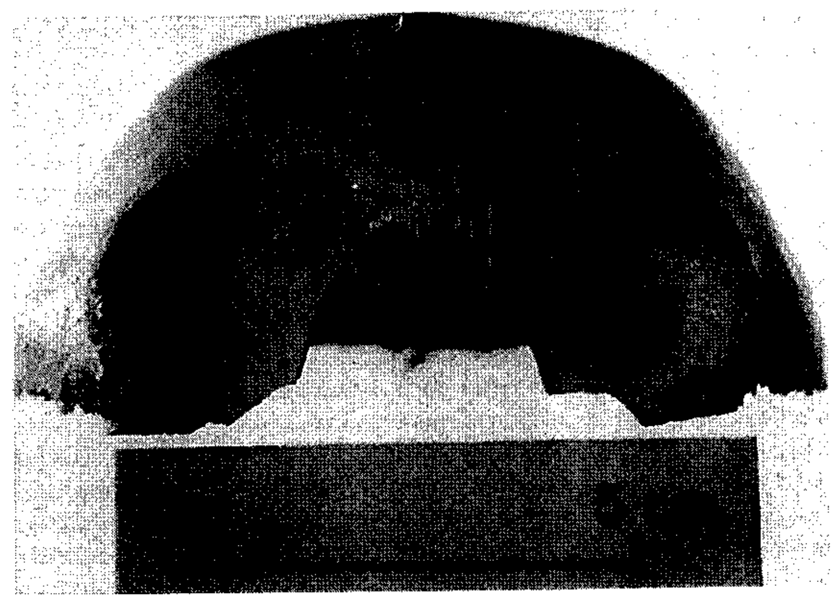

Figure 2.3. Porotic hyperostosis in the orbital region. The individual is a 5–10-year-old child from northeastern Arizona (ca. A.D. 900–1150).

most pronounced in younger children because of diarrheal disease during weaning combined with poor diet.

Palkovich (1985, 1987) studied more than two hundred burials from New Mexico representing thirteenth-century ancestral Pueblo groups. She found an early age of onset of porotic hyperostosis in infants (newborn to one year). Her interpretation is that a chronically poor diet was affecting the pregnant females and their fetuses. Other studies utilizing human remains from the ancestral Pueblo populations living throughout the American Southwest have demonstrated similar findings. Walker (1985) provided an extensive review of the skeletal data on nutritional anemia for many Southwest groups before the fourteenth century and suggested that lack of iron in the diet, prolonged breastfeeding, diarrheal and helminth infections, and living conditions conducive to the spread of disease all seem to have contributed to the prevalence of anemia.

In other regions such as the Lower Mississippi Valley (Rose, Burnett, and Harmon 1991), the coast of Georgia (Larsen 1987), and the islands off the coast of California (Walker 1996), rates of porotic hyperostosis are 30–80 percent in children and 10–45 percent in adults. In general, the skeletal record of porotic hyperostosis documents a long history of poor iron status as a major health condition across North America, particularly once maize was adopted as a primary source of food (Cohen and Armelagos 1984). However, even in marine and terrestrial environments where maize agriculture was not practiced, iron deficiency was prevalent. This suggests that local conditions caused parasitism or diarrheal disease that contributed to iron loss (Walker 1996).

Infectious Diseases

Infectious diseases are among the most significant selective forces in human evolution (Armelagos and Dewey 1970) and, in combination with undernutrition, continue to be the largest contributor to morbidity and mortality worldwide (Keusch and Farthing 1986). Although most infectious diseases leave no diagnostic markers, it is fortunate for the paleopathologist that some do affect the skeleton, changing the morphology of bone tissue (Van Blerkom 1985). Ortner and Putschar (1981, 106) estimated that the most frequent causes of infectious disease in prehistory are common microorganisms such as staphylococcus and streptococcus, with conditions such as tuberculosis and venereal and nonvenereal syphilis relatively rare and more controversial to diagnosis. The chronic (typically nonlethal) conditions are important to track at the community level because these illnesses perhaps shed the most light on everyday occurrences of poor diet, transmissible diseases, and the state of waste disposal and hygiene.

Osteomyelitis results from the introduction of pyogenic infection, and the

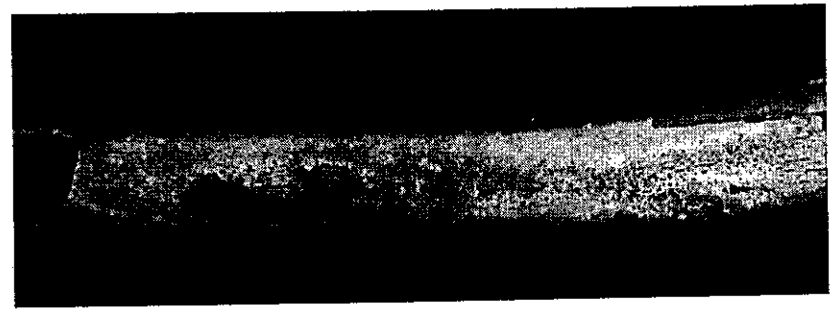

Figure 2.4. Periosteal reaction on the shaft of a femur. The individual is an 11–15-year-old child from northeastern Arizona (ca. A.D. 900–1150).

skeletal response involves the periosteum, cortex, and medullary cavity. Osteitis is another form of this phenomenon, but the reaction is primarily localized within the cortical bone. Periostitis occurs when the reaction is restricted to the outer shaft, or periosteum. It can occur as a direct response to a skin infection, through trauma, through systemic bacterial invasions, or from other soft-tissue infections (Ortner and Putschar 1981). Diagnosis and identification of the cause of the infection are very difficult, and paleopathologists have now advocated using general descriptive categories for classification of the skeletal changes observed (Buikstra and Ubelaker 1994). Referred to as *nonspecific infectious lesions,* the skeletal manifestations are categorized as periosteal reactions because the great majority of the infectious conditions seen on prehistoric bones tend to fall in this category (Figure 2.4). Specific diagnoses are attempted by paleopathologists when there are lesions that seem to fit the pattern reported for treponemal or tubercular infections, although the number of these in pre-Columbian individuals is relatively rare (Fink 1985; Micozzi and Kelly 1985).

Lallo, Armelagos, and Rose (1977) noted that the severity of periosteal reactions among Mississippian burials increased nearly fourfold during the period spanning the hunter-gatherer phase through intensive agriculture. The increase in infectious disease in the intensive agriculturalists was thought to be related to increased population density and sedentism, coupled with low dietary quality and overreliance on maize. Other trends in infectious disease demonstrated that adult women had higher rates than did men and that individuals with infections died at an earlier age. Individuals had a high co-occurrence of porotic hyperostosis and infections, suggesting that iron deficiency may have predisposed children to infectious disease by lowering resistance.

Rose, Burnett, and Harmon (1991) demonstrated that, for the Lower Mississippi Valley and the Trans-Mississippi South, there was a consistent relationship between maize agriculture dependency and increases in the infectious disease rate *only* when aggregated settlement limited the diversity of collectable resources. This suggests that, when the dietary base remained variable, infectious disease rates were lower. Thus, population density itself is not always the single determinant of the rate of infection.

Walker (1996) demonstrated that, for the Native Americans living on the Channel Islands off the coast of California, health status declined over time as people shifted from a generalized maritime hunting and gathering economy to one that focused exclusively on fishing. Despite the increase in protein in the diet, there was a decrease in overall stature and an increase in infectious disease from 10 to 30 percent for the population. Walker suggested that deficiency in other nutrients and microelements may have made the population more susceptible to infections.

Otitis media (middle ear infection) is present in many prehistoric and modern accounts of infectious diseases of children (Titche et al. 1981), and lesions found on the temporal and mastoid bones show generally high rates—up to 50 percent of children under the age of four (Martin et al. 1991). Gregg, Steel, and Holzheuter (1965) cited a rate of 52 percent for prehistoric and historic samples of Arikara, Middle Plains, and Sioux Indians. Rates of otitis media for ancestral Pueblo children from the American Southwest show that this problem was present as far back as 300 B.C., with reported frequencies approaching 80 percent of children under the age of 15 (Martin et al. 1991).

Although tuberculosis affects virtually any bone or articular surface, less than 10 percent of cases develop osseous changes, making the analysis of tuberculosis in prehistoric populations very tenuous (Ortner and Putschar 1981). Lesions thought to be tuberculosis have been identified in numerous prehistoric remains from North America. For many years it was argued as to whether tuberculosis was present in the Americas before 1492. Although the answer is in the affirmative, there are still many problems with differential diagnosis of tuberculosis on skeletal remains. Since the breakthrough study in 1973 of identification of acid-fast bacilli in prehistoric mummified tissue from South America, several seemingly secure cases of tuberculosis have been identified (Buikstra 1981, 15). Then, in 1994, a team of scientists used the DNA-amplifying polymerase chain reaction (PCR) technique to demonstrate that cells from a 1,000-year-old mummy from Peru had a segment of DNA unique to *Mycobacterium tuberculosis*. Stodder (1990) summarized findings in Southwest human remains suggesting that most of the tuberculosis cases occurred after A.D. 1200 in the larger prehistoric population centers in Arizona and New Mexico.

Treponemal infections include diseases such as venereal syphilis, yaws, pinta, and nonvenereal (endemic) syphilis. It has been demonstrated that a mild, chronic, and nonvenereal type of infection existed in precontact North America, but its distribution and frequency are still relatively unknown (Baker and Armelagos 1988). As in the case of tuberculosis, differential diagnosis is difficult. Key diagnostic traits of advanced syphilis include "saber shin," polydactylitis, and osteolytic lesions of the external nasal vault and nasopalatal region. There are numerous cases in prehistoric North American specimens (El-Najjar 1979; Stodder 1990), but all of these cases are still under intense scrutiny by the medical community.

Dental Health and Pathological Conditions

Dental caries, premortem tooth loss, abscesses, and periodontal disease are all common in studies of prehistoric dentition, although much less so than among present-day Native Americans exposed to refined and soft foods. Edentulism is common in the ancient elderly. For example, in many ancestral Pueblo groups (A.D. 1000–1300) nearly all adults over age 50 have lost all of their teeth, which has implications for their dietary intake and ultimate survival.

The advent of agriculture had a clearly detrimental effect on dental health (Clarke et al. 1986). Costa (1982) reviewed dental disease in the prehistoric Ipiutak and Tigera remains from Alaska and found moderate rates of dental disease. Conversely, the majority of adults in agriculturally based populations have multiple caries (Martin et al. 1991). Frequencies for dental caries range from 10 percent to 80 percent of dentition present (Martin and Goodman 1995).

A key factor in dental health is the grittiness of the diet and the rate of dental attrition. Sand, dirt, and small stones often are processed with maize as well as other food, which increases the rate at which teeth are worn down. A moderate rate of wear may actually protect teeth: abrasion cleans the teeth and may eliminate incipient caries. Severe attrition may expose pulp cavities and lead to premature tooth loss.

Trauma

Traumatic lesions encompass a broad range of pathologies that include fractures, crushing injuries, wounds caused by weapons, dislocations, and degenerative problems such as exostoses, osteochondritis dissecans, and spondylolysis (Ortner and Putschar 1981; Merbs 1989). The cause can sometimes be determined by analyzing the intensity and direction of the force involved as well as the degree to which healing has occurred. These provide a clue to the relationship between the event and the possible contribution of the trauma to morbidity and mortality. Forms of interpersonal violence such as warfare, scalping, mutilation, lacerations, cannibalism, trephination, and amputations can sometimes be specifically identified (Merbs 1989; White 1992). Fractures of the forearm (radius and ulna) can reveal information about the activities of the group. Colles fractures have been found in many specimens. These wrist fractures result when an individual extends the arms to break or soften a fall. More proximally located forearm fracture may result from raising the arm in front of the face to ward off a blow.

Although some studies of trauma have demonstrated that the fractures and healed lesions are indicative of the kinds of daily occupational hazards and accidents to which people are susceptible (Merbs 1983), other studies have focused on the distribution and severity of healed lesions as an indicator of interpersonal violence. Most studies of osteologic evidence of trauma have tended to focus on male activities related to warfare (Wells 1964; Brothwell and Sandison 1967). Injury and risk-group identification that contextualized violence has been reported for a precontact site in Michigan (Wilkinson and Van Wagenen 1993) and for precontact sites along the California coast (Walker 1989). Both of these studies provide models for considering ritualized, institutionalized, or sanctioned violence against women in the Michigan case and men in the California case.

The osteologic and archaeologic literature on ancestral Pueblo Indians of the Southwest (A.D. 1100–1300) provides an example of the health effects of trauma and violence. Wilcox and Haas (1994) provide detailed overviews of archaeologic data that demonstrate evidence of sustained intervillage conflict in the form of fortified villages, palisades, and towers. Skeletal assemblages that are disarticulated, broken, chapped, sometimes burned, and with signs of dismembering have been identified. These collections, which include both children and adult men and women, have been interpreted to represent episodes of cannibalism (Turner 1993; White 1992), witchcraft retribution (Darling 1993), warfare (Wilcox and Haas 1994), or ritualized dismemberment (Ogilvie and Hilton 1993). Whatever the motivation behind these deaths, the evidence suggests violent action directed against certain subgroups.

Evidence for violence directed against women in the tenth through thirteenth centuries comes from ancestral Pueblo sites in the La Plata Valley region of northern New Mexico (Martin 1997). Compared to men, women had a threefold increase in the frequency of healed cranial depression fractures among adults and a twofold increase in trauma of the ribs and limbs. Females also had more cases of infection than males, and they demonstrated higher frequencies of enamel defects, again suggesting that they were possibly members of a targeted group from childhood onward. Although this one case study clarifies the kinds of related studies that are needed to understand trauma in prehistory, local conditions in highly variable settings suggest generally low frequencies of broken bones and sustained injuries (Cohen and Armelagos 1984). Several studies

have documented an increase in trauma, particularly at the time of Columbian contact (Stodder 1989).

Osteoarthritis

Osteoarthritis is among the oldest and most commonly known diseases affecting humans. Measuring the amount of arthritic involvement with skeletal remains is sometimes difficult because of the potentially large number of areas to be assessed (each vertebra and all joint systems) and the range of variation in bony response among individuals. Although many factors may contribute to the breakdown of skeletal tissue, the primary cause of osteoarthritis is related to biomechanical wear and tear and functional stress (Ortner and Putschar 1981). Biomechanical stress is most apparent at the articular surfaces of long bone joint systems and is referred to as *degenerative joint disease* (DJD). There may be a relationship between DJD and other health problems. For example, a study correlating the incidence of DJD and infection was undertaken for a Mississippian population from Illinois (A.D. 1000–1200). Individuals with multiple joint involvement demonstrated a statistically higher percentage of periosteal reactions. Both infectious lesions and DJD increased with age, and women demonstrated greater frequencies of DJD in the shoulder and elbows than did age-matched men.

In general, early Native Americans appeared to sustain osteoarthritis at rates comparable with individuals today, although the earlier rate of onset and decreased life span of earlier Native Americans may have served to compress the observable cases into a shorter time frame within the life span (Aegerter and Kirkpatric 1968). Much work in the area of osteologic correlates of occupational stress and weapon use suggest strong associations between lifestyle and patterns of osteoarthritic and other bone changes (Kennedy 1989; Bridges 1990).

Demography and Disease at Contact

There is wide agreement about the effects of diseases and epidemics associated with European contact (Dobyns 1983; Ramenofsky 1987; Reff 1988). The first well-documented, widespread epidemic in what was to become New Mexico was smallpox in 1636. Shortly thereafter, measles entered the area, and many Pueblos lost up to a quarter of their inhabitants (Chavez 1957). After the founding of Spanish settlements and missions, there was substantially more contact, and throughout the seventeenth century, epidemic disease was repeatedly imported.

Osteologic data demonstrate that native groups were most definitely not living in a pristine, disease-free environment before contact. Although New World indigenous disease was mostly of the chronic and episodic kind, Old World diseases were largely acute and epidemic. However, different populations were affected at different times and suffered varying rates of mortality (Larsen 1994, 109). Diseases such as treponemiasis and tuberculosis were already present in the New World, along with diseases such as tularemia, giardia, rabies, amebic dysentery, hepatitis, herpes, pertussis, and poliomyelitis, although the prevalence of almost all of these was probably quite low in any given population (Ortner and Putschar 1981). Old World diseases that were not present in the Americas until contact include bubonic plague, measles, smallpox, mumps, chicken pox, influenza, cholera, diphtheria, typhus, malaria, leprosy, and yellow fever (Larsen 1994). Indians in the Americas had no acquired immunity to these infectious diseases, and these diseases caused what Crosby (1976) referred to as *virgin-soil epidemics,* where all members of a population would be infected simultaneously.

It is important to look not only at the effects of specific events like epidemic outbreaks, but also at longer-term processes that influence the age and mortality structure of populations. Kunitz and Euler (1972, 40) stated that "one does not need to invoke large-scale dramatic epidemics; prosaic entities like malnutrition and infectious diarrhea are more than sufficient to do the job." Neel (1977, 155) likewise cautioned that, to understand the influence of introduced diseases on indigenous peoples, one must first know the longer history and "epidemiologic profile" of the populations. This points to the value of incorporating the information on precontact health as a precursor to understanding the impact of contact.

Lessons from the Past

The importance of understanding health within a broad historical framework is illustrated by the following example, which draws on recent collaborative investigations into endemic health problems of the indigenous groups who call themselves the Pima and Tohono O'odham in southern Arizona. High rates of diabetes, hypertension, and obesity have plagued members of these groups since the 1940s. Recent multidisciplinary efforts to understand the etiology of these patterns have combined oral history, anthropologic, archaeologic, and epidemiologic information on diet and health to better understand the progression of these health problems over time (Smith, Schakel, and Nelson 1991). Some Pima Indians have begun to incorporate traditional foods such as lima beans, tepary beans, mesquite pods, and maize into their diet, with positive health results

(Cowen 1990). Research such as this examines the larger interacting sphere of culture, environment, and biology, and such studies on ancestral menus and ancestral health trends may continue to provide important clues to today's health problems.

Archaeologic remains have value beyond locating disease in time and space. They can aid in guiding current assessment of and decisions regarding health care. For example, at the request of Omaha Indians, paleopathologists analyzed Omaha burials from the late 1700s (Associated Press 1991). It was originally thought that many deaths during that time were a result of epidemic infectious diseases. The analysis, however, demonstrated very high levels of lead isotopes in 50 percent of the skeletal remains, suggesting that many of the deaths may have been due to lead poisoning. This was traced to the use of trade items procured by Indians from colonists, such as casks, paint, and bullets. Dennis Hastings, a tribal historian, stated that "the skeletal remains of our ancestors are speaking to us through science" (Associated Press 1991, F1).

REFERENCES

Aegerter E, Kirkpatric JA Jr. 1968. *Orthopedic Diseases.* 3d ed. Philadelphia: W. B. Saunders.

Angel JL. 1969. The bases of paleodemography. *Am J Phys Anthropol* 30:427–37.

Armelagos GJ. 1969. Diseases in ancient Nubia. *Science* 163:255–59.

Armelagos GJ, Dewey JR. 1970. Evolutionary response to human infectious disease. In: Logan MH, Hunt EE, eds. *Health and the Human Condition,* 101–6. North Scituate, Mass.: Duxbury Press.

Associated Press. 1991. Lead poisoning culprit in Omaha tribe's death. *Albuquerque Journal,* October 4, F1.

Baker B, Armelagos GJ. 1988. The origin and antiquity of syphilis: Paleopathological diagnosis and interpretation. *Curr Anthropol* 29:703–20.

Barrios P. 1993. Native Americans and archaeologists working together toward common goals in California. *Soc Am Archaeol Bull* 11(3):6–7.

Bridges PS. 1990. Osteological correlates of weapon use. In: Buikstra J, ed. *A Life in Science: Papers in Honor of J. Lawrence Angel,* 87–98. Center for American Archaeology Scientific Papers 6. Washington, D.C.: Center for American Archaeology.

Brothwell D, Sandison AT. 1967. *Disease in Antiquity.* Springfield, Ill.: Charles C Thomas.

Buikstra JE, ed. 1981. *Prehistoric Tuberculosis in the Americas.* Evanston, Ill.: Northwestern University Press.

Buikstra JE, Cook DC. 1980. Paleopathology: An American account. *Annu Rev Anthropol* 9:433–70.

Buikstra JE, Konigsberg LW, Bullington J. 1986. Fertility and the development of agriculture in the prehistoric Midwest. *Am Antiquity* 51:528–46.

Buikstra JE, Mielke JH. 1985. Demography, diet, and health. In: Gilbert RI, Mielke JH, eds. *The Analysis of Prehistoric Diets,* 359–422. New York: Academic Press.

Ward RH, Weiss KM, eds. *The Demographic Evolution of Human Populations*, 59–74. New York: Academic Press.
Wells C. 1964. *Bones, Bodies, and Disease*. New York: Praeger.
Wetterstrom W. 1986. *Food, Diet, and Population at Prehistoric Arroyo Hondo Pueblo, New Mexico*. Santa Fe: School of American Research Press.
White TD. 1992. *Prehistoric Cannibalism at Mancos 5MTUMR-2346*. Princeton: Princeton University Press.
Wilcox DR, Haas J. 1994. Competition and conflict in the prehistoric Southwest. In: Gumerman GJ, ed. *Themes in Southwest Prehistory*, 211–38. Santa Fe: School of American Research Press.
Wilkinson RG, Van Wagenen KM. 1993. Violence against women: Prehistoric skeletal evidence from Michigan. *Midcontinental J Archaeol* 18:190–216.

3

C. Matthew Snipp, Ph.D.

Selected Demographic Characteristics of Indians

The planning and implementation of health-care programs begin with an assessment of the demographic characteristics of the population under consideration. This chapter provides an overview of some of the demographic characteristics of American Indians considered to be useful in understanding disease patterns and planning health programs. It is not intended to be an exhaustive analysis of the factors underlying various changes within Indian populations. Such information includes the numbers of Indian populations and subpopulations, fertility and birth rates, age and gender distributions, recent migration patterns, locations of residence, and levels of economic attainment.

Enumeration of the Indian Population

Enumeration of the Indian population has always been confounded by a number of factors: variations in self-identification, isolation, mobility, and rapid change. The base estimates of the Indian population are derived from the decennial censuses. Several important qualifications should be borne in mind. Continued modifications and refinements of censuses make comparisons between various time periods somewhat problematic. For example, a major shift occurred in the 1960 Census, when race was first designated by the individual rather than by the enumerator. In the 1990 Census, approximately 8.8 million individuals indicated that they had *some* Indian heritage. Of these, 1,959,200 indicated that this heritage was significant enough that they designated their race as American Indian or Alaska Native. The self-identified population that is most appropriate for health planning is thus open to some question. However, the smaller number is the one that has generally been used for health planning.

The dramatic growth in the Indian population since 1960 (an average annual