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PRECONCEIVED NOTIONS AND HYPOTHESIS TESTING: HOLES IN THE BLUE HOLE

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Reconciling reported frequencies of periosteal reaction has been compromised by variable "criteria" for its recognition. One of the most important aspects of paleopathologic diagnosis is logical consideration of data, while avoiding biases introduced by preconceived notions. Documentation that skeletal manifestations of the treponemal diseases (as a population phenomena) are sufficiently (and reproducibly) distinct would allow meaningful assessment of the course of invasion and spread of treponemal disease in the Western Hemisphere. Quantitative assessment of the nature of osseous impact of specific treponemal diseases has resulted in identification of reproducible discriminating characteristics. The osseous reaction to treponemal infection, although reproducible for each variety, is not uniform among them. Examination of population frequency, demographics, character, and skeletal distribution of osseous treponemal impact provides clear, reproducible clues to the identity of the underlying treponematosis and help to distinguish them from other periosteal/cortical disorders. Application of the standard for distinguishing among the treponematoses has revealed only four patterns of disease: Those categorized as syphilis, yaws, bejel and a null pattern. The apparently inviolate categorization allows confidence in distinguishing among them.

Key words: Treponematosis, paleopathology, differential diagnosis.

El ajuste de las frecuencias reportadas de reacción periostal ha sido comprometido por el "criterio" variable de su identificación. Uno de los aspectos mas importantes del diagnóstico paleopatólogico son las consideraciones lógicas de los datos, mientras se evitan prejuicios de nociones preconcebidas. La documentación relativa a que las manifestaciones esqueletales de las treponematosis (como fenómeno poblacional) son suficientemente distintas permitiría la evaluación significativa del curso de la invasión de la treponematosis en el Hemisferio Occidental. La evaluación cuantitativa de la naturaleza del impacto óseo de las treponematosis específicas ha permitido la identificación de las características discriminantes. La reacción ósea a la infección por treponema, aunque repetitiva para cada variedad, no es uniforme entre ellas. El examen de la frecuencia poblacional, la demografía, el carácter y la distribución esqueletal del impacto de la treponematosis provee de pistas claras para la identificación de la treponematosis y permite diferenciarlas de otras condiciones periostales/corticales. Las aplicaciones del standard para distinguir entre las treponematosis ha revelado sólo cuatro patrones de la enfermedad: las categorizadas como sífilis, pián, bejel y un patrón nulo. La categorización aparentemente inviolada otorga un mayor grado de confianza para poder diferenciarlas.

Palabras claves: *Treponematosis, paleopatología, diagnóstico diferencial.*

Assumptions

Advancement of science is predicated upon testing of new ideas according to scientifically established information (Spodick 1975). The challenge is distinguishing between scientifically-established information and assumption. Much of what Heathcote et al. (1998) refer to as the "collective consciousness" of anthropology "on the etiology, evolutionary ecology and epidemiology of the treponematoses" seems to be predicated solely on assumption. Unfortunately, repetition of assumptions does not validate them. To paraphrase Will Rogers (Spodick 1975), it ain't what we don't know that gets us into trouble, so much as what we think we know, that ain't so.

Learning Curve

Variability in reported frequency of periosteal reaction (e.g., Mack and Armelagos 1992; Pietrusewsky et al. 1997) must be addressed. Does this variation represent real differences or simply interobserves variation - not only in selection of criteria, but also in their application. There are many learning curves in paleopathology. One of the most challenging has been recognizing periosteal reaction and distinguishing it from diagenesis.

It is intriguing that the skeletal distribution of periosteal reaction in the treponematoses is independent of severity (Rothschild and Rothschild 1994a,b, 1995a,b, 1996a,b, 1997a, Rothschild et al. 1995a). Thus, overlooking subtle changes or confusing them with diagenesis may lead to the false perspective that periosteal reaction is limited in frequency or unilateral. It would seem useful for those individuals, who believe they have found variant populations, to share those cases. Collaborative examination might well resolve the apparent variation.

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Similarly, failure to recognize diagenesis may lead to bizarre perspectives of almost total population occurrence. The enigma of the Blue Hole site perhaps exemplifies the problem. Mack and Armelagos (1992) submitted a site report suggesting a high frequency (7 of 9 individuals) of periosteal reaction, yet we found the bones to be absolutely smooth, with the exception of slight periosteal reaction in a single tibia. This appears to be an inter-observer/learning curve/communication issue, rather then an occurrence issue. Thus, establishment within the general field of anthropology does not validate the assumption of advanced position on the periosteal reaction/treponemal disease learning curve.

Perhaps a fundamental problem is understanding the difference between pathology and anthropology. Perhaps this is best illustrated by a medical school experience. One pathology professor spilled his slides on the way into the lecture hall. He then picked up the pile of slides, replacing them in the slide carousel in random order. The slides were all photographs, without any text. He then gave the lecture. I subsequently learned that this was a yearly routine, "performed" to make the point that the *pathology speaks for itself.* Context is not the issue in pathology. Clinical case reports may appear to be context-based, until one realizes that a case report is simply a clinical guess/hypothesis. The pathology is the test of that hypothesis!

Comparison of skeletal and clinical frequencies is useful. However, selection of the appropriate clinical comparison sample is essential. If a treatable disease is being studied, it is essential to select comparison populations from the pre-treatment era. Antibiotics have changed the dynamics of the treponematoses, precluding comparison with "naive" disease. Outbreaks under treatment also cannot be compared to untreated endemic disease (Mills 1955). Attention to detail is essential.

Distinguishing Treponematoses from Non-treponemal Disease

This is simple for the nonvenereal treponematoses. There are no other diseases that have population frequencies of periosteal reaction in the 20-40% range (McCarty and Koopman 1993; Rothschild 1982; Resnick and Niwayama 1988; Rothschild and Martin 1993). The challenge is more complicated for venereal syphilis, as the osseous lesions have low population frequency (Rothschild and Rothschild 1994a,b, 1995a,b, 1996a,b; Rothschild et al. 1995a). Its pauciarticular pattern and skeletal distribution can occasionally be mimicked by other forms of osteomyelitis, bone neoplasia, and perhaps by rickets, but trauma, leprosy and tropical ulcers are easily distinguished (Moller-Christensen 1967; Resnick and Niwayama 1988; Rothschild and Martin 1993).

Trauma represents an often repeated, but unsubstantiated speculation. Such trauma-induced focal bony overgrowths are rare and easily distinguished. The latter appears to derive from misunderstanding of the medical literature. This is exemplified by Meese and Sebastianelli's (1996) claim of periostitis in athletes, in spite of normal x-rays. Their impression was based solely on radionucleotide bone scans. However, the scans showed only very focal isotope uptake, surrounded by a zone of lesser uptake. While they diagnosed periostitis, the images are actually classic for stress fractures! Stress fractures are readily recognized and distinguished in the osseous record (Resnick and Niwayama 1988; Rothschild and Martin 1993), even across species lines (Rothschild 1988).

One critique to recognizing specific diseases is clearly based on what might be considered "diagnostic nihilism". Heathcote et al. (1998) state that "Conventional wisdom has it that... most... bone lesions observed in prehistoric remains cannot be attributed to a specific etiologic agent". That comment might be validly applied to isolated examination of lesions in isolated bones. It might even have application to examination of individuals. However, it has been clearly demonstrated not to be true for population studies. If such perspective were valid, then why study paleopathology?

Populations studies have clearly demonstrated the reproducibility of osseous findings for a given disease, independent of geography and socioeconomic status. The skeletal distribution and character of a given disease are clearly indistinguishable for populations with rheumatoid arthritis and spondyloarthropathy (Rothschild and Martin 1993; Rothschild and Rothschild 1993; Rothschild and Woods 1991; Rothschild et al. 1992, 1993a). The general reproducibility of osseous findings (for a given disease) is so substantial that it even crosses species lines (Rothschild and Rothschild 1994c; Rothschild and Woods 1992; Rothschild et al.

1993b, 1994). Thus, the osseous appearance of spondyloarthropathy in gorillas is no different in appearance than that noted in humans (Rothschild and Woods 1989).

Distinguishing among the Treponematoses

Unproven Speculation

Invalid Criteria: While cranial lesions have been considered, distinguishing among the treponematoses (Ortner and Putschar 1981; Steinbock 1975), Hackett (1976) stated that he would not even attempt to distinguish among the treponematoses. He felt his skull samples were compromised by significant collection bias, and he did not have documented examples of the various treponemal diseases. Skull findings do not lend themselves to epidemiologic differentiation of the treponematoses.

Insensitive Criteria: Dental stigmata would seem to be a reasonable differential tool, but the various forms of syphilis-attributed hypoplasia are infrequently observed in any syphilis-affected population

(El-Najjar et al. 1978; Rothschild and Rothschild 1997a). Because they represent hypoplastic teeth, the dental elements often do not survive (in recognizable form) into adulthood and through taphonomic influences (Pinborg 1970; Putkonen and Paatero 1961; Sullivan 1986). Osseous lesions of congenital or syphilis are a short-lived phenomenon (Levin 1970), typically resolving over the course of several months, usually precluding their recognition in subadult skeletons (McLean 1931; Rothschild and Rothschild 1997a).

Circular Reasoning: Time course perspectives of disease epidemiology are dependent on modern distribution, the historical record, and paleopathologic evidence (Cockburn 1963). The preconceived notion of climate determination (Powell 1995) does not seem to fit with the paleo-epidemiologic findings (Bogdan and Weaver 1992; Bullen 1972; Neuman 1975; Parramore 1970; Powell 1995; Rothschild and Rothschild 1994a,b, 1995a,b, 1996a,b; Rothschild et al. 1995a; Schermer et al. 1994). It seems appropriate to explore other explanations for the current catchment areas, "islands" where non-venereal treponematoses still exist. Perhaps if we understand the timing of their eradication in other areas of the world, we may have a tool to understand their contemporary persistence patterns. Such would be in keeping with Cockburn's (1963) cogent observations. Heathcote et al. (1998) confuse the hypothesis of climate as a significant cofactor in treponemal disease manifestation with evolution. That seems somewhat Lamarckian (Gould 1998). If climate determines manifestation of a single organism, this would be phenotype, not genotype.

Unitarian Hypothesis

Heathcote et al. (1998) suggest that contemporary anthropologic thinking assumes bejel, yaws and syphilis are simply manifestations of the same disease. Differential animal sensitivity to the different treponemes provides unequivocal evidence that they are different species (Larsen et al. 1995; Schell et al. 1981). Manifestations of the different treponematoses differed from each other through repetitive passage, while strains of a given treponematosis produced identical findings (Chacko 1966; Turner and Hollander 1957).

Documented Criteria

Distinguishing syphilis, yaws, and bejel among the treponemal diseases was made possible because of validation (Rothschild and Rothschild 1994a, 1995a, 1996a; Rothschild et al. 1995b) of criteria (Rothschild and Rothschild 1994a,b, 1995b, 1996a,b; Rothschild et al. 1995a) for distinguishing among them. These skeletal findings are also indistinguishable from those derived from clinical/radiologic observation (Csonka 1953; Hackett 1946; Helfet 1944; Hudson 1958; Hunt and Johnson 1923; Jostes and Roche 1929; Moss 1922).

Examined as population phenomenon in *over 100* archaeologic sites, only three patterns of disease were observed. Review of over 100 skeletal populations revealed no population with syphilis affecting more than 14% of the population and no population with yaws or bejel affecting less than 20% (Hershkovitz et al. 1995; Rothschild and Rothschild 1994a,b, 1995a,b, 1996a,b; Rothschild et al. 1995a). Unilateral tibial involvement and/or total sabre shin remodeling was found only in populations with syphilis. Subadults were affected

in yaws and bejel at the same frequency as adults, while less than 5% (usually less than 1%) of subadults were affected in any population with syphilis. Hand and foot involvement was essentially limited to yaws, present in less than 5% of individuals with bejel or syphilis. Average number of bone groups affected was always less than 3 in populations with syphilis and bejel, with the converse noted in yaws. The skeletal impact of these patterns (representing syphilis, yaws and bejel) were sufficiently disparate to allow their individual recognition.

Use of Criteria to Validate Previous Speculation

Baker and Armelagos (1988) speculated that venereal transmission was a post-Columbian event in North America. Others have not been so certain, instead identifying non-venereal treponemal disease (Bullen 1972; Neuman 1975; Powell 1995; Schermer et al. 1994). Such studies have speculated (on the basis of examination of "classic cases" that treponemal infection in North America was likely yaws or bejel. Saint-Hoyme (1969) specifically reported on yaws-like changes in the midwest of North America. Validated criteria (Rothschild and Rothschild 1995b) allowed verification of their perspective (Rothschild and Rothschild 1994a,b, 1995a; Rothschild et al. 1995a).

Summary

Critical examination of assumptions/speculations and data clarifies ability to recognize and distinguish among the treponematoses. Interobserver error and misconceptions contribute significantly to confusion. Challenges seem to have been predicated upon untested assumptions and misconceptions. Speculation (that bejel, yaws and syphilis are a single disease, that yaws is always tropical, and that bejel is solely a desert phenomenon) are exposed for what they are - untested or rebutted hypotheses.

Conventional wisdom has suggested that the world is flat at that giraffes developed long necks so they could reach trees. Is anthropology a science or a philosophy? Should anthropology be "Descartian" - I think, therefore I publish - or should it be predicated on the scientific method? Do the "Lamarckian" and "flat-earther" aspects and history of conventional wisdom really represent concepts helpful in understanding the treponematoses or are do they represent pseudoscience often attributed to creationist defenses?

The prepared mind sometimes sees only what it is prepared to see. It is not what we don't know that gets us into trouble, so much as what we think we know, that simply isn't so. Is it not time to allow the data to speak for itself? That data-based approach forms the basis for this symposium.

References Cited

Baker, B.J. and G.J. Armelagos
1988 The origins and antiquity of syphilis. *Curr. Anthropol.* 29:703-720,732-737.

Bogdan, G. and D.S. Weaver
1992 Pre-Columbian treponematosis in Costal North Carolina. In *Disease and Demography in the Americas*, edited by J.W. Verano and D.H. Ubelaker, pp. 155-163. Smithsonian Institution Press, Washington D.C.

Bullen, A.K.
1972 Paleoepidemiology and distribution of prehistoric treponemiasis in Florida. *Florida Anthropol.* 25:133-174.

Chacko, C.W.
1966 Accidental human infection in the laboratory with the Nichols rabbit-adapted virulent strain of Treponema allidum. *Bull. World Hlth. Org.* 35:809-810.

Clutton, H.H.
1886 Symmetrical synovitis of the knee in hereditary syphilis. *Lancet* 1:391-393.

Csonka, G.W.
1953 Clinical aspects of bejel. *Brit. J. Vener. Dis.* 29:95-103.

El-Najjar, M., MV Desanti, and L Ozebek
1978 Prevalence and possible etiology of dental enamel hypoplasia. *Amer. J. Phys. Anthropol.* 48:185-192.

Gould, S.J.
1998 An awful, terrible dinosaurian irony. *Natural History* 107(1):24-26, 61-68.

Hackett, C.J.
1946 The clinical course of yaws in Lango, Uganda. *Trans. Roy. Soc. Trop. Med. Hyg.* 40:206-217.

Hackett, C.J.
1976 *Diagnostic Criteria of Syphilis, Yaws and Treponarid (Treponematoses) and of Some Other Diseases in Dry Bones.* Springer-Verlag, Berlin.

Heathcote, G.M, A.L. Stodder, H.R. Buckley, D.B. Hanson, M.T. Douglas, J.H. Underwood, T.F. Taisipic, and V.P. Diego
1998 On Treponemal disease in the Western Pacific: Corrections and Critique. *Current Anthropology 39: 359-368.*

Helfet, A.J.
1944 Acute manifestations of yaws of bone and joint. *J. Bone Jt. Surg.* 26B:672-685.

Hershkovitz, I., B.M. Rothschild, S. Wish-Baratz, and C. Rothschild

1995 Natural variation and differential diagnosis of skeletal changes in Bejel (endemic syphilis). In *The Origin of Syphilis in Europe*, edited by O. Dutour, G. Palfi, J. Berato, and J.P. Brun, pp. 81-87. Centre Archeologique du Var, Toulon, France.

Hudson, E.H.
1958 *Non-venereal syphilis: A Sociological and Medical Study of Bejel.* Livingston, London.

Hunt, D. and A.L. Johnson
1923 Yaws: A study based on over 2000 cases treated on American Somoa. *U. S. Naval Bull.* 18:559-581.

Jostes, F.A. and M.B. Roche
1939 Syphilis of the bones and joints. *J. Missouri Med. Assoc.* 36:61-65.

Larsen, S.A., B.M. Steiner, and A.H. Rudolph
1995 Laboratory diagnosis and interpretation of tests for syphilis. *Clin. Microbiol. Rev.* 8:1-21.

Levin, E.J.
1970 Healing in congenital osseous syphilis. *Amer. J. Roentgenol.* 110:591-597.

Mack, M.E. and G.J. Armelagos
1992 Skeletal analysis of the Sanctuary Blue Hole Remains: The Lucayan Taino. Report submitted to the Bahamian Department of Archives, Nassau, The Bahamas.

McCarty, D.J. and W.J. Koopman
1993 *Arthritis and Allied Conditions: A Textbook of Rheumatology.* Philadelphia: Lea and Febiger.

McLean, S.
1931 Roentgenographic and pathologic aspects of congenital osseous syphilis. *Amer. J. Dis. Child.* 41:130-152, 411-418.

Meese, M.A. and W.J. Sebastianelli
1996 Periostitis of the upper extremity: A report of 2 cases and literature review. *Clin. Orthopaed. Rel. Res.* 324:222-226.

Mills, A.R.
1955 The incidence of yaws in the New Hebrides. *Trans. Roy. Soc. Trop. Med. Hyg.* 49:58-61.

Moller-Christensen, V.
1967 Evidence of leprosy in earlier peoples. In *Diseases in Antiquity*, edited by D Brothwell and AT Sandison, pp. 295-306. Charles C. Thomas, Springfield, Illinois.

Moss, W.L. and G.H. Bigelow.
1922 Yaws: An analysis of 1046 cases in the Dominican Republic. *Bull. J. Hopkins Hosp.* 33:43-47.

Neuman, R.W.
1975 The Sonota Complex and Associated Sites on the Northern Great Plains. Nebraska State Historical Society, *Publications in Anthropology* No. 6.

Ortner, D.J. and W.G. Putschar
1981 Identification of Pathological Conditions in Human Skeletal Remains. *Smithsonian Contributions to Anthropology* 28.

Ortner, D.J., N. Tuross, and A. Stix
1992 New approaches to the study of disease in archaeological New World populations. *Human Biol* 64:337-360.

Pietrusewsky, M., M.T. Douglas, and R.M. Ikehara-Quebral
1997 An assessment of health and disease in the prehistoric inhabitants of the Mariana Islands. *Amer. J. Phys. Anthropol.* 104:315-342.

Pinborg, J.J.
1970 *Pathology of the Dental Hard Tissues.* Philadelphia: W.B. Saunders.

Powell, M.L.
1995 Why call it syphilis? Treponematosis before 1492 in the Southeastern United States of America. In *L'Origine de la Syphilis en Europe Avant our Apres 1493?*, edited by O Dutour, and G. Palfi, pp. 158-163. Centre Archeologique du Var, Toulon, France.

Putkonen, T. and Paatero Y.V.
1961 X-ray photography of unerupted permanent teeth in congenital syphilis. *Brit. J. Vener. Dis.* 37:190-196.

Resnick, D. and G. Niwayama
1988 *Diagnosis of Bone and Joint Disorders.* 2nd edition. Philadelphia: Saunders.

Rothschild, B.M.
1982 *Rheumatology: A Primary Care Approach.* New York City: Yorke Medical Press.

Rothschild, B.M.
1988 Stress fracture in a ceratopsian phalanx. *J. Paleontol.* 62:302-303.

Rothschild, B.M. and L. Martin
1993 *Paleopathology: Disease in the Fossil Record.* London: CRC Press.

Rothschild, B.M. and C. Rothschild
1993 Nineteenth century spondyloarthropathy independent of socioeconomic status: Lack of skeletal collection bias. *J. Rheumatol.* 20:314-319.

Rothschild, B.M. and C. Rothschild
1994a Yaws, mine and ours: Treponemal disease transitions in prehistory. *J. Comp. Human Biol.* 45:S115.

Rothschild, C. and B.M. Rothschild
1994b Syphilis, yaws and bejel: Population distribution in North America. *Amer. J. Phys. Anthropol.* 94;174-175.

Rothschild, B.M. and C. Rothschild
1994c No laughing matter: Spondyloarthropathy in Hyaenidae. *J. Zoo Wildlife Med.* 25:259-263.

Rothschild, B.M. and C. Rothschild
1995a Distinction des maladies treponemiques: Syphilis, Pian et Bejel a partir des differences de leurs atteintes osseous respectives. In *The Origin of Syphilis in Europe,* edited by O Dutour, G Palfi, J Berato, and J.P. Brun, pp. 68-71. Centre Archeologique du Var, Toulon, France.

Rothschild, B.M. and C. Rothschild
1995b Treponemal disease revisited: Skeletal discriminators for yaws, Bejel and venereal syphilis. *Clin. Infect. Dis.* 20:1402-1408.

Rothschild, B.M. and C Rothschild
1996a Treponemal disease in the New World. *Curr. Anthropol.* 37:555-561.

Rothschild, B.M. and C Rothschild
1996b Analysis of treponemal disease in North Africa: The case for Bejel in the Sudan, but absence in West North Africa. *Human Evolution* 11:11-15.

Rothschild, B.M. and C. Rothschild
1997a Congenital syphilis in the archaeologic record: Diagnostic insensitivity of osseous lesions. *Intl. J. Osteoarchaeol* 7:39-42.

Rothschild, B.M. and C. Rothschild
1997b Nature and distribution of periosteal reaction in hy-

pertrophic osteoarthropathy (HOA). *Amer. J. Phys. Anthropol. Suppl* 24:200-201.

Rothschild, B.M. and R.J. Woods
1989 Spondyloarthropathy in gorillas. *Semin. Arthritis Rheum.* 18:267-276.

Rothschild, B.M. and R.J. Woods
1991 Spondyloarthropathy: Erosive arthritis in representative defleshed bones. *Amer. J. Phys. Anthropol.* 85:125-134.

Rothschild, B.M. and R.J. Woods
1992 Spondyloarthropathy as an Old World phenomenon. *Semin. Arthritis Rheum.* 21:306-316.

Rothschild, B.M., R.J. Woods, C. Rothschild, and J.I. Sebes
1992 Geographic distribution of rheumatoid arthritis in ancient North America: Implications for pathogenesis. *Semin. Arthritis Rheum.* 22:181-187.

Rothschild, C., B.M. Rothschild, and R.J. Woods
1993a Patterns of spread of arthritis in North America. *Prog. Rheumatol.* 5:116-119.

Rothschild, B.M. X.M. Wang, and R. Cifelli
1993b Spondyloarthropathy in Ursidae: A Sexually Transmitted Disease? *Natl. Geographic Res.* 9:382-284.

Rothschild, B.M. X.M. Wang, and J. Shoshani
1994 Spondyloarthropathy in proboscideans. *J. Zoo Wildlife Med.* 25:360-366

Rothschild, B.M., C. Rothschild, and M.C. Hill
1995a Origin and transition of varieties of treponemal disease in the New World. *Amer. J. Phys. Anthropol. Suppl* 20:185.

Rothschild, B.M., I. Hershkovitz, and C. Rothschild
1995b Origin of Yaws in Pleistocene East Africa: Homo erectus KNM-ER 1808. *Nature* 378:343-344.

Saint-Hoyme, L.E.
1969 On the origins of New World Palaeopathology. *Amer. J. Phys. Anthropol.* 31:295-302.

Schell, R.F., J.L. Lefrock, J.K. Chan, and O. Bagasra
1981 LSH hamster model of syphilitic infection and transfer of resistance with immune T cells. In *Hamster Immune Responses in Infections and Oncologic Diseases*, edited by J.W. Streilein, D.A. Hart, J. Stein-Streilein, W.R. Duncan and R.E. Billingham, pp 291-200. New York: Plenum Publishing Corp.

Schermer, S.J., Fisher A.K, and D.C. Hodges
1994 Endemic treponematosis in prehistoric western Iowa. In *Skeletal Biology in the Great Plains: Migration, Warfare, Health, and Subsistence*, edited by D.W. Owsley and R.L. Jantz, pp. 109-116. Smithsonian Institution Press, Washington D.C.

Soetopo, M. and R. Wasito
1953 Experience with Yaws Control in Indonesia" in First international symposium on yaws control. Who Monograph No. 15: 273-292.

Steinbock, R.T.
1975 *Palaeopathological Diagnosis and Interpretation.* Springfield Thomas.

Sullivan, N.C.
1986 Enamel hypoplasia as an indicator of biologic stress in two Wisconsin populations. *Wisconsin Archeol.* 67:97-103.

Turner, T.B. and D.H. Hollander
1957 Biology of the treponematoses. *WHO Series* 35.