Mummies, Disease & Ancient Cultures

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ideas are associated with cannibalism, because the eaten parts of the foe's body transfer analogous qualities to the eater, an idea still believed by many primitive populations. Human sacrifices of any kind, including headhunting, are intimately related to fertility rites (the cycle of life), to the initiation of boys to manhood, to better status in the other world, where the head of the victim will assure his services to the owner, and to immanent or real power in the widest sense of the word— for example, related to the building of a new house or the launching of a war canoe. The special importance of hair has been mentioned already and may be compared to the biblical story of Samson and the use of amulets, arm rings, and necklets made from the hair of slain foes and therefore of magic virtue. In the British Museum in London, there is a tsantsa of a sloth, considered by the Jíbaros and other South American tribes as the forefather of mankind, probably because of its hairy aspect. Because of the reduced size of tsantsas, the hair of the head, which was practically never cut during the life span of the victim, seems extremely long and is frequently braided and/or adorned with feathers or beads (Kleiss 1984, 1989).

Because of the commercial interest in tsantsas all over the world, fake ones made from heads of monkeys or with the hairy skin of other animals abound on the market. In some cases, especially when they were made by the Indians themselves, their identification as fakes is rather difficult. However, even in such specimens, we must admire the masterly skill of primitive men.

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DISEASE IN SOUTH AMERICAN Mummies
John W. Verano

Only a relatively small number of diseases that affect humans leave any trace of their presence in the skeleton, and some diseases affect bone in similar ways, making a confident diagnosis difficult in many cases (Ortner 1992). Diseases that affect the skeleton are most commonly long term ailments such as arthritis, chronic infections, and certain dietary deficiencies. Most illnesses that kill quickly, particularly acute infectious diseases such as influenza and pneumonia, do not leave their signature on the skeleton. Paleopathologists studying skeletal populations are therefore limited to a relatively narrow field of inquiry, although the development of new molecular techniques in recent
years, as described in this chapter, holds new promise for the diagnosis of disease in ancient skeletons. Preservational conditions in such arid regions of the New World as the American Southwest and the west coast of South America provide unique opportunities for paleopathological research. Mummified human remains and well-preserved coprolites have been recovered from numerous archaeological sites in South America, some dating back as early as 9000 years BP (Muñoz et al. 1993). The extremely dry western coast of Peru and Chile, in particular, provides an exceptional preservational environment, and spontaneous mummification of bodies is common.

Over the past 20 years, studies of these mummified remains have provided evidence of chronic infectious diseases such as tuberculosis and blastomycosis, as well as acute infectious diseases such as bronchopneumonia and lobar pneumonia. Mummy dissections and coprolite studies have provided additional insight into intestinal parasite infestation in precontact populations of the Americas.

Although the roots of paleopathological studies of South American mummies can be traced back to the beginnings of this century, the first systematic studies of pathology in South American mummies were pioneered in the early 1970s by Allison, Gerszten, and colleagues (Allison and Gerszten 1975). These studies involved the autopsies of mummies from numerous archaeological sites in coastal Peru and Chile. This work has been important not only in documenting the presence of various disease conditions in pre-Columbian populations, but also in calling attention to the exceptional research potential of South American mummies (Allison 1979).

After some years of quiescence, the past decade has seen renewed intensity in the study of South American mummies, brought about in part by the development of new laboratory techniques for paleodietary analysis and for the extraction and amplification of DNA from bone and mummified tissue. Research questions have evolved as well, reflecting the application of paleodemographic and epidemiological models to the identification of disease in the archaeological record.

Studies of disease and general health conditions in pre-Columbian South American populations fall into two broad categories: case reports and population studies. Case reports, which document specific pathologic conditions in single specimens (Allison et al. 1973, 1974, 1979; Kelley and Lytle 1995), have been important in establishing the presence of particular diseases in pre-Columbian New World cultures. Population studies examine broader patterns of morbidity across space and time. Some of these focus on a single disease, such as tuberculosis or Carrió’s disease, and use demo-
graphic or epidemiological models to explain the observed frequencies and characteristics of skeletal and soft tissue lesions (Schultz 1968; Buikstra and Williams 1991; Arriaza et al. 1995). Others look at general indicators of community health such as childhood growth, anemia, non-specific bone infection, and dental disease (Elzay et al. 1977; Allison 1984; Ubelaker 1992; Benfer 1990; Kelley et al. 1991). All three kinds of studies have made important contributions to the understanding of patterns of health and disease in pre-Columbian South America (Verano and Ubelaker 1991; Verano 1992).

Recent decades have witnessed the development of new analytical tools for the reconstruction of ancient diet, for the evaluation of environmental health risks such as heavy metal poisoning, and for identifying the ingestion of particular medicinal plants like coca. Elemental and stable isotope analyses of ancient human tissue have been used successfully to reconstruct diet in various prehistoric populations from Peru and Chile (Burger and van der Merwe 1990; Aufrheide and Allison 1992; Verano and DeNiro 1993). The results of such studies have provided information on the relative importance of marine and terrestrial foods in their diets (Aufrheide and Allison 1992), the adaptation of highland immigrants to coastal environments (Aufrheide 1996), the relative contribution of particular cultigens such as maize to the diet (Burger and van der Merwe 1990), and the possible population affiliation of sacrificial victims (Verano and DeNiro 1993). Combined with dietary information that can be extracted from coprolites (Holden and Nuñez 1993), such studies have made significant advances in our understanding of ancient diet in South America. In an important series of studies, Cartmell and associates (Aufrheide 1996; Cartmell et al. 1991) have identified cocaine metabolites (from coca chewing) in the hair of mummies from coastal Chile. Positive results first show up in a single mummy dated to approximately 1000 BC, and become common in mummies from the later phases of the Alto Ramiro culture (AD 0–350). These results correlate well with archaeological evidence of increased cultural contact with the highlands (source of coca) during this time period. Trace element analysis has also been applied to evaluating environmental hazards to health, such as chronic arsenic poisoning from local water sources (Allison 1996).

**Infectious disease**

**Tuberculosis** There has been a long debate over whether tuberculosis was present in the New World in pre-Columbian times (Buikstra 1981). The number of reported examples of lesions suggestive of tuberculosis in
pre-Columbian skeletal remains has grown rapidly in recent decades (Figure 10.9), but confident diagnosis of many of these cases has remained elusive. Since the early 1970s, however, examination of South American mummies has provided increasingly convincing evidence that tuberculosis was indeed a pre-Columbian health problem.

In 1973, Allison, Mendoza, and Pezzia published the first diagnosis of pre-Columbian tuberculosis based on both skeletal and soft tissue evidence. The case involved the mummy of a child from a Nasca (c. AD 700) cemetery in southern coastal Peru. The mummy showed evidence of chronic bone and
soft tissue disease suggestive of tuberculosis but, more important, Allison and colleagues were able to extract and identify acid-fast bacilli morphologically similar to *Mycobacterium tuberculosis*. Since this pioneering study, many additional cases of probable tuberculosis have been identified from skeletal and mumified remains from southern Peru and northern Chile (Allison et al. 1981; Buikstra and Williams 1991; Arriaza et al. 1995). Whereas differentiating bone lesions produced by tuberculosis from those by other diseases continues to present challenges (Buikstra 1981; Ortner and Putschar 1981), recent developments in ancient DNA recovery and amplification by polymerase chain reaction (PCR; see Chapter 16) have resulted in a major advance in the identification of tuberculosis in ancient tissues. Salo et al. (1994) recently reported the successful extraction of DNA characteristic of *M. tuberculosis* from a pre-Columbian mummy from southern Peru. Similar identifications of *M. tuberculosis* and *M. leprae* DNA in skeletal samples have been reported by other researchers, supporting the utility of PCR amplification of ancient DNA in the identification of pathogenic organisms (Spigelman and Lemma 1993; Rafi et al. 1994). It now appears indisputable that tuberculosis was present in the Americas before European contact.

**Treponemal disease** Since the late nineteenth century, there also has been debate over whether syphilis was present in pre-Columbian South America (Stewart 1950). Some suggestive cases have been illustrated by Weiss (1984), but convincing evidence of venereal or congenital syphilis in pre-Columbian skeletal remains has yet to be demonstrated. Some form of treponemal disease appears to have been present in prehistoric populations of northern Chile. Most cases consist of individuals with pronounced periosteal inflammation of the tibias, although one individual showed cranial involvement as well (Allison et al. 1982; Arriaza 1995). In a recent study, Rogan and Lentz (1994) report that they have successfully extracted ribosomal DNA (rDNA) characteristic of treponemal bacteria from the muscle tissue of four prehistoric individuals from El Morro, Arica and San Miguel de Azapa in northern Chile who showed characteristic tibial lesions. Thus, both skeletal and molecular evidence indicate that a treponemal disease such as yaws or endemic syphilis was present in Andean South American before European contact, although the specific nature of the disease and its mode of transmission are not fully understood.

**Carrión's Disease** Carrión's disease, also known as Bartonellosis, is caused by the bacterium *Bartonella bacilliformis*. Transmitted by sandflies, it is a
Parasites

Recent studies of mummies and coprolites have demonstrated that some parasites previously thought to have been Old World introductions in fact plagued pre-Columbian New World populations. These include at least one species of hookworm, *Ankylostoma duodenale*, and the whipworm *Trichuris trichiura* (Allison et al. 1974). Research has also documented the presence of roundworms (*Ascaris lumbricoides*), marine tapeworm (*Diphyllobothrium pacificum*), pinworm (*Enterobius vermicularis*), hairworm (*Strongyloides* spp.), *Trichinella spiralis*, *Echinococcus granulosis*, and the ectoparasite *Pediculus humanus* (louse). *Entamoeba* spp. and *Moniliformis clarki*, a thorny-headed worm, were probably present as well (Confalonieri et al. 1991; Horne 1985; Patrucco et al. 1983; Reinhard 1990, 1992, Chapter 16). Coprolite samples from the central coast of Peru document the presence of tapeworm and roundworm in cultural strata dating to approximately 2800 BC, and pinworm at approximately 2300 BC. Although some parasites show great antiquity, most of the evidence has come from later agricultural populations living a sedentary village life.

Parasitism may, in part, provide a key to explaining regional variation in the frequency of porotic hyperostosis and cribra orbitalia in prehistoric Ecuador and Peru. Porotic hyperostosis and cribra orbitalia, porous lesions found on the external table of the skull vault and orbital roofs, are generally considered to represent a physiological response to iron deficiency anemia, which can be caused and exacerbated by a variety of factors, including dietary deficiencies, intestinal parasites, infectious disease, and their synergistic effects (Goodman et al. 1984). Hereditary anemias like sickle cell disease and thalassemia do not appear to have been present in the Americas in pre-Columbian times (Ortner and Putschar 1981). In his studies of skeletal samples from prehistoric Ecuador, Ubelaker (1992) found a significantly higher frequency of porotic hyperostosis in coastal populations. Ubelaker hypothesized that parasitism, due to hookworm and possibly other parasites that require warm and damp conditions to propagate, may have been a significant contributing factor, citing similar geographic patterning of hookworm infestation from modern clinical data in Ecuador. Hrdlička (1914) and Weiss (1961) found similar patterns in the frequency of porotic hyperostosis in prehistoric Peruvian crania from coastal and highland sites. Although parasitism is probably not the only factor that might explain these differences, Ubelaker believes it played a significant role in producing the distribution of porotic hyperostosis observed in prehistoric population samples from Peru and Ecuador.
Tumors
In a recent review of soft tissue tumors in paleopathology, Gerszten and Allison (1991) echo previous workers in noting how rarely they have been found in mummy studies. In autopsies of over 1000 mummies from Chile and Peru, they found only two examples of soft tissue tumors: a subcutaneous lipoma on the right side of the chest of an adolescent male, and a rhabdomyosarcoma on the right cheek of a male child approximately 12 to 18 months old. Tumors affecting bone, whether primary or metastatic in origin, are more common in the paleopathological literature, probably due to the much greater quantity of skeletal material available for study. Nevertheless, there is not a great number of cases noted in South American skeletal remains. One of the earliest reported and most visually impressive examples of a malignancy, probably a meningioma, was first described by MacCurdy (1923), from an Inca site near Cuzco (Figure 10.10). I found another possible example of a meningioma (Figure 10.11) while studying skeletal and mummified remains excavated by Tello at the site of Paracas on the south coast of Peru (Tello 1929), and have described several examples of tumors in skeletal remains from Pacatnamu on the north coast of Peru (Verano 1997). Merbs has described bony tumors from the Hrdlička Paleopathology Collection (Tyson and Alcauskas 1980), and Baraybar and Shimada (1993) have recently reported a probable case of metastatic carcinoma in an adult male from the site of Batán Grande on the north coast of Peru.

Population studies
In contrast to studies that focus on single diseases, some researchers have taken a broader approach and have attempted to identify general trends in human health through time in pre-Columbian South America. The focus of most of these studies is the effect of subsistence and settlement pattern changes on community health, as measured by the frequencies of skeletal and dental stress indicators such as Harris lines, enamel hypoplasias, periostitis, porotic hyperostosis, dental caries, and other indicators (Goodman et al. 1984). The results of these studies reveal some general patterns in health through time, and provide important baseline data with which future studies can be compared. Benfer and associates examined the early transition from migratory hunting and gathering to sedentary village life and incipient agriculture on the central coast of Peru at the site of La Paloma, which dates to between 8000 and 4500 BP (Benfer 1984, 1991). Based on the age distribution of burials in different occupational levels and the relative frequency of skeletal stress indicators, Benfer concluded that although the earliest inhabitants
of La Paloma were severely stressed, there was evidence of decreased infant mortality, greater adult life expectancy, and some indications of improved nutritional status with the adaptation to sedentism and incipient food production.

Based on a study of 16 populations from coastal Peru and Chile ranging in time from approximately 2000 BC to the early Colonial Period, Allison (1984) examined patterns of demography and disease through time. He found childhood mortality to be high, with nearly 50 percent of children in most samples dying before 15 years of age. No evidence of a general improvement in health was observed with the adoption of sedentism and intensification of
agricultural production. On the contrary, Allison interprets his data as indicating that sedentary village life was generally detrimental to health, due to crowding and sanitation problems, and that the increasing social stratification seen at some later sites resulted in health benefits only for the elite minority.

In a review of temporal trends in disease and demography in prehistoric Ecuador, Ubelaker (1992) concludes that although early populations of coastal Ecuador had low levels of infectious disease, anemia, dental caries, and various measures of nutritional stress, samples of human remains from more recent time periods show regular temporal increases in the frequencies of these problems. These frequency increases are particularly notable in coastal populations, and correlate with an increase in sedentism and a less varied diet.

Differences in the frequency of porotic hyperostosis in highland and coastal Andean skeletal samples suggest that parasite ecology, in addition to other factors such as settlement density and sanitary conditions, may have been a significant determinant of community health in prehistoric Andean populations. On the other hand, variability in the frequency of porotic hyperostosis among different coastal population samples, and between contemporary cemeteries at a single site, suggests that additional factors such as the degree of social stratification, local differences in residential pattern and settlement density, and differential access to dietary resources, also need to be considered in reconstructing the dynamics of community health at complex sites (Verano 1992).
Although Benfer’s study of La Paloma suggests that there was some improvement in general health and life expectancy with the initial adaptation to sedentism and food production on the central coast of Peru, surveys of long-term temporal trends in skeletal pathology by Allison and Ubelaker point to a general deterioration in health conditions with increasing sedentism, agricultural intensification, and population growth. Studies of mummified human remains from coastal Peruvian and Chilean sites indicate that both chronic infectious diseases, such as tuberculosis, and acute pulmonary infections were significant factors in morbidity and mortality in prehistoric Andean populations. Coprolite studies have documented the presence of various intestinal parasites in Andean populations as early as 3000 BC, and some data suggest that parasite infestation may have been an important contributing factor in elevated frequencies of porotic hyperostosis seen in later prehistoric coastal Ecuadorian and Peruvian populations. Paleopathological evidence indicates that prehistoric South American populations faced significant health challenges in their adaptation to sedentism, agricultural production and population growth. With increasing population size and density came inevitable problems of sanitation, parasitism, and increase in infectious disease. Agricultural intensification and social stratification led to a less varied diet for many, exacerbating the effects of infectious disease and parasitism. It should be emphasized, however, that such problems were not unique to populations of prehistoric South America, but were challenges faced by human populations worldwide in the transition in lifestyle from mobile foragers to sedentary agriculturists (Cohen 1989).

Ancient surgery
Medical treatment in ancient times is a subject of continuing interest for paleopathologists. Although accurate knowledge of the causes and treatment of most diseases is a relatively recent development in the history of medicine, evidence of some forms of surgery is found surprisingly early in various parts of the world. Evidence of two forms of early surgery has been reported in prehistoric South American mummified and skeletal remains: trephination and amputation. In the case of amputation, only a few possible cases have been reported (Tyson and Alcauskas 1980; Merbs 1989; Anderson and Verano 1996), although artistic representations of individuals with missing limbs are well known from several north coastal Peruvian cultures (Donnan 1978; Urteaga-Ballon 1991). Evidence of trephination, in contrast, is extensive and widespread, both geographically and temporally.

Trephination (or trepanation), the surgical removal of a portion of the
skull vault, is known to have been practiced in prehistoric times in many parts of the world. Andean South America stands out for having more examples of trephined skulls than all other geographic areas of the world combined. Stewart estimated that more than 1000 South American trephined skulls could be found in museums and private collections, and my own research indicates that this is a reasonable estimate (Stewart 1957; Verano 1996). Trephination is known to have been practiced widely in the region encompassed by the boundaries of modern Peru and Bolivia for over 2000 years, from circa 500 BC until the sixteenth century AD (Verano and Williams 1992; Verano 1996).

Since the late nineteenth century, when prehistoric trephined skulls were first described from Peru and Bolivia, there has been continued speculation about the motivation for the procedure. Early observers noted that trephinations were often associated with skull fracture, and suggested that the procedure might have been a practical treatment for acute head injury (MacCurdy 1923; Daland 1935; Stewart 1957). Others suggested different motivations for the practice, including the treatment of headaches, the removal of tumors, and the release of spirits (Muñiz and McGee 1897; Moodie 1929; Canalis et al. 1981; Weiss 1984; Mann 1991). Although some theories are more plausible than others, most arguments have been based on very small samples or even single specimens. Unfortunately, few researchers have systematically collected data on large samples of trephined skulls.

Four principal trephination techniques were practiced in Andean South America: scraping, linear cutting, circular grooving, and boring and cutting (Lisowski 1967; Merbs 1989). Scraping was the earliest technique practiced. It appeared on the south coast of Peru circa 500 BC, and continued to be a popular technique in later times. The linear cutting technique is most characteristic of the central highlands of Peru, although trephinations by both the scraping, and the boring and cutting techniques are also found in this area, as well as in the highland valleys and high jungle of northern Peru. Circular grooving appears later, and is characteristic of the southern highlands of Peru during the Inca Empire. In general, a trend can be seen towards a reduction in the size of trephination openings through time, although there is substantial variability within samples. The largest trephinations are found in the early samples from the south coast, whereas the smallest are found in the southern highlands during the Inca Empire (Verano and Williams 1992; Verano 1996). Many South American trephinations are clearly associated with skull fracture (Figure 10.12). Depressed skull fractures are common in skeletal collections from Peru, with particularly high frequencies found in areas
such as the central highlands (Verano and Williams 1992; Verano 1996). The majority of these injuries were probably produced by blows from clubs and sling stones, weapons widely used in the Andes in prehistoric times, although some fractures may have been the result of falls or other accidents. In these cases, the objective of the trephination was presumably to elevate or remove depressed bone fragments, smooth broken edges, and, possibly, evacuate epidural hematomas. Although there is no soft tissue evidence to confirm this, practitioners probably learned to avoid penetration of the dura mater, due to the high risk of infection and physical damage to the brain.
A significant percentage of South American trephinations show evidence of healing, indicating survival following the procedure (Stewart 1956, 1957; Lastres and Cabieses 1960). Healing can be classified into three general categories, based on the degree of bony reaction to the trephination: (1) none, where there is no evidence of bony reaction, suggesting that death occurred during the procedure or shortly thereafter; (2) short-term survival, where evidence of osteoclastic activity, bone necrosis, or hypervascularity is evident around the margins of the trephination opening, indicating survival perhaps for several weeks, and (3) long-term survival, where there is evidence of extensive remodeling of the margins of the defect. In general, trephinations by the scraping and by the circular grooving technique seem to show the highest success rate, whereas trephinations by straight cutting or by drilling and cutting show the lowest. This probably reflects the fact that penetration of the dura mater was more frequent with the latter two techniques. The most impressive cases of healing are found in some crania from Inca sites that show from four to seven well-healed trephinations (Figure 10.13). Overall, the Inca appear to have developed the most successful methods, as data I have collected show a long-term survival rate of over 70 percent for Inca trephinations, in contrast to a roughly 40 percent survival rate for the earliest trephinations from southern coastal Peru (Verano and Williams 1992; Verano 1996). Such statistics certainly compare favorably with the 25 percent or lower survival rate of neurosurgery patients in nineteenth and early twentieth century Europe and North America (Aufderheide 1985).


Shrunken Heads


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Hrdlicka, A. 1914. Anthropological work in Peru in 1913, with notes on the pathology of the ancient Peruvians. Smithsonian Miscellaneous Collections 61(18): 57–69


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