

A STUDY OF THE PATHOLOGICAL CHANGES IN SOME MOUND-BUILDERS' BONES FROM THE OHIO VALLEY, WITH ESPECIAL REFERENCE TO SYPHILIS.

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Not infrequently among the skeletal remains of the Mississippi and Ohio Valley mound-builders are found bones exhibiting very evident gross pathological changes. The Museum of the Ohio State Archæological and Historical Society at the Ohio State University in Columbus has among its rich collection quite an amount of this material, and through the kindness of Mr. Wm. C. Mills, the curator of the museum, some of the bones were obtained for examination, the results of which are given below.

During the summers of 1899 and 1900 the Society's exploration party were at work on what is known as the Baum Village site, and a short account of this work is appended here as descriptive of the general source of the material. The village site lies on the Baum farm in the valley of Paint Creek, one of the smaller tributaries of the Scioto River, whose valleys make up much of Ohio's richest farm land. The village had been apparently roughly semicircular in outline, standing at that time, in all probability, on a point of land jutting out into Paint Creek (now about one-half mile distant), and having as its centre a mound about sixteen feet high and forty feet in diameter. This mound was explored about ten years ago by a party from the Smithsonian Institute, and a report of the findings there show by comparison with material from the village site that the two were beyond doubt isochronological. This statement also holds true with reference to the other mounds, village sites, and mound-builders' remains of the Ohio and Mississippi valleys.

The site is now a part of a cultivated field, and the surface of the ground is scattered for a space of an acre or more with bits of shell and bone, and fragments of pottery turned up by the plow. This ground, however, had all been worked over before the advent of the steel plow-share, and on going down from the surface an average depth of three feet the earth contains flakes of flint, arrow-heads, bones of various wild animals, ashes, charcoal, broken fresh water mussel-shells, and other refuse of the village, with a sharp line of demarcation between the "worked" loam above and the gravel "hard-pan" below. Scattered here and there throughout this area were found places where the soft loam continued down below the general depth, and on removal of the earth here these proved to be pits from three to six feet in diameter and of an equivalent depth filled with much the same material as was scattered through the surface soil, but in greater abundance. These refuse pits proved a fertile field for exploration, and in them, though not exclusively, were found in addition to the things mentioned above numerous implements and ornaments, such as shell and bone beads, bone awls and fish-hooks, hide scrapers carved from the metatarsal bones of the deer, shell and bone amulets and pendants, flint arrow and spear points, charred cobs of the maize, charred bits of cloth and shells of nuts (including the hazel, hickory, butternut, and black walnut), ashes in great heaps, broken pottery, split and shattered bones of all of our common small wild animals, and also of the mountain lion, bear, elk, and deer, and an occasional human skeleton. The majority of the human burials had been made, however, in the surface soil, most of them on the sandy gravel substratum, although some had so shallow a covering as to have been disturbed by the plows. All of the bones were in an exceedingly good state of preservation considering their undoubted age, and this is accounted for probably in part by the topography and constitution of the soil in which they were buried, which favored quick and full drainage of surface water, and in part by the great quantities of wood ashes with which they were more or less surrounded. One or two of the bodies had been buried in rough stone coffins, built of large, flat, unshapen slabs of the slaty limestone of the neighborhood, but for the most part no attempt was made to enclose the bodies, which were interred apparently in the very back yard of their premises. The remains were buried in the recumbent position, with no regular arrangement in regard to the points of the compass, as is sometimes seen, and were more or less scattered throughout the whole area.*

As will be seen below the lesions of the bones examined are such as to lead to the diagnosis of syphilis as their etiological factor. The reader of works on the history of syphilis will find interest in the discussions of many syphilographers and historians on the origin of this now almost universal disease. The French writers especially have taken up the argument, and we find opinion divided between three possibilities: (1) That the disease was endemic both in this continent and the old world before communication was established across the Atlantic. (2) That the origin of the infection was in the American races, and that it was carried to Europe by the sailors of Columbus' expedition on their return; and, (3) the reverse of the latter theory—*i. e.*, that its place of endemicity was in Europe, and that it was brought westward to this side of the Atlantic by Columbus' men and so implanted here.

It will be readily seen that the results of the present investigation have no bearing on the two former hypotheses.

* At one place, however, some skeletons were uncovered in one small area; these bones were on exhibition in their relative positions in the enclosure at the centre of the Anthropological Building at the Pan-American Exposition in Buffalo in 1901.

If the diagnosis given is correct, in view of the undoubted pre-Columbian time of these remains, it is entirely incompatible with the third explanation. It may well be added here, however, that the supporters of this theory are comparatively few.

A vast amount of literature has been published in discussion of this question, and strong arguments brought to bear on all sides.

The work of Buret[1] in support of the universal pre-Columbian distribution brings up some very strong proofs. These volumes, while of only a semiscientific nature, give a *résumé* of a great amount of evidence of various worth. Early in the first volume is an account of lesions found on human osseous remains exhumed at Solutrè in the Department of Saône-et-Loire in western France. These bones, found buried with those of the horse and reindeer and cut flints, etc., belonging to the Gallo-Roman or Merovingian epochs, were referred by anthropologists of the best authority to the Stone Age, and, the author adds, "examined by Broca, Ollier, Parrot, and Virchow, the lesions were, by common consent, pronounced syphilitic." Then follow reports of examinations of several Peruvian prehistoric skulls showing evidences of acquired and hereditary syphilis and, by way of contrast, lesions which from their description seem identical, on bony remains from the caverns and dolmens inhabited by "tribes who peopled the Gauls during the Stone Age and in the druidical times before the Frankish dynasties." In another chapter is given an abstract of translations from Chinese documents collected by the Emperor Hoang-ty, 2637 B.C., and forming the volume Hoang-ty-mi-King or the *Medical Treatise of Hoang-ty.* Quotations of this translation give very apt descriptions of the two main varieties of venereal ulcers with reference to the connection between the Hunterian sore and the secondary eruption, with an account of the varieties of the latter which is easily recognizable, and as treatment advise mercurial frictions, aided by an oily mixture and a powder composed of mercury.* In support of the existence of syphilis in Biblical times, during the ascendancy of the Greeks and Romans and in the Middle Ages, is quoted a mass of documents largely secular which show beyond doubt that venereal diseases of some kind were rampant then, and would seem to indicate the probability of the existence of lues venerea, but hardly prove the point.

On the other side the discussion was headed by Astruc,[2] the early French syphilographer. His articles, while able, were written before the discovery of many important pieces of evidence, and hence are not of such worth as the work of Bloch,[3] which is among the most recent writing on the subject.

Bloch credits the appearance of the disease in Europe to the return of Columbus' first expedition and its rapid dissemination to the debauchery of the troops of Henry the VIII. of France on his expedition against Naples and their widespread dispersion, carrying the infection with them, at the end of the siege. He uses the malignancy of the epidemic of Naples as an argument in support of his theory that European peoples were before that outbreak free from the disease and consequently lacked that immunity which would obtain through long exposure of the race to infection. To quote directly: "Wenn der Syphilis schon Jahrtausende bestanden hätte, dann hätte doch im Laufe dieser langen Zeit ein so grosse Immuniseirung der Völker des Orbis antiquus gegen das syphilitische Gift eintreten müssen dass die ereignisse am ende des 15 Jahrhunderts einfach unmöglich gewesen wären."

He asks how else can the early appearance of the secondary lesions, the high fever, the pain, the high mortality, etc., in the Neapolitan outbreak be explained. It seems not untenable to believe that the infection had been present on both sides of the Atlantic for thousands of years and that in this way the virus may have become attenuated in each continent—so much so in Europe as to have been overlooked during the dark era of the Middle Ages, or to have been confounded with leprosy or other current diseases—and to have owed its virulence in the epidemic of 1495–6 to a transplantation of the infection of American origin on to what might be for it a favorable soil. Evidences of this variability in infective agencies is seen sometimes in cases where inhabitants of a notorious typhoid centre remain free from infection for indefinite periods only to succumb to the disease on removal to another endemic focus. Here also may be mentioned the severity of the venereal infections brought back by our own troops from the Philippines. One author has spoken of the organism of gonorrhœal infection from this source as the micrococcus gonorrhœæ malignus.

Considerable work has been done on the lesions found in the bones of the prehistoric or at least pre-Columbian inhabitants of this country with the result of a diagnosis of syphilis. Among this are the investigations of Jones[4] in 1876 and 1878, of Brühl[5] in 1880 and 1890, and of Hyde[6] in 1891, all of which are articles of interest and of great value to a study of this question.

If the evidence quoted above from Buret of the early existence of syphilis in China be granted, its presence on the American continent in pre-Columbian times might be considered as an addition to the theory, upheld by some anthropologists of repute, that the prehistoric inhabitants of this hemisphere found their way here from northeastern China and Siberia, across Behring Straits to Alaska, and thence down the Pacific coast to be widely scattered from there over the whole continent.

* It is of interest here to mention also the account of vaccination against variola practised by the Hindoo physicians 1000 years B.C., by taking the liquid of the pustule of the cow's teat or from the arm of a human being, placing it upon the point of a lancet and introducing it into the arm of the patient to be vaccinated, mixing the fluid with the blood, etc.

With regard to the pathology of the specimens under examination a considerable handicap is apparent in that the cellular constituents of the bones are long since disintegrated, but the lesions of the resistant parts are sufficiently characteristic to permit of diagnosis. These changes in the hard parts in syphilitic diseases exclusive of the cellular study are reviewed here for comparison with the results to be shown presently.

All authors agree on the subject that the bones most frequently the seat of syphilitic changes are those which are most exposed to trauma, which seems to act as a focalizing factor for the morbid process. The order of preference given is: the tibia, clavicle, cranium, ulna, sternum, ribs, etc. This is notoriously the distribution of lesions found in the mound-builders. One particular skeleton is recalled in which gross changes were apparent in both tibiæ, the vault of the cranium, one clavicle, and one ulna, and this was noted before the sites of election of the syphilitic processes were known to the observer, and, indeed, before syphilis was suspected as being a factor in the case. The following figures furnished by Mr. Mills will show something of the distribution: Of 127 skeletons exhumed at the Baum Village site 21 were diseased. Fully 60 per cent. of those affected show the lesions worst upon the tibia, the ulna coming next perhaps, then the cranium and then the sternum. But few ribs were affected.

Given the disease attacking a long bone Lang[7] says: "It is interesting to note that the diaphyses are much more frequently affected than their epiphyses."

Again, all authors seem in accord with the statement that the two processes of osteoporosis and osteosclerosis occurring side by side in adjacent portions of the same bone are almost pathognomonic of syphilis. Hyde and Montgomery[8] put it thus: "These processes of rarefaction, bone formation, and even bone degeneration to the point of production of a sequestrum through an ulcerative opening may occur simultaneously in different parts of one bone or side by side, one lamella thickening while that adjacent softens. This multiformity of processes is a characteristic feature of bone syphilis. . . . . In examination of bones with a view to determine the probable causes of death the existence of worm-eaten cavities, of irregular thickenings, and of perforations of entire plates of bone is indicative of syphilis."

Le Baron[9] describes a syphilitic tibia in these terms: "Near the middle of the crest of the tibia there exists a considerable hyperostosis of the anterior half of the diaphysis. As a result the anterior border presents a very marked curve with an anterior convexity. This hypertrophy has an elongated, ovoid form, and its surface is as smooth as the rest of the bone. It extends to a length of 85 mm. In this locality the tibia is 24 mm. thick. A longitudinal section made through the tumor shows that it is composed of compact tissue. The medullary canal has preserved its normal dimensions."

In this quotation the word "hyperostosis" is used apparently to describe an overgrowth of a portion of the bone, but not of its entirety, which latter seems to be the accepted meaning. Thus the *American Text-book of Genitourinary Diseases, Syphilis, and Diseases of the Skin*[10] defines hyperostosis as an enlargement of the *whole* bone, exostosis as a large growth on the bone, and osteophytes as small, superficial elevations.

The gross changes brought about by the syphilitic process in long bones consist of one or more large exostoses (rarely a hyperostosis) in the diaphysis. In the tibia, for instance, the exostosis is usually single when well advanced and is a large, ovoid hypertrophy, most frequently in the upper half of the shaft, although sometimes the whole of the diaphysis is involved. This new growth of bone to be typical shows both in the gross section and microscopically the condition of rarefying osteitis side by side with one of condensing osteitis which may be far enough advanced to justify the term "eburnation." In any given specimen, however, the lesions may be chiefly confined to any one of these three types, dependent on the progress of the disease—but the other types are always present to a greater or less degree. There may be also on the surface of the bone small osteophytes either of intense hardness when they are, as a rule, more or less regular and polished, or when they occur in the line of origin or insertion of a muscle roughened, irregular projections.

Sometimes the exostosis, which is nearly always on the anterior aspect of the bone (that part exposed to trauma), may involve the entire length of the diaphysis, giving a curve of large radius with convexity forward and distorting the whole of the bone except the epiphyses, which seem to be entirely normal. This gives rise to the condition called "sabre-blade" deformity when occurring in the tibia, where it is most frequently seen. The lumen of the medullary canal may be enlarged through absorption of the bone surrounding it. This may be greater or less than, or equal to, the deposition of bone from the periosteal side, thus giving a large canal with thin walls or thick walls with an increased lumen, or an increased lumen with walls of about normal thickness. Sometimes deposition of bone takes place from the endosteum, encroaching on the medullary canal either through the formation of dense bone or through a mesh of very fine interlacing spicules of osseous material, almost or entirely filling up the original canal. The external surface of an exostosis of a long bone may be as smooth as, or even smoother than, the normal bone surface, in which case the condition of sclerosis will usually be found to be the predominant one, or it may be marked with irregular lines or depressions more or less parallel with the long diameter of the shaft, or deeply grooved with branching channels in which lay the enlarged periosteal vessels, or filled with small holes running into the body, which on section prove to be enlarged Haversian canals perpendicular

to the shaft. The perpendicular arrangement of the new canals is explained by Cornil and Ranvier[11] as follows: "The direction of the Haversian canals follows that of the bloodvessels. The periosteal or granulation vessels come from the Haversian canals at the surface of the bone and it is around these vessels that the new osseous lamellæ are formed."

In the skull the process is essentially the same—*i. e.*, rarefaction in some areas with sclerosis in others. The sclerosis here often takes the form of small, exceedingly dense, smooth, eburnated bosses or osteophytes or in an increase of bony substance in the cancellous diploë, sometimes progressing to such an extent as to obliterate the vascular spaces there, to which process some authors ascribe the necrosis which is associated with the syphilitic lesions in the cranium and is so noticeably absent elsewhere. In the words of Cornil and Ranvier: " . . . il est bien certain que la mort de l'os resulte souvent d'une osteite condensante ou sclerosé, poussee jusqua l'obliteration des canaux vasculaires."

Differential diagnosis is here made from tuberculosis, chronic osteomyelitis, and osteitis deformans. The pathological changes of bone syphilis are so clear and well defined, however, as not to require elaborate differentiation. Osteitis deformans while a rare disease, now, is included in view of the fact that so little is known of the diseases prevalent at the time from which our material has come. In the osseous lesions of tuberculosis and chronic osteomyelitis the formation of an involucrum with sequestra and cloacæ is usually a prominent feature. In the tuberculous bone affections the disease is very often manifested in the epiphyses and joints and leaves there unmistakable traces of its ravages. Lazarus-Barlow[12] is quoted here: "Tuberculous disease of bones differs in the fact that sclerosis is almost characterized by its absence. . . . It is never found that a focus of tuberculous disease shows a considerable formation of new bone in the neighborhood of the principal seat of the disease. The utmost that we see is the presence of a few osteophytic growths." Again, the same author says of osteitis deformans: "All bones are usually affected and the whole bone is involved." This is a true hyperostosis of general distribution rather than exostosis on certain selected bones as is the case in syphilis.

The microscopic picture of bone syphilis exclusive of the cellular changes is directly comparable to the gross lesions—*i. e.*, concurrent rarefying and condensing osteitis. Cornil and Ranvier, in describing the result of rarefaction by enlargement of the Haversian canals, says: " . . . The canals communicate and by their junction form irregular spaces filled with marrow of an embryonal type." Simes and White in their translation of Cornil's *Syphilis*[13] describe the sclerotic changes as follows: "When under the influence of appropriate treatment or following the natural course of the malady, the inflammation ceases and the disease retrogrades, there is seen a reparation of the diseased and partially destroyed bone. . . . There result new lamellæ with new osteoblasts, and these form several series parallel one with another, or follow the irregular arrangement of the Haversian canals. This exuberant formation of new osseous lamellæ may constitute beneath the periosteum exostoses of varying size and in the bone a parenchymatous exostosis or eburnation." Again in Shakespeare and Simes' translation of Cornil and Ranvier's work appears the following: "A transformation which has taken place in consequence of the formation of osseous tissue which being deposited in the interior of the canals has narrowed them. The new osseous layers may be so arranged that the lumen of the canal does not correspond to the centre of the original canal. This process continuing the canal may be completely obliterated so that at the centre of the concentric layers, instead of a canal there is found one or more bone corpuscles."

A rough qualitative analysis of the material under examination showed large amounts of calcium and magnesium, some aluminum, a trace of iron, the carbonic, sulphuric, and hydrochloric acid radicals, and considerable organic matter. On complete incineration of a portion of bone in the oxidizing flame, reducing it to an amorphous white powder a loss of 17 per cent. by weight was noted. After heating until the mass charred and then lost its black color (becoming gray and not white as above and leaving no residue on solution with dilute hydrochloric acid) the percentage weight loss was on an average 10. Although the conclusions here are reached by a very rough method and are probably far from accurate, the 10 per cent. weight loss is taken to represent approximately the amount of organic matter and the additional 7 per cent. accounted for by the breaking up of the carbonates and the evolution of carbon dioxide. The source of the organic matter here is a question—whether remains of the original animal matter of the bone, or vegetable replacement during their stay in the soil. The latter possibility seems more reasonable and is supported by the finding of small roots in the medullary cavity of some of the bones sending their finer branchs into the cancellous structure and enlarged Haversian canals.

A description of the gross lesions of the bones is given here.

Specimen No. 1 ($\frac{106}{1000}$).* Complete right tibia which shows on its anterior and two lateral faces a large exostosis beginning about 3 cm. from the lower border of the tibial tubercle and extending down the whole length of the shaft to its junction with the lower epiphyseal portion. The joint surfaces are smooth and there are no periarticular projections. The exostosis is fusiform in shape and of such size as to result in a curving of the tibial crest with the con-

* The figures in parentheses refer to the Museum catalogue numbers of the Ohio State Archæological and Historical Society's collection.

vexity forward. Its surface is irregular and grooved with fine striæ each of which ends in an opening. The whole mass shows shallow, circumferential, wavy lines passing from behind forward and branching as they go. On longitudinal section the wall of the bone making up the exostosis is abnormally thick (1.5 cm.), and is made up of a layer of bone of slightly increased density (0.75 cm. in thickness), and of a mass of loose cellular construction encroaching on the medullary canal, which at one point is entirely shut off by a web-like mass of interwoven trabeculæ. The posterior wall of the bone is very slightly if at all affected either in thickness or density (to the unaided eye). The cancellous bone of the epiphyses is apparently unaltered.

Specimen No. 2 ($\frac{101}{1000}$). Left tibia (complete) showing slight curvature of the crest in the middle third of the shaft with a very smooth surface and few perforations. On the posterior surface at about the junction of the middle and lower thirds is an exostosis roughly ovoid in shape (4 cm. long by 3 cm. in width), sharply limited by the postero-external border, but extending for about 1 cm. on to the internal surface. This mass is smooth in its central portions, but grooved and perforated near its periphery and marked by one transverse furrow. On the internal aspect of the upper portion of the shaft at about the point of insertion of the sartorius, gracilis, and semimembranous muscles is an area of exceedingly rough contour and surface made up of numerous small, irregular, osteophytic growths. On the internal aspect and a little lower on the shaft in the origin of the tibialis posticus is another area with even more marked elevations and depressions, and surrounded by a zone in which appear numerous, closely arranged, narrow, parallel furrows, which appear as though they might have been the lines of attachment of fascicular bundles of connective tissue. Cross-section through the greatest prominence of the anterior curve shows very marked thickening of the bone forming the crest (2 cm.), which is very dense and was sawn with difficulty, in contrast to the fragility of most of the specimens. The epiphyses and articular surfaces appear normal and longitudinal section through the upper fourth shows no gross changes in the cancellous bone there.

Specimen No. 3 ($\frac{108}{1000}$). Right clavicle showing marked enlargement throughout its entire length with several small osteophytes at different points and an ill-defined exostosis on its superior surface just external to the junction of the two curves.

Specimen No. 4 (808). Left tibia, externally entirely normal in contour, surface, etc., except in the middle third of its shaft, which bears on its crest and the anterior part of its internal surfaces an exostosis 14 cm. long and raised, at its highest point, fully 1.5 cm. above the original crest. This growth is fusiform in shape, tapering off gradually to the normal size above and below. Its surface is smooth except where crossed in several places by vascular channels. Longitudinal and transverse sections through this bone revealed an intense hardness and a great thickening of the walls, which were for the most part very dense, but showed even in the most sclerotic areas various-sized intercommunicating cavities. Fig. 1 is a reproduction of a photograph of a cross-section of this bone through the exostosis compared with a cross-section of a normal (recent) tibia at a corresponding point on the shaft. The total width of this section from the crest to its posterior surface is 4 cm., of which 1.5 cm. is dense bone, 1.5 cm. cancellous tissue, and the remainder, 1 cm., medullary cavity. In this specimen although the external appearances gave no evidence thereof, the sclerosis and thickening were not confined to the exostotic area, nor to the anterior aspect, as all the walls were thickened and of increased density for almost the entire length of the shaft. Again, nothing abnormal was evident in the joints nor the epiphyseal cancellous structure. This specimen was most productive on microscopic examination, as will be shown later.

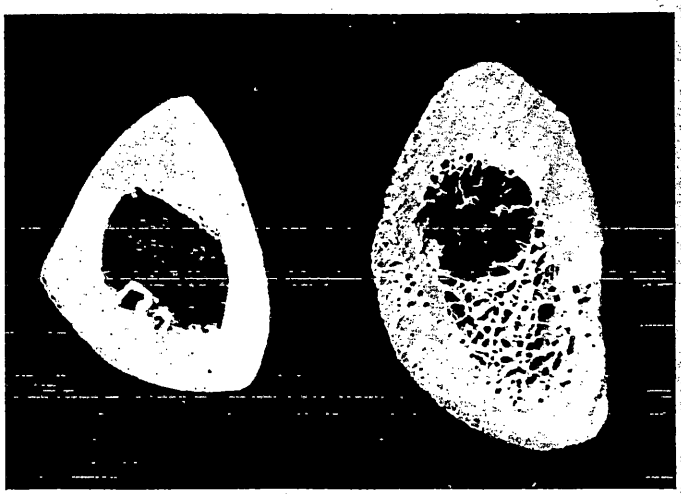

FIG. 1.—Cross-section through apex of exostosis of Specimen No. 4 (on the right) compared with a cross-section through a normal (recent) tibia at a corresponding part of the shaft. The exostotic section shows encroachment on the medullary cavity with thick sclerotic walls containing irregular porotic cavities. Four-fifths natural size.

Specimen No. 5 ($\frac{104}{1000}$). Fragment of upper end of left tibia, 9 cm. in length, showing very marked enlargement anteriorly, beginning at the tibial tubercle and extending down to the end. This growth gives the largest antero-posterior diameter of any of the bones at hand, *i.e.*, 5.5 cm., and its surface is scarred with minute pits and small osteophytes, vascular grooves, and the narrow furrows (origin of muscle bundles (?)) described in Specimen No. 2. The area of insertion of the popliteus is ridged and furrowed and the oblique line presents a tangled mass of osteophytes. The transverse section afforded by the broken end is pictured in Fig 2; it shows rarefaction to an intense degree, the worm-eaten spaces extending almost to the surface, and yet no evidence of an attempt at sequestrum formation. The smaller fragment in Fig. 5 is a view of the internal surface of this specimen and shows the roughness in the neigh-

borhood of the points of insertion of the sartorius, gracilis. and semimembranosus.

Specimen No. 6 ($\frac{103}{1000}$). Fragment of lower end of left tibia, 9 cm. long. Here is seen an exostosis covering the

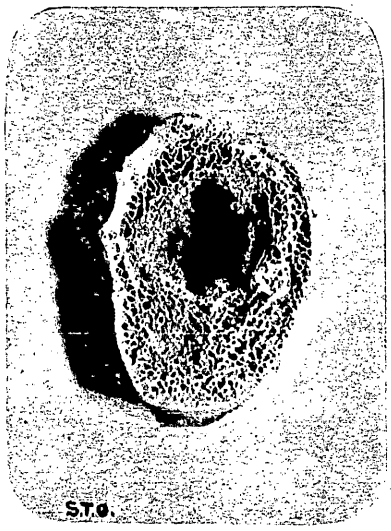

FIG. 2.—View of end of fragment (Specimen No. 5) showing advanced osteoporosis, with encroachment on the medullary cavity by cancellous material. Four-fifths natural size.

internal face and extending on to the adjacent portion of the posterior. This is quite smooth, but marked by several branching bloodvessel grooves and through it, along the line of attachment of the interosseous membrane, runs a serrated ridge made up of irregular osteophytes. Cross-section of this fragment (Fig. 3) shows rarefying osteitis of

FIG. 3.—Cross-section of Specimen No. 6. Sclerosis was demonstrated in the wall. Porosis is evident in the gross appearance. Medullary canal almost filled with interlacing spicules. Five-thirds natural size.

the walls and a network of interlacing trabeculæ almost filling the central canal.

Specimen No. 7 ($\frac{107}{1000}$). Fragment of tibia consisting of one-half the upper articular surface and two-thirds of the shaft. This bone presents a very marked anterior curving which begins just below the tibial tubercle and extends to the end of the fragment. The posterior border is about normal, but the curve of the crest is so great as to give an anteroposterior diameter varying between 4 and 5 cm. The surface of this exostosis (the term seems proper here from the fact that all of the bone which remains above the line of the tubercle is unaltered) is lined with the fine, parallel vertical furrows, described above, but bears very few vascular grooves and no osteophytes. On cross-section the walls are thin, the marrow cavity is much enlarged, and there is a large amount of cancellous bone throughout the length of the shaft. This specimen is in contour very like the so-called "sabre-blade" deformity.* Fig. 4 is a photograph

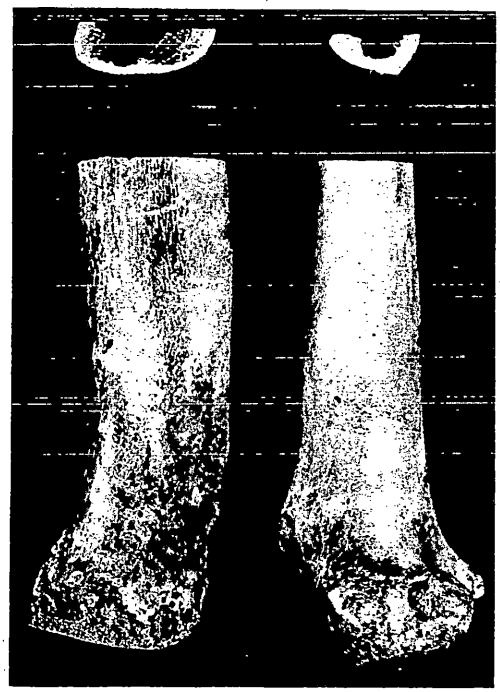

FIG. 4.—Lateral aspect of upper 15 cm. of Specimen No. 7 (on the left) with a corresponding portion of a normal (recent) tibia (on the right) and a cross-section of each above. Two-fifths natural size.

of the upper 15 cm. mounted for contrast by the side of a corresponding part of a normal (recent) tibia and with a cross-section of each above its respective source.

* There is to be seen in the Smithsonian Institution a tibia taken from a mound in Butler County, Ohio, which shows involvement of the whole of the diaphysis This exostosis gives rise to an anterior curvature of the crest similar to that described above, with the addition of deformity of the posterior border. The external surface of the internal malleolus is also involved. The joint surfaces of both epiphyses are normal. Cross-section afforded by an accidental recent fracture shows concurrent rarefying and condensing osteitis The medullary canal is reduced to a thickness of about 0.5 cm., surrounded anteriorly by a mass of cancellous material, about 1 cm. in thickness, the remainder of the shaft, which is fully 6 cm. in its anteroposterior diameter, being made up of sclerotic material.

Specimen No. 8 ($\frac{100}{1000}$). Fragment of upper end of right tibia, 13 cm. in length. A portion of this bone amounting to about one-third of the full circumference and extending the full length of the fragment is lacking. The remainder presents much the same appearance as Specimen No. 5 with even more marked roughening of the oblique line by the osteophytic excresences. (Fig. 5, large fragment.) The broken end of this piece shows a thin shell of hard bone encasing a layer of cancellous material except on the posterior edge where the dense bone is about normal in thickness. There is considerable enlargement anteriorly, and the outlines of the circumference is distorted to a rough ovoid shape.

Specimen No. 9 ($\frac{105}{1000}$). Fragment of shaft of tibia 5 cm. long and probably coming from about the middle of the diaphysis. Its external surface is rough and uneven, perforated by many small holes in some areas, marked by ridges and grooves in others, and on one side giving the impression that thin sheets of bone had been "plastered" on by the overlying periosteum. In cross-section it is ovoid and 4 cm. in its long axis. Anteriorly appears a wall of bone containing numerous communicating open spaces giving it a worm-eaten appearance. This is 0.5 cm. in thickness and is followed by 1.5 cm. of cancellous bone, then a marrow cavity 1 cm. in diameter, with rather definite walls from which bristle many very delicate interlacing spicules. About midway in the length of the central canal is a transverse septum of thin bone perforated by numerous small openings.

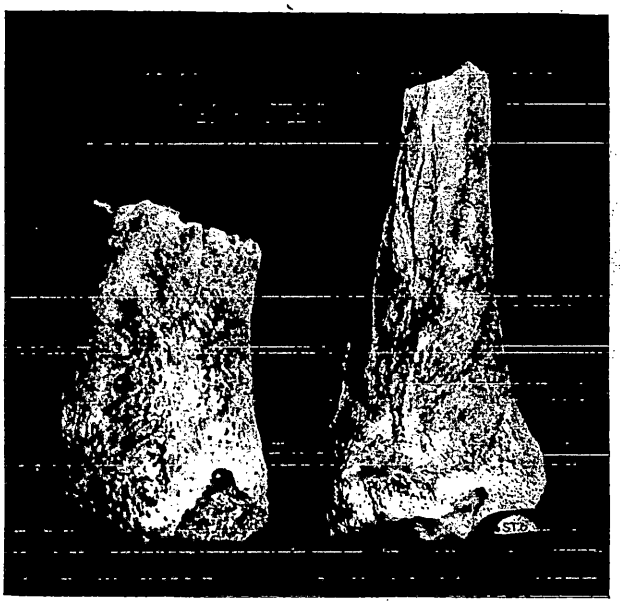

FIG. 5.—Smaller fragment ; lateral aspect of Specimen No. 5, showing anterior enlargement and rough, irregular surface at point of muscle attachments. (Fig. 2 is a view of the end of this specimen.)

Larger fragment—posterior aspect of Specimen No. 8, showing rough osteophytic excrescences on the oblique line and ridges in the area of origin of the tibialis posticus. One-half natural size.

Specimen No. 10 ($\frac{109}{1000}$). External cuneiform and third metatarsal bones firmly united by a complete bony ankylosis. The superficial layers of the cuneiform have been destroyed in places exposing the internal cancellous structures. The shaft of the metatarsal and its distal extremity appear normal and except for slight bony projections along the line of ankylosis there is nothing to suggest changes other than those which might arise from a traumatic or septic arthritis.

Considerable difficulty was encountered in cutting sections for microscopic examination. The final procedure adopted as productive of the best results was as follows: Rather thick sections were removed from the bone by means of a bracket saw and embedded in paraffin to allow of the cutting of narrower strips without destruction of the more delicate portions by crumbling. The paraffin was then removed by boiling on a flat sheet of metal, and the thin plates of bone were re-embedded and mounted on slides with Canada balsam, which had previously been boiled to remove the turpentine in order to give the proper consistence for the grinding which was done by means of files of varying degrees of coarseness. Grinding with whetstones, carborundum plates, pumice stone, and glass slides, and a variety of other things was tried, but without the success which followed the somewhat laborious task of filing.

FIG. 6.—Microphotograph of a portion of a section from Specimen No. 9, showing enlarged, irregular, and intercommunicating Haversian canals. This illustration is of an adjacent portion of the same slide as that shown in Fig. 7 and of the same magnification. Magnified 30 diameters.

Microscopic evidence was not needed to demonstrate the condition of rarefaction which was evident to the unaided eye in all the specimens. The demonstration of increase in density, however, required a more careful examination. In most of the sections the bone matrix appeared to be in an almost amorphous condition and showed little of the structure of the lamellæ or of the arrangement of the lacunæ and canaliculi, but even in these the size and shape of the Haversian canals was easily recognizable. Figs. 6 and 7

are microphotographs taken from the same slide which was a section of Specimen No. 9. These two pictures were of parts of the bone only a few millimetres apart, and show a marked contrast between the enlarged irregular communicating spaces of Fig. 6, which was in the line of the original bony wall and the dense structure with narrowed Haversian canals and areas with no apparent canal, which came from the compact part lying just beneath the periosteum. In this case the matrix was amorphous and the true arrangement of the lamellæ could not be made out. The specimen was deeply stained with gentian violet before filing to give contrast between the bone and the embedding balsam sufficient for the photograph.

Positive sclerosis was noted in specimens Nos. 1, 2, 4, 6, and 9. No sections were cut from Nos. 3, 5, 8, nor 10. No. 7, which was the tibia showing the "sabre-blade" deformity, gave no evidence of sclerosis. In nearly every case the

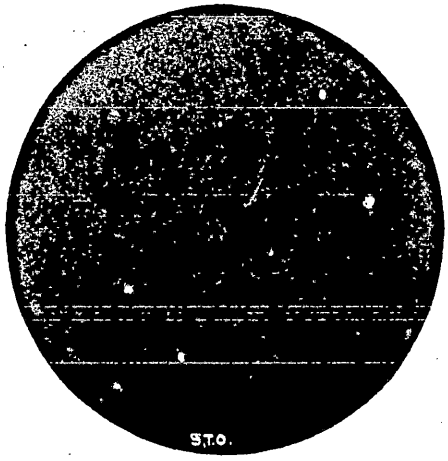

FIG. 7.—Microphotograph of an adjacent portion of the same slide from which Fig 6 was taken and of the same magnification; showing very marked narrowing of the lumina of the Haversian canals. Magnified 30 diameters.

sclerotic portion of the bone was its periosteal surface, the inner layers being porotic to an extreme degree.

One bone gave a picture which was in startling contrast to the structureless material of most. This one (No. 4) came from a mound at Chillicothe, Ohio, and its value in section was due to the fact that it had been infiltrated from its surface with a material later proved to contain iron, probably through the agency of the soil water. This was visible even to the naked eye as a dark staining, extending in from the surface and to some extent out from the medullary canal, and on section it showed as a deposit in the Haversian canals and in places even in the lacunæ and canaliculi giving an impregnated specimen. This enabled more careful study and showed some interesting conditions. Chemical tests of this bone showed that it contained quite an amount of iron, so a section was ground without the use of a file or other iron implements, and under the low power of the microscope the reaction in a slightly acid medium between the impregnating substance and a solution of potassium ferrocyanide was watched, as suggested by Dr. A. J. Smith, for this purpose, with the result that the deep color of Prussian blue appeared at first in the deposit, gradually spreading throughout the entire liquid. In view of the well-known preservative effects of the copper ornaments occasionally found with these remains it was suspected that possibly that metal might also be a factor with the iron in the impregnation, but all tests for it have proven negative.

In some parts of sections of this infiltrated bone is seen a microscopic picture which conforms closely with and at first was mistaken for the condition illustrated and described in Ziegler's *Pathology* as halisteresis ossium. The centre of bone trabeculæ in some fields was comparatively opaque and filled with more or less distinct lacunæ, while bordering the enlarged Haversian spaces was a facing of more translucent material. This condition is illustrated in Fig. 8.

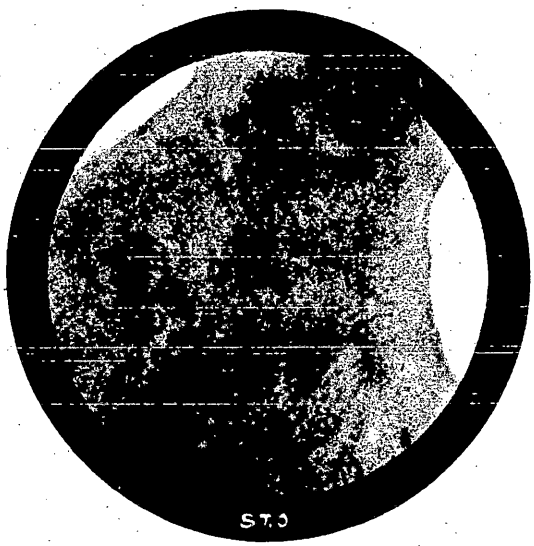

FIG. 8.—Lighter layers of new-formed bone lying around enlarged Haversian canals and on the old trabeculæ. From a slide from Specimen No. 4. Magnified 350 diameters.

On closer examination, however, of this facing it was seen that it had a definitely laminated structure with fine cross-striations and some lacunæ and canaliculi. The relative scarcity of the lacunæ here is probably one factor in the difference in translucence, although the structure of the matrix itself is apparently also unlike that of the centre of the trabeculæ. To differentiate it still more clearly from osteoid tissue, its method of solution in dilute acid was watched under the microscope and the evolution of carbon dioxide was equally as rapid and voluminous there as in the adjoining portions. The cell spaces besides being fewer in number were considerably larger than their neighbors. Fig. 9 shows a microphotograph of two impregnated lacunæ with their canaliculi lying in these lighter layers. As an interpretation of this finding it is believed that this portion of the section represents an area where the change from cancellous material to sclerotic bone has just begun, that these lamellæ are the first of a new series to be laid down

on the old trabeculæ, and that the paucity of the cells and their size is an evidence of the changed conditions under which this new deposit was forming.

In other areas from these same sections, where the condensing osteitis had proceeded to a greater extent, were seen the outlines of old trabeculæ as marked by the arrangement of their lamellæ, and, within these, new Haversian systems lacking the normal symmetry of these structures and showing in many places the eccentric arrangement spoken of above in quotation from Cornil and Ranvier, and in several instances two complete systems within the outer lamellæ of a former. Here also were canals with their lumina almost or entirely obliterated.

A section of one of the thin layers of bone described in Specimen No. 9 as appearing as though "plastered" on by

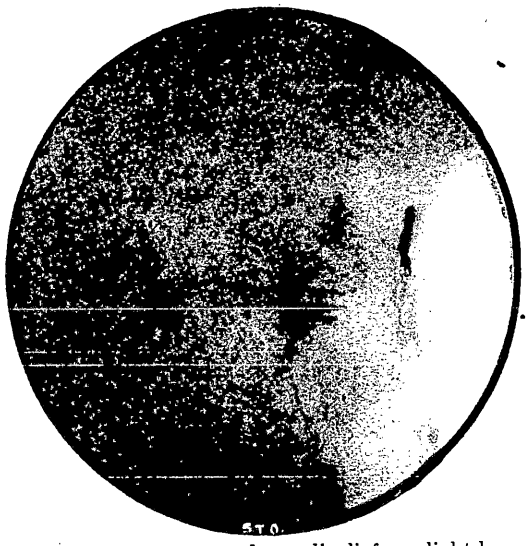

FIG. 9.—Infiltrated lacunæ and canaliculi from light layer of new-formed bone similar to that illustrated in Fig. 8 and from a slide of the same specimen. Magnified 400 diameters.

the periosteum proved that the canals here were perpendicular to the long axis of the shaft and to the canals of the bone beneath. This was also found in some of the osteophytic growths removed from lines of muscle insertion and origin, but in this case the arrangement was far from being so regular, and the canals were seen to cross and interweave in a promiscuous tangle.

RÉSUMÉ. The material under examination is from a source undoubtedly pre-Columbian and the lesions are such as to justify the diagnosis of syphilis by the following pathological evidence: Changes affecting chiefly the diaphyses where long bones are concerned, showing a predilection for those bones which are most exposed to trauma, consisting of large exostoses and osteophytic overgrowths, and characterized by the concurrent presence in the same specimen of both a rarefying and condensing osteitis as demonstrated by gross and microscopic examination. Of 127 skeletons from one series of excavations, 21 showed traces of disease. 60 per cent. of the affected showed the changes most upon the tibia with the ulna, cranium, and sternum following in order. Of the specimens examined rarefying osteitis was grossly manifest in all but two, one of which (ankylosed metatarsal and cuneiform) was probably of traumatic or septic nature, and the other (a clavicle) was not examined in cross-section. Grossly sclerosis was evident in 3 of the 10, while on microscopic examination only 1 of 6 from which sections were taken failed to show condensation in some areas.

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