Venereal Syphilis: The Mystery Continues

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Introduction
Paleopathology is the study of the evolution and progression of disease over long periods of time, and the study of how humans have adapted to changes in their environment (Roberts and Manchester 1995:1). By documenting the character and epidemiology of past diseases, the origins and causes of present diseases may be better understood (Rothschild 2003). The topic of treponemal disease, specifically venereal syphilis, has received much attention in paleopathology. Indeed, Roberts and Manchester (1995) believe that the concentration of thought on venereal syphilis has almost been at the expense of other treponemal diseases. These authors believe that this concentration can be attributed to the moral undertones surrounding the study of venereal syphilis. Yaws, pinta and endemic syphilis have not been pointed out as diseases of ‘immorality’ because they are spread through nonvenereal means. Venereal syphilis, on the other hand, has been surrounded by moral judgements, both in the past and the present, due to the sexual nature of its transmission (Roberts and Manchester 1995).

Treponemal diseases are perfect examples of pathological conditions that contribute to Wood and colleagues’ (1992) ‘osteological paradox’ (Cook and Powell 2005). Being able to distinguish endemic treponemal diseases from venereal and congenital syphilis is important because of this paradox; skeletal evidence in long-term survivors indicates a disease that lacks the serious consequences of venereal syphilis. Moreover, the study and diagnosis of venereal syphilis in past populations has important implications for population fertility and demography, since there is a high mortality rate associated with the congenital transmission of venereal syphilis (Cook and Powell 2005).

The purpose of this paper is to survey the most recent paleopathological literature on treponemal disease, and the effect of this research on theories regarding the origins and history of venereal syphilis. To place this research in context, an overview will be given of treponemal disease and venereal syphilis, including its definition and taxonomy; its traditional diagnosis in the skeleton; and the current theories surrounding the origins of history of venereal disease.

Definition and Taxonomy
Syphilis is one infection in a larger group of diseases referred to as the treponematoses. Treponematosis is a chronic or subacute infection caused by bacterial spirochetes of the genus Treponema. In addition to venereal syphilis, the treponematoses include pinta, yaws, and endemic syphilis (also known as nonvenereal syphilis, bejel, or treponarid). These four diseases are characterized by self-limited, primary and secondary lesions, a clinically disease-free latent period, and late, destructive lesions (Aufederheide and Rodriguez-Martin 1998). All are associated with inflammatory changes in most body tissues, although pinta never manifests itself in the skeleton; additionally, venereal syphilis is characterized by the involvement of the...
arterial and nervous systems. Pinta, yaws, and endemic syphilis are usually diseases of childhood, while venereal syphilis affects juveniles and adults (Roberts and Manchester 1995). Venereal syphilis can also be passed transplacentally to the developing fetus of an infected mother; this is termed congenital syphilis (Ortner 2003). Each of the four syndromes is associated with distinct geographical, climatic, and sociocultural features. Pinta is geographically restricted to the tropical regions of America, stretching from Mexico to Ecuador. Yaws is found in humid tropical and subtropical areas, while endemic syphilis is present in non-humid temperate and subtropical regions. Venereal syphilis occurs in all geographic areas, primarily in urban populations (Aufderheide and Rodriguez-Martin 1998).

The Treponema genus is part of the order Spirochaetales, which includes flexible, spiral bacteria. Spirochetes are considered to be the most complex of the bacteria; they are not readily stained, and are usually examined in the living state with darkfield microscopy (Aufderheide and Rodriguez-Martin 1998). Moreover, the various species are morphologically indistinguishable using light or electron microscopy. Baker and Armelagos (1988) suggest that all treponemes are identical, based on homologies in their DNA sequences, and that partial cross-immunity between the treponemal syndromes; this idea of cross-immunity is supported by Roberts and Manchester (1995). Powell and Cook (2005) assert, however, that although various degrees of cross-immunity have been claimed, there is no conclusive documentation to support this theory.

The four treponemal syndromes are caused by two species of Treponema. Pinta is caused by T. carateum, while the remaining three are caused by subspecies of T. pallidum; venereal syphilis is caused by T. pallidum pallidum, endemic syphilis by T. pallidum endemicum, and yaws by T. pallidum pertenue. Controversy has previously existed over whether the four treponemal syndromes were caused by different species within the genus, since morphological comparisons between carateum and pallidum appear identical. Recent molecular analysis of the bacterial DNA using polymerase chain reaction (PCR) amplification and synthetic DNA probes has begun to unravel the complex genetic relationships between the species (Antal et al 2002). More work is needed, however, to fully understand these complex relationships and their implications for the history and origins of treponemal disease (Brothwell 2005).

Skeletal Pathology and Traditional Diagnosis

Yaws
Without proper medical treatment, 1-5% of cases will develop skeletal involvement some years after the primary infection. This secondary stage generally involves exuberant periosteal reactions resulting in cortical thickening and bony expansion. Bones distal to the knee and elbow are commonly involved, and lesions are generally bilateral. Joint involvement may be extensive; bony ankylosis may be produced by metaphyseal lesions afflicting joints. Generally, secondary lesions resolve themselves within a few months (Aufderheide and Rodriguez-Martin 1998). The tertiary stage appears 5 to 10 years after the primary stage, and
involves more destructive and extensive skeletal lesions. All lesions found in tertiary yaws may be found in syphilis; the difference is only quantitative (Steinbock 1976). The ‘saber shin’ tibia, expressed asymmetrically, is the most typical lesion in this stage. It involves the curving of the anterior tibial surface and the flattening of the posterior surface, due to the extensive deposition of subperiosteal bone in the tibial crests (Aufderheide and Rodriguez-Martin 1998). Features more specific to yaws include dactylitis of the hands in young individuals; prominent gummatous osteomyelitis of the long bones; joint and para-articular involvement; less extensive cranial vault involvement than syphilis; gangosa, an extensive destruction of the nasal area, palate and maxilla; and goundou, a tumour-like expansion of the maxilla (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998).

**Endemic Syphilis**
Endemic syphilis demonstrates lesion development and distribution almost identical to those of yaws. Nasal-palatal destruction and saber shin are the most common lesions (Aufderheide and Rodriguez-Martin 1998). A diagnosis of endemic syphilis, as opposed to yaws, is generally based on the geographic origin of the sample (Roberts and Manchester 1995).

**Venereal Syphilis**
The frequency of bone involvement in venereal syphilis cases is 10 - 12% (Roberts and Manchester 1995). Bone involvement typically occurs during the tertiary stage of the disease; the most characteristic lesions are those involving the cranial vault, particularly the frontal and parietals (caries sicca). The tibia is again the most affected skeletal element, but the nasal-palatal region can also manifest severe, destructive lesions (Aufderheide and Rodriguez-Martin 1998). A prominent osteosclerotic response to infection is the most consistent feature shared by tertiary syphilitic lesions (Ortner and Putschar 1985). The most characteristic lesion of tertiary syphilis is the gumma; gummatous lesions are found in both the skull and the long bones (Aufderheide and Rodriguez-Martin 1998). Joint changes may also result, although they are uncommon. Typically, joint change is unilateral and monoarticular, with the knee being most characteristically affected. The loss of deep pain sensation due to neurosyphilis (the involvement of the nervous system) can result in joint damage; this type of joint disease is called Charcot’s joint (Aufderheide and Rodriguez-Martin 1998; Roberts and Manchester 1995).

**Congenital Syphilis**
Congenital syphilis can be divided into early and late forms. The early, or infantile, form is present at birth or during early infancy and is characterized by three forms of bone change: syphilitic osteochondritis during the first 6 months of life, affecting the epiphyseal-metaphyseal junction of long bone costochondral regions; diaphyseal osteomyelitis; and periostitis, commonly in the femur and tibia (Aufderheide and Rodriguez-Martin 1998). Late form congenital syphilis is common between childhood and early adulthood, and is similar to venereal syphilis in appearance. More specific identifiers are the ‘dental stigmata’ of congenital syphilis, consisting of Hutchinson’s incisors, mulberry molars, and Moon’s molars. These dental characteristics
actually represent the effects of early congenital syphilis, but are not apparent until the eruption of the permanent dentition. Additionally, frontal bossing and the collapse of the nasal bridge (‘saddle-nose’) are common indicators (Aufderheide and Rodriguez-Martin 1998; Hillson 1998; Roberts and Manchester 1995).

History and Origins of Venereal Syphilis

History
Venereal syphilis was first recognized as a distinct disease in Europe following epidemics at the end of the fifteenth century, shortly after Columbus’ return from his first trip to the New World (Aufderheide and Rodriguez-Martin 1998). In AD 1495, the Spanish Army was at war with French troops who had conquered Naples; during this siege, a new disease appeared among the French army. The disease was reported to have caused sores and ulcers, as well as aching bones, and resulted in either invalid status or death. After the surrender of the French and their return to their home countries, the disease was spread throughout Italy, France, and Germany. By AD 1500, all of Europe was experiencing epidemics of the disease (Aufderheide and Rodriguez-Martin 1998). The first reference to syphilis in the medical and non-medical literature was Niccolò Leoniceno’s ‘Handbook of the epidemic that the Italians call the French disease’, published in AD 1497. The most important text on syphilis would be published by Girolamo Fracastoro in AD 1530, in the form of a poem that gave the new disease a technical name – ‘syphilis sive Morbus Gallicus’, meaning ‘syphilis is a Gallic disease’.

In general, Europeans preferred to relate the European onset of the disease to the return of the first Columbus expedition. On the other hand, people living in the Americas chose to see the disease as an import from the Old World, although not necessarily from Europe (Roberts and Manchester 1995). A few decades after the initial European epidemics, three authors – Fernández de Oviedo y Valdés, Ruy Diaz de Isla, and Fray Bartolomé de las Casas – attributed the origin of the disease to the New World and the introduction to Europe by the crew of Columbus’ first expedition. These authors believed that the disease was brought back from Haiti (Hispaniola), and that the first case appeared in Barcelona, Spain, in AD 1493 (Powell and Cook 2005). Regardless of the target of blame, venereal syphilis experienced a startling and swift rise to importance in sixteenth century Europe (Roberts and Manchester 1995).

At the end of the sixteenth century the disease began to decrease in frequency and severity. During the Enlightenment, pathologists began to separate syphilis from other venereal diseases such as gonorrhea. In 1905, Fritz Schaudinn isolated the microorganism responsible for syphilis – T. pallidum. In 1906, the first serological procedure for diagnosing syphilis was developed by A. Wassermann, A. Neisser, W. Bruck, and other German scientists (Aufderheide and Rodriguez-Martin 1998). The first description of endemic syphilis was published by E. H. Hudson in 1928, after observing the disease in Bedouin Arabs (Kiple 1993).

Geographic Origins
The origin of the treponematoses is one of the most controversial problems in the
history of infectious disease. Three theories exist regarding the geographic origin of venereal syphilis: the Columbian theory, the pre-Columbian theory, and Livingstone’s ‘alternative hypothesis’ (Aufderheide and Rodriguez-Martin 1998). The Columbian theory proposes that venereal syphilis was introduced to the Old World in 1493 after the return of Columbus’ first expedition; this theory found its basis in the works of Oviedo, de lIsa, and las Casas (Powell and Cook 2005). Many historians (Crosby 1972; Munger 1944; Quetel 1990; and Steinbock 1976) have suggested that there was a strong financial reason for sixteenth century acceptance of this New World origin – namely, a lucrative trade in guiac wood from the West Indies. Europeans believed that if the treatment came from the New World, the disease must also originate from this region (Powell and Cook 2005). It is also possible that upon returning from the New World, the Columbus expedition brought back a more virulent strain of T. pallidum. Although some form of treponemal disease was present in Europe at the time, this new strain was responsible for converting a longstanding and relatively mild treponemal disease into one that was particularly sudden and violent (Roberts and Manchester 1995).

The pre-Columbian hypothesis asserts that venereal syphilis existed throughout the Old World prior to AD 1493, but was diagnostically confused with other diseases, particularly ‘venereal leprosy’ (Powell and Cook 2005). Steinbock (1976) supports this theory with the fact that ‘Saracen Ointment’ was used in the twelfth and thirteenth centuries to treat ‘venereal leprosy’. This ointment contained mercury, which is ineffective against leprosy but was used as a syphilis treatment for four centuries.

Based on comparisons of pre- and post-Columbian skeletal material, Stewart and Spoehr (1967) have reported that a syphilis-like disease spread rapidly among Native Americans shortly after the discovery of the Americas. The authors traditionally explained this phenomenon as resulting from different strains of syphilis being present in Europe and the Americas prior to AD1492. Upon discovery, the strains were exchanged between populations, with the recipient populations lacking the appropriate immunity (Aufderheide and Rodriguez-Martin 1998). Livingstone’s ‘alternative hypothesis’ (1991) asserts that the post-Columbian increase in cases in the Americas was due to the introduction of a virulent strain from the Old World at the time of discovery (Aufderheide and Rodriguez-Martin 1998). Increased contact with tropical Africa around the time of Contact facilitated this phenomenon.

The Portuguese had established a fort and trading post in Ghana fifteen years prior to Columbus’ arrival in the New World. A nonvenereal treponeme would have then been carried back to Europe, before being transferred on to the Americans (Aufderheide and Rodriguez-Martin 1998). Livingstone also attributes the sudden epidemics in Europe to the spread of this new treponemal disease from West Africa by the Portuguese, most likely yaws (Livingstone, 1991).

**Biological Origins**

In addition to the mystery surrounding the geographic origins of treponemal disease, and venereal syphilis in particular, there is great debate over the
evolutionary relationships between the four treponemal syndromes. Specifically, a major question is whether or not the four syndromes are discrete diseases, or different manifestations of one disease. Two general theories attempt to answer this question – the Unitarian theory and the Nonunitarian theory.

The Unitarian theory has been championed by Hudson (1965), and asserts that one treponemal disease is responsible for all four syndromes; the expression of the disease varies based on different environmental and sociocultural conditions (Powell and Cook 2005). Yaws has been suggested as the first treponemal infection, with an origin in the Palaeolithic hunter-gatherers of central Africa. As humans migrated out of Africa, the disease spread throughout the rest of the world 100000 years ago and adapted to local conditions as yaws, pinta, or endemic syphilis. The disease was transmitted to the New World through either relatively new migrant groups, or through the original settlers that crossed the Bering Strait (Aufderheide and Rodriguez-Martin 1998; Powell and Cook 2005).

The Nonunitarian theory has been defended by Hackett (1963, 1967). This theory asserts that the different expressions of treponemal disease are due to at least four mutations in treponemal strains that have occurred in the last 12000 years. Hackett believes that pinta was the original treponemal disease, and that 15000 years ago it extended from Africa and Asia to the Americas. The first mutation took place about 12000 years ago, stimulated by a warm and humid climate. This mutation produced yaws, which spread through Africa, Southeast Asia, the Pacific Islands, and Australia. Climate change, resulting in decreasing humidity, brought about a second mutation around 9000 years ago resulting in endemic syphilis. This disease appeared in northern and Saharan Africa, southwestern and central Asia, and central Australia. A third mutation occurred around 5000 years ago with the development of urban areas and the increased use of clothing in the eastern Mediterranean and southwestern Asia. It was in these regions that Hackett hypothesized venereal syphilis to have arisen. The fourth and final mutation took place in Europe in the late fifteenth century, and resulted in a much more serious form of venereal syphilis (Aufderheide and Rodriguez-Martin 1998).

The Nonunitarian theory has been criticized by Livingstone (1991) because it fails to conform to epidemiological expectations, thereby straining its credibility. Additionally, Brothwell (1981) has proposed that pinta was the most recent, rather than the oldest, variant of treponemal disease. This is based on its restricted geographical region and the fact that it maintains the least harmful relationship with its human hosts (Powell and Cook 2005).

**Traditional Paleopathological Evidence for Treponemal Disease and Venereal Syphilis**

**New World**

Brothwell (2005) has stated that America contains the greatest number of skeletons with treponemal bone lesions in the entire world. According to Roberts and Manchester (1995), North and Central America show indisputable evidence of pre-Columbian venereal syphilis. Although this preponderance of evidence
for venereal syphilis has been called into question (Cook and Powell 2005), it is still clear that some form of treponemal disease was present in the New World before Columbus visited.

In 1871, J. Wyman made the first paleopathological diagnosis of treponematosis in pre-Columbian New World skeletal remains, which were recovered from caves in the southeastern United States (Aufderheide and Rodriguez-Martin 1998). Since this initial discovery, numerous diagnoses have been made with New World skeletons. The United States demonstrates an abundance of treponemal cases, mostly concentrated in the southern half. Sites are located in Florida, Georgia, Alabama, North Carolina, Delaware, Virginia, Maryland, Illinois, Arkansas, Oklahoma, South Dakota, California, New Mexico, Colorado, and Arizona (Aufderheide and Rodriguez-Martin 1998). Evidence is lacking in northwestern North America, although a handful of prehistoric cases have been documented in the Pacific Northwest (Curtin 2005).

Pre-contact treponemal disease has been found in Mexico at Tula, Cueva de la Candelaria, Santiago Tlatelolco, Ochicalco, and Valle to Tehuacán. Central American samples originate from Guatemala, Belize, Antilles, and Santo Domingo. South American samples mostly originate from ancient Peru, but a few come from Columbia and Argentina (Aufderheide and Rodriguez-Martin 1998).

**Old World**
In their 1988 article, Baker and Armelagos found that the evidence for a pre-Columbian treponemal disease in Europe was sparse and inconclusive. Moreover, Steinbock (1976) provided important negative evidence by demonstrating a lack of treponemal lesions in a large Egyptian skeletal series (Aufderheide and Rodriguez-Martin 1998). This situation is slowly reversing, however. A steady trickle of discoveries, beginning in the 1990s, has indicated an established presence of treponemal disease in pre-Columbian Europe (Brothwell 2005; Roberts and Manchester 1995). These early discoveries included Stirland (1991) and Palfi et al (1992), which are cases from England and France, respectively. Meyer et al (2002) provide an excellent review of the skeletal evidence documented since the publishing of Baker and Armelagos (1988). The review brings together evidence from Europe, Africa, Asia, Australia, and Oceania. Additionally, Meyer et al (2002) suggest that the lack of Old World evidence, relative to the abundance of New World evidence, may be attributed to a lack of research funding and personnel in these regions rather than to a lack of treponemal disease.

**Recent Evidence, New Histories (2002 Onwards)**

**Rethinking Diagnostic Criteria**
The task of distinguishing venereal from nonvenereal treponemal infection in dry bone lesions is not straightforward. Rothschild and Rothschild (1995) published a formal attempt to differentiate between venereal syphilis, yaws, and endemic syphilis when dealing with skeletal populations of adequate size. This ‘SPIRAL’ method was based on the differing frequencies of lesions within the three diseases. Diagnostic criteria included the presence
of saber shin without visible surface periostitis; prepubescence; bilateral tibia involvement; involvement of the hand or foot; average number of bone groups affected; and tibia lacking periostitis, but flattened (Aufderheide and Rodriguez-Martin 1998). Three skeletal collections were used to develop these criteria: precontact Guam (yaws), nineteenth century Negev desert Bedouins (endemic syphilis), and twentieth century cadavers from the Hamann-Todd collection (venereal syphilis) (Rothschild and Rothschild 1995). Aufderheide and Rodriguez-Martin (1998) believe this approach could potentially make a great contribution to the controversies surrounding the evolution of the treponematoses.

The SPIRAL technique has recently been called into question by Cook and Powell (2005). The authors feel this method has numerous inherent flaws which render it ineffective. The first flaw arises from the Rothschilds’ inclusion of only clinically diagnosed cases of venereal syphilis from the Hamann-Todd collection. This choice compromises the statistical comparison of lesion prevalence between the three samples; there is no indication of the number of false positives that the SPIRAL method may yield. Additionally, the authors do not report how many ‘diagnosed’ individuals in the Hamann-Todd collection do not present SPIRAL symptoms. A second fatal flaw is the assumption that a single skeletal series can represent the epidemiological pattern of each treponemal disease, and that the derived patterns can be applied to contexts that differ in climate, population density and structure, diet, and the presence of other infectious diseases (Cook and Powell 2005). A third problem in the creation of the SPIRAL technique was the attribution of all periostitis in the yaws and endemic syphilis series to treponemal infection. The fourth flaw arises from the fact that cranial lesions were not taken into consideration. In fact, the criteria concentrate heavily on lesions of the tibia – three of the six criteria are based on tibial evidence. This focus is considered to be quite short-sighted and limited (Cook and Powell 2005). Cook and Powell (2005) believe that the diagnostic criteria for distinguishing treponemal disease must be looked at more closely, and all the evidence to date must be re-examined and reinterpreted in this new light.

Rethinking the Distribution of Treponemes in the Body
It has traditionally been thought that the infecting treponemal organisms disseminate throughout the body and reach the bones via the bloodstream (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1985). Buckley and Dias (2002) point out, however, that the specific mechanism responsible for the characteristic distribution of bone involvement is unclear. The authors propose a mechanism based on the close association between the lymphatic and skeletal systems and the pathogenesis of treponemal infection. Treponemes are known to evade immune recognition and are therefore able to travel unimpeded to regional lymph nodes. They are also known to proliferate within lymph nodes, suggesting that the lymphatic system may play a role in the skeletal response to infection. The frequent involvement of the tibia in treponemal infection may be explained by the presence of the anterior tibial lymph
node in the region of the proximal anterior tibia. Lymph fluid is known to pool in the distal portion of limbs due to gravity; this could also account for the involvement of the tibia, as well as the involvement of the hands and feet in yaws. Periostitis of the nasal bones may be explained by the inflammation of the nasolabial lymph nodes, which are located directly over this skeletal region. *New World Evidence*

Powell and Cook (2005) have edited a volume examining the evidence for venereal syphilis in North America. Seventeen papers were included in the volume, covering a wide geographical and temporal range – from 8000 BP to post-contact; from Alaska to Belize and the U.S. Virgin Islands. Based on these papers, the editors assessed whether or not there were any specific cases of venereal treponemal disease definitively dated to before 1492. They found a handful of cases of skeletal pathology in young subadults firmly dated to pre-Columbian contexts, tentatively diagnosed as congenital treponemal disease (Cook and Powell 2005). Two cases from the Piggott site in North Carolina were diagnosed based on the presence of Hutchinson’s incisors and Moon’s molar (Weaver et al. 2005). One juvenile case from the Late Prehistoric Austin site in Mississippi displayed nasal and postcranial lesions interpreted as possibly being congenital (Powell et al. 2005). A 5 to 6 year old child from Gabriola Island, British Columbia, dated to approximately AD 650, displayed bilateral first permanent mandibular mulberry molars. Additionally, two neonates from this site also showed possible congenital skeletal lesions (Curtin 2005). Brothwell (2005) notes, however, that it should no longer be assumed that venereal syphilis was the only treponemal variant capable of producing congenital defects in the past.

Of all the adult cases examined in this volume, only one individual was identified as having lesions related to venereal, and not endemic, treponematosis (Hodges and Schermer, 2005). An adult male, from the Bracken Cairn site in Saskatchewan, exhibited skeletal lesions consistent with an aortic aneurysm. This condition is well documented in untreated tertiary venereal syphilis, and is caused by the involvement of the arterial system in infection; this condition is not known to occur in nonvenereal treponemal diseases. It is possible, however, that this lesion could have been produced by many other factors (Cook and Powell 2005). Overall, the remainder of the adult cases in which a diagnosis of venereal syphilis was made are not conclusive. These diagnoses rested almost entirely on two lesion types: caries sicca of the cranial vault, and saber shin of the tibia. It is important to note that both these lesion types have been identified in tertiary stage cases of yaws and endemic syphilis. Therefore, the authors emphasize, these ‘venereal’ cases in North America remain suspect.

Cook and Powell (2005) went on to draw a number of general conclusions. They found treponemal disease to be present in the ancient New World, and likely in more than one form depending on time and place. The skeletal evidence indicates a gradient of endemic treponemal forms, similar but not identical to modern yaws and endemic syphilis. Lastly, they found no solid support for the hypothesis that a distinct, venereal form of treponematosis was
present in the New World at AD 1492—and that this disease was the New World’s ‘revenge’ on Columbus and his crew.

An examination of the recent New World literature indicates a trend towards more general diagnoses of treponematis, rather than attempting to specify venereal syphilis or one of the other treponemal syndromes. Hutchinson and Norr (2006) analyzed skeletal remains from Tatham Mound, a mortuary site from central Gulf Coast Florida. These skeletal remains are important because they date to AD 1525-1550, which was the period of initial contact with Europeans. Four postcontact individuals were found to have stellate lesions on the cranium—indicative of treponemal infection. Eighteen tibiae (out of an available 337) were observed to have periosteal apposition or reaction consistent with treponemal infection. In general, 3 precontact individuals and 30 postcontact individuals showed signs of systemic infection. The authors believed that all of these infections could be attributed to either nonspecific osteomyelitis or treponematis. It was estimated that at least 17 individuals had suffered from treponemal infections (Hutchinson and Norr 2006).

Ostendorf Smith (2006) examined 581 individuals from 8 Western Tennessee River Valley sites, dating from 8,000 BP to 2,000 BP. Thirteen individuals were found to exhibit periostitis indicative of treponemal disease, and two individuals displayed nonspecific periostitis that could possibly be attributed to treponemal infection. Of the 13 arguable treponemal cases, 9 were adults and 4 were subadults. No individuals were found to exhibit caries sicca, and no indicators of congenital treponematis were observed. The author concluded that the incidence of periostitis, especially its occurrence in subadults, was consistent with a nonvenereal treponemal disease, such as yaws or endemic syphilis (Ostendorf Smith 2006).

Hutchinson and Richman (2006) assessed 2410 individuals from 25 skeletal series to shed light on the origin, evolution, and relationship of treponemal diseases in prehistoric southeastern United States. The samples ranged temporally from 10000-400 BP, and geographically from the coast to the mountains in Alabama, Florida, North Carolina, and Tennessee. Concentration was placed on the assessment of crania and dentition, and the observance of three lesion types: radial scars on the cranium, Hutchinson’s incisor of the maxillary first incisor, and Moon’s molars of the first permanent molars. Forty-seven individuals were found to exhibit radial scars, but no individuals exhibited the dental lesions. Since no indicators of congenital disease were present, the authors were not able to find substantial evidence to support the pre-Columbian presence of venereal syphilis in the southeastern United States. Their assessment was limited, however, by the small percentage of teeth available for observation—8% of the sample had observable permanent maxillary central incisors and 15% had observable permanent first molars, as compared to 68% of individuals having examinable crania (Hutchinson and Richman, 2006).

Lastly, Buckley and Tayles (2003) published a study on a skeletal sample of 226 individuals from the Southeast
Solomon Islands, Melanesia. The skeletal sample had been excavated in the 1970's, and dated by electron spin resonance to AD 1530-1700. Based on the types of lesions present, the skeletal distribution of lesions, and the epidemiology of the lesions, a diagnosis of yaws was suggested for almost half the affected adults. The remaining adult lesions could not be diagnosed specifically as treponemal, and were attributed to other infectious diseases, such as leprosy. This study is important because it illustrates a pre-contact presence of treponemal disease in the Pacific region (Buckley and Tayles 2003).

**Old World Evidence**

As previously mentioned, there has been a slow but steady stream of Old World treponemal cases being documented over the previous seventeen years. Recently documented cases range in geography from Northern Europe to the Eastern Mediterranean. Mitchell (2003) presents the case of a skull from the Safed site in Israel, radiocarbon dated to AD 1290-1420. The skull was one of a group of 68 removed from the site in 1912 and deposited at the University of Cambridge; unfortunately, no detailed provenience information accompanies the skulls. The skull in question was comprised of only the right and left parietal bones and a partial occipital bone. Multiple lesions were present on these vault bones, and after differential diagnosis the lesions were believed to be treponemal in origin. Examination of the postcranial skeleton was not possible in this case, as only the skulls had been excavated from the Safed site. Nonetheless, the author concluded that the lesions are compatible with treponematosis, thereby providing evidence for the pre-Columbian presence of treponemal disease in the Old World. This finding also has important implications for the understanding of the introduction of the disease to the Middle East (Mitchell 2003).

Ersdal (2006) presents an interesting case study from Anatolia (Turkey). The skeleton of a 14-15 year old child was excavated from a Roman amphitheatre in Bursa, Turkey. The remains were dated to the thirteenth century (AD 1222-1254) based on associated artifacts and site stratigraphy. The skeleton exhibits traditional late congenital syphilis symptoms: an upper left central Hutchinson's incisor; an upper right first 'mulberry' molar; darkened tooth enamel; a radial scar on the frontal bone; bilateral saber shin of the tibiae; syphilitic dactylitis; and gummatous and non-gummatous legions on most of the present postcranial bones. Thus, the author states that this skeleton provides evidence for the pre-Columbian presence of venereal syphilis in the Old World. Moreover, Ersdal (2006) believes that Anatolia has the potential to answer many controversial paleopathological questions because it has provided thousands of human remains, with documented archaeological contexts, dating back to the post-Pleistocene period.

Two recent studies have focused on the presence of treponemal disease in England. The first, by Mays et al (2003), examined two skeletons from Rivenhall, Essex and Ipswich, Suffolk. The Rivenhall skeleton, a female aged 25-50 years, was radiocarbon dated to AD 1295-1445; the Ipswich skeleton, a female over 50 years, was radiocarbon dated to AD 1445-1520. Both skeletons...
were examined macroscopically and radiographically. The resulting distribution and morphology of lesions indicated a chronic, systemic disease. The Rivenhall skeleton exhibited multiple long bones with concentric thickening of the diaphyses and metaphyses by subperiosteal bone deposition. The elbow and wrist joints exhibit erosive joint lesions; the frontal and facial bones of the cranium were not present. The Ipswich skeleton exhibited similar lesions, but without any erosive joint changes. The ectocranial surface of the frontal bone exhibited multiple shallow, circular or oval depressions with no endocranial involvement. Differential diagnosis ruled out Paget’s disease, pyogenic osteomyelitis, osteomyelitis of Garré, and various fungal infections. Mays et al (2003) therefore concluded that treponemal infection was present in both skeletons, but chose not to specify a particular syndrome.

The second study of skeletal remains from England was published by von Hunnius et al (2006). Four skeletons excavated from a medieval friary located in Kingston upon Hull were examined macroscopically and microscopically. Macroscopically, two individuals were diagnosed with syphilis based on the presence of caries sicca, while the remaining two were diagnosed based on the widespread presence of periostitis and osteitis. A tentative histological diagnosis of treponemal disease was possible for the two skeletons without caries sicca, but was not possible for the skeletons exhibiting these lesions. The authors believe this study is a significant contribution because it increased the methodological repertoire in paleopathology. Moreover, it illustrated the range in variation of the characteristic histological structures associated with treponemal disease (von Hunnius et al 2006).

Lefort and Bennike (2007) present the differential diagnosis of a medieval Danish skeleton, first excavated and studied by Vilhelm Møller-Christensen. The skeleton, a female aged 20-25 years, was originally diagnosed by Møller-Christensen as having leprosy, and then rediagnosed as suffering from ergotism. In this study, Lefort and Bennike aimed to reevaluate this diagnosis and provide alternative suggestions. The differential diagnosis considered treponematosis, leprosy, smallpox, ergotism, rheumatoid arthritis, tuberculosis, and sarcoidosis. The skeleton exhibited medullary and cortical lytic foci, periosteal reaction, and enhanced cortical density. The authors found that the lesions present on the skeleton differed from those typical of leprosy, ergotism, rheumatoid arthritis, and tuberculosis. Almost half the expected smallpox lesions were absent, and one or two major sarcoidosis indicators were absent. Treponematosis was declared the probable diagnosis, but neither smallpox nor sarcoidosis could be excluded completely (Lefort and Bennike 2007). The authors were careful to distinguish this diagnosis of treponematosis from one of venereal syphilis, since the typical venereal syphilis lesion (caries sicca) was missing.

**Diagnostic Methods**

In their survey of North American evidence for treponemal disease, Cook and Powell (2005) found that radiography and histology were employed less frequently than could be hoped. Indeed, the majority of the
studies reviewed in this paper employed only macroscopic diagnostic techniques. This is an interesting observation, considering the importance of the article published by Schultz in 2001. In this article, Schultz emphasized the importance of light microscopy, and particularly polarized light microscopy, in the diagnosis of dry bone lesions. Moreover, the author states that the diagnostic criteria published by Hackett (1976) are based on years of experience with the histopathology of dry bones. It would make sense for researchers to use this reference to its fullest – by examining lesions on the histological level. Additionally, Schultz identifies two micro-level characteristics of treponemal disease: grenzstreifen (line indicating the original surface of bone) and polsters (structure of new bone formation). These indicators, used in conjunction with the results of macroscopic, radiological, and scanning-electron microscopy can provide a reliable diagnosis for treponemal disease (Schultz 2001). The micro-level characteristics presented by Schultz were expanded on and refined by von Hunnius et al (2006).

Rühli et al (2007) compared the diagnostic values of micro-CT technology and histological analysis in the evaluation of human skull bone lesions. Micro-CT scans had many advantages over traditional histology: the architecture of the bone could be visualized with a high spatial resolution, without preparation or destruction of the sample (unless the sample is too large to be scanned as a whole); changes in the bone surfaces and diploë can be assessed; the technique is relatively fast; and image acquisition can be automated. On the downside, the morphological patterns caused by reactive bone response, such as the arrangement of collagen fibres, can only be visualized by polarized microscopy of bone thin sections. The need to differentiate lamellar bone from woven bone makes histology an indispensable technique (Rühli et al 2007).

Lastly, the increased analysis of DNA from treponemal lesions, both ancient and modern, will be important in resolving the many questions surround treponematosis and venereal syphilis (Brothwell 2005). Molecular paleopathology is increasingly being applied in the study of ancient disease, by searching for biomolecular evidence of host/pathogen interaction in the past (Powell and Cook 2005). Unfortunately for molecular paleopathologists, the skeletal lesions diagnostic of treponemal disease usually accompany the tertiary stage of the disease; this stage is when the actual pathogen load in the host’s body is relatively low. A more promising approach is the identification of distinctive immunoglobulins from ancient bone (such as Fornaciari et al 1989), but a review of the literature indicates this technique is not yet popular (Powell and Cook 2005).

Conclusions
Multiple theories exist regarding the geographic and biological origins of venereal syphilis. A survey of the most recent paleopathological literature indicates that there are no simple answers to these questions. Rather, there now may be more confusion surrounding this topic than ever before. Two facts are clear: firstly, venereal syphilis was present in the Old World prior to the return of the Columbus expeditions; secondly, some form of treponematosis
was present in the New World prior to contact with Europeans, but the idea that this disease was venereal syphilis is losing support. Moreover, long-held assumptions are being challenged, such as the idea that only venereal syphilis may be transmitted congenitally (Brothwell 2005). The standard diagnostic criteria for differentiating between treponemal syndromes in bone have been questioned. Multiple authors (Cook and Powell 2005; Brothwell 2005) have suggested the re-examination of skeletal material with this shift in thinking in mind; perhaps new interpretations will be made that will help to resolve the debate. It appears that the traditional theories regarding venereal syphilis may have to be revamped.

DNA and immunoglobulin analysis have begun to unravel the relationships between the various treponemal syndromes, but this work is in its infancy (Antal et al 2002; Fornaciari et al 1989). Brothwell (2005) has stated that more ancient skeletal evidence must be recovered, more existing skeletal material must be re-examined, and more molecular analysis must be conducted before any substantial progress can be made in answering the questions surrounding venereal syphilis. Until that time, the mystery surrounding the treponematoses, and specifically venereal syphilis, will continue.

References


