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EAR EXOSTOSES

(WITH FIVE PLATES)

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BY ALEŠ HRDLIČKA

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(WITH FIVE PLATES)

INTRODUCTION

Few subjects in racial osteopathology have received more attention than that of ear exostoses, and this not only in Whites, but also in the American aborigines.

The term "ear exostoses" is used here for the sake of brevity. Under it are understood all distinct bony excrescences or tumors within the external auditory canal, of whatever form or size, from the eminence, ridge, or "pearl", that can definitely be recognized as an abnormal formation, to the more or less irregular bony masses that in some cases fill almost the whole lumen of the meatus and may even protrude from its mouth.

These growths have received a number of names. They belong to the "enosthoses" of Von Rokitansky; Toyabee called them "osteomata", Roosa "hyperplastic osteomata", Steinbrügge "periosteal osteomata". Kessel distinguished hyperostoses, exostoses, periostoses, and osteophytes. Other authors use mostly the terms hyperostoses and exostoses, acknowledging that the two merge into each other. In general, however, as stated by Dahlstrom (1923, p. 217), "these growths have come to be understood as exostoses."

LITERATURE

Bony growths in the auditory canal were doubtless known to medical men long ago, but what seems to be the first printed record of such an abnormality appeared in 1809, when Autenrieth¹ reported a case

¹ Autenrieth, J. H. F., Arch. Physiol., vol. 9, p. 349, Halle, 1809. As the first report, the case deserves perhaps to be cited in full and in the original:

"Bey einem vierzigjährigen Weibe, das sieben Jahre früher eine Hemiplegie der linken Seite erlitten hatte, und im Frühjahr von 1808 an einer Wiederholung des Schlagflusses gestorben war; ihr ganzer Schädel zeigte sich schief, und weiter auf der rechten, als linken Seite, die Jugular-Venen Grube ungewöhnlich weit, links äusserst klein. Die eigentlich Zitzenfortsätze waren gehörig gross und sich einander gleich; aber der rechte knöcherne Gehörgang durch einen

in a white female. In a woman of 40 who died of apoplexy and whose skull showed asymmetry, "the right external meatus was nearly closed, except for a vertical fissure hardly as broad as a line, by a bubblelike bony growth proceeding from the posterior and upper side." The interior of the exostosis was cancellous; and no connection was found between its cellular spaces and those of the mastoid.

In the thirties of the last century these bony growths in the ears were evidently repeatedly encountered by Kramer, who does not, however, clearly differentiate them from polyps. Kramer (1837), says, speaking of polypoid conditions:

These granulations may be either soft, spongy, of a very red colour, vesicular, bleeding readily on the slightest touch, sensitive, covered with copious mucous secretion, pedunculated, or globular; or they may be broad of base, and be of cartilaginous or almost bony hardness, insensible, bleeding little or not at all, and rather of a pale red colour. (P. 107.)

* * * *

One case in particular I cannot avoid here mentioning. A stalactite-shaped growth hung from the superior surface of the meatus, very near the membrana tympani, and was of so remarkable a bony hardness and density, that it was impossible to pierce it even with the sharpest knife. (P. 118.) [This could only have been an ear exostosis.]

Notwithstanding these early reports, the knowledge of bony growths in the ears lags until the middle of the nineteenth century. Von Rokitsky (1864) lays a broad foundation for the knowledge and differential diagnosis of exostoses, hyperostoses, and osteophytic excrescences of human bones. Toynbee (1855-60) reports nine cases of ear tumors from his practice and discusses ably the whole subject of these exostoses. Von Troeltsch (1862-81) gives due attention to bony growths of the ear, to be followed by Bonnafont (1865-68) and others. Beginning with 1864, these conditions commence to assume also an anthropological importance.

blasenförmigen Knochenauswuchs von der obern und hintern Seite her, bis zu einer in der Mitte kaum linien breiten senkrechten Spalte verschossen. Dieser, einer knöchernen Gehörblase der Thier ähnliche, Knochenauswuchs war durch eine Rinne von den übrigen Theilen des Schlafknochen geschieden, ihnen ganz zellig; doch fanden wir keine Verbindung dieser Luftzellen mit denen des eigentlichen Zitzenfortsatzes; der Gehörgang wurde durch ihn in der Mitte seiner Länge noch mehr zusammengedrückt, als bey seinem Eingang, doch erhielt er gegen die Trommelhöhle zu wieder seine gewöhnliche Weite. Die Substanz des Knochenauswuches selbst war gesund, so wie inneren Theile des Gehörganges waren."

Seligmann (1864),² of Vienna, reports finding ear exostoses in five out of six highland "Inca" skulls with Aymara deformation (four out of five in his 1870 account). All the skulls with the exostoses were males, the remaining one was a female. Seligmann concluded that these abnormalities did not occur in the Peruvian "flat-heads"; that the circular deformation of his specimens was not the cause, for similarly deformed skulls from elsewhere did not show the tumors; that the exostoses were restricted to males above 16 years of age; and that they were caused by an extension of an inflammatory process brought on by irritation due to the piercing of the ears, forceful enlargement of the openings for large ear ornaments, and the carrying of such heavy ornaments—at and after the initiation ceremonies of the Incaic youth.

The next report of anthropological interest on these abnormalities is that of Welcker (1864), who opposes Seligmann's views as to the causation of the tumors.³ He found them in two out of nine crania of Marquesas Islanders of the Barnard Davis collection and also in an undeformed skull of a Fox Indian.

Toynbee (1860) gives the first statistical datum on the frequency of these growths in a given population—in 1,013 diseased ears of the English he found ear exostoses in 14, or 1.03 percent of the temporals.

The year 1874 brings to light the first two American contributions to the subject, one by a physical anthropologist of note, the other by a physician. Jeffries Wyman (1874), Curator of the Peabody Museum, reports having found the exostoses in 8 out of 330 crania from Ancon, Peru; and Blake informs Wyman (Wyman, 1874), that he found the growths in about 5 of 1,000 cases (or 0.5 percent) of American Whites treated for diseases of the ear. There is not much discussion, but Wyman states that the growths "vary in size from a pin's head to that of the whole calibre of the canal."

In his *Thesaurus Craniorum* (London, 1867) and its supplementary volume (1874), J. Barnard Davis refers to the presence of auditory exostoses, among the crania of his collection, in the two skulls reported by Welcker, in another specimen from the Marquesas Islands,

² One or two authors give the credit of the first report of an ear exostosis in an American Indian to Zschokke (*Über eine merkwürdige bisher unbekannte krankhafte Veränderung an Menschenknochen aus Peru. Würzburger Inaug.—Diss., Arau, 1845*), but this author reports on peculiar multiple exostoses in six old Peruvian bones without touching on those of the skull.

³ According to Virchow (*Klin. Wochenschr., 1893, p. 636*), Seligmann himself in later years gave up his former opinion.

in a skull from the Loyalty Islands, in three Kanaka crania from the Sandwich Islands, in the skull of one of the Khas tribe from Nepal, in the skull of an ancient Roman, and in four Peruvian crania belonging to the Quichua Indians (quoted also by Turner, 1878).

Lucien Carr (1878) includes the following notes on ear exostoses in his report on 67 crania from the stone graves in Tennessee: "*Small bony tumors* are found in the outer opening of the ear in seven of the brachycephalic and in two among the flattened skulls of class four; but they are not present in either of the other groups. This percentage, a little more than one in seven, is greater than Professor Wyman found among the Peruvian crania in which it existed one in 41.25, or among Europeans, among whom it is said by Dr. C. J. Blake to be found in about five out of a thousand."

In 1879, in an article on the "Exostoses within the External Auditory Meatus", William Turner reports ear exostoses in a deformed skull from Peru, and also in one of a flat-head Chinook Indian. Seventeen other artificially deformed crania from North and South America were free of exostoses, though several presented a greater or lesser narrowing of the auditory canal. "There would thus appear to be a tendency on the part of the aboriginal inhabitants of the American continent to possess modifications in the configuration of the external auditory passage."

In the same year (1879) Flower, in his well-known "Catalogue", notes ear exostoses in 20 crania, as follows: of 12 Guancho, exostoses in 1; of 44 Chatham Islanders, in 4; of 11 "flat-heads" of Northwest American coast, in 1; of 3 from Tennessee mounds, in 2; of 147 from Peru, in 9; of 107 Australians, in 1; of 20 Melanesians, in 2. There is no discussion.

An important account of ear exostoses in North American crania is that of Blake (1880). He reexamined for this abnormality the Indian crania in the Peabody Museum of Harvard University and found the growths in 36 of 195 skulls (a large majority with fronto-occipital compression) from the old mounds and stone graves of Tennessee (18.5 percent), and in 5 out of 108 (undeformed) Indian crania of California (4.6 percent). The exostoses "occurred in both canals in 12 out of 36 crania, and of the remainder in the right canal in 9, in the left canal in 15. Of all the exostoses detected, 54 in number (counting the triple exostosis found, as one), 42 occurred on the posterior and 12 on the anterior wall of the canal. Making the division into 'rounded' and 'flattened' to distinguish the two forms principally assumed by these growths, 12 belonged to the former and 42 to the latter class." In discussing the etiology of these formations Blake reaches no definite

conclusion, but points to the probable influence of "hereditary tendency", without intimation as to what he means by this term.

Miss Studley (1881), in a study of 22 adult Indian crania from Coahuila, Mexico (15 male, 7 female), found ear exostoses in 7 of the males, in none of the females.

In 1864, 1875, 1885, 1889, 1892 and again in 1893, attention to ear exostoses, particularly in American crania, is called by Rudolf Virchow. Among 134 mostly deformed ("flat-head") skulls from Ancon, Peru, he found 18 (13.4 percent) with one or more bony tumors in the external auditory canal. Virchow accentuates the fact that these growths start generally from the tympanic-ring portion of the meatus. In discussing their causation he is at first strongly inclined to associate them with arthritis deformans. Later he evidently weakens in this opinion and believes (1893) that they "are plainly products of a pathological nature"; that "like all exostoses, they owe their inception to a pathological irritation restricted to the pars tympanica"; that possibly they may have some connection with chronic arthritis deformans, also with multiple exostoses of the skeleton; that mechanical causes such as suggested by Seligmann may have a favoring effect on their production; that they are "examples of disturbed development, which probably begins in and proceeds from the end parts of the annulus tympanicus"; and that head deformation is without effect on their production.

Politzer (1889) reports a case of an aural exostosis in a skull from Borneo. He gives considerable attention to the subject of ear exostoses in his well-known Textbook and in other writings. He failed to find any instance of the abnormality in over 1,000 crania of Whites.

Hartmann (1893) reports 14 cases of bony ear tumors in a little over 9,000 White patients (German), or about 1.5 percent.

An extensive series of observations on these abnormalities is published by Ostmann (1894). His report extends to 2,633 skulls, on 2,320 of which he made personal observations, the others being taken from various other authors. The specimens were in the main those of the Königsberg, Berlin, Halle, Senkenberg, Darmstadt, and Breslau anatomical collections, and the series comprised skulls of 1,054 Europeans, 516 Egyptians, 491 Asiatics, 267 Negroes, 113 Australians and Pacific Islanders, and 202 American Indians.

In this material bony outgrowths in the auditory meatus were found in but 16 crania, of which 13 (6.4 percent) were American, 2 (1.8 percent) Polynesian (both Hawaiians), and 1 (0.2 percent) Egyptian. No exostoses were found in the Negroes, the Asiatics, or the Europeans.

Of the 13 American skulls with exostoses in the Ostmann report, 12 are from Peru. The total number of Peruvian crania examined is 111, which gives the frequency of 10.8 percent. As to location of the abnormality in the 12 Peruvian skulls, there was some form of bony outgrowth three times on the right side, twice on the left, and seven times bilaterally. In the remaining Indians and the three non-Indian skulls with ear exostoses, the condition was bilateral in all.

Struck by the frequency of the outgrowths in the American Indians and apparently also in the Polynesians, Ostmann collected all other cases relating to these two groups from previous reports, so that the final number of specimens reached 606 Indians (largely Peruvian), with bony ear growths in 78 (11.5 percent); and 283 "Pacific Islanders" with ear exostoses in 10 (3.5 percent). The American skulls included those of Blake and others mentioned in the present references. Ostmann failed to find records of the abnormality in other races.

As to location, Ostmann saw the exostoses always at the edges of the tympanic ring, on its posterior as well as the anterior border. In one case, however, he found two little "buttons" originating within the meatus near the ring; the picture of that specimen shows the tympanic ring to be thick and bulging at its edges.

Ostmann enters into the discussion of exostoses of the ear in relation to skull deformation. Like Blake, he has given close attention to the shape and size of the opening of the auditory canal and believes erroneously "that, on the whole, the form of the lumen of the meatus depends on the form of the skull, and that in general dolichocephalic crania will show a rounder, brachycephalic crania a more oblongly-oval meatus."⁴ Artificial deformation of the skull, he believes, has a decided effect on the form of the meatus, and the cause of the tympanic exostoses is largely connected with the deformations of the skull. It seems very probable to Ostmann that the narrowing of the opening of the meatus consequent upon the skull deformation results in an irritation which so disturbs the development of the tympanic ring that, especially when any other tendency toward the formation of exostoses exists, hypertrophies in the ossifying parts will result, leading to exostoses.⁵ "The frequent occurrence of exostoses of the outer ear

⁴"Wir können demnach sagen, dass die Form des Gehörgangslumens im Grossen und Ganzen abhängig ist von der Schädelform, und dass im Allgemeinen zu dem dolichocephalen Schädel der mehr kreisrunde, zu dem brachycephalen Schädel der mehr länglichovale Gehörgang gehört." (P. 273.)

⁵"In diesen künstlich veränderten oder in der Veränderung begriffenen Raum wächst der knöcherne Gehörgang hinein, und es will mir als sehr wahrscheinlich

in the old Peruvians may be explained through the action of two causes, the peculiar compression of the outer part of the canal in the brachy- and hyper-brachycephalic [i. e., deformed, flat-head] skulls, and especially a given tendency towards excessive bone growth, such as is manifested through multiple exostoses.”^o

The same year (1894) George Dorsey reports, in his paper on the “Crania from the Necropolis of Ancon, Peru”, 4 crania with ear exostoses among 58 skulls of males (near 7 percent), and 2 among 28 undeformed skulls of females (a little over 9 percent); but the report is of a somewhat casual nature and probably does not fully represent conditions in this respect as they existed in the series of skulls Dr. Dorsey examined.

Bezold (1895) reports the frequency of ear exostoses in over 19,000 White (mainly German) patients with ear troubles to have been 0.6 percent.

A brief report on ear exostoses in American crania is made by Ten Kate (1896). In 50 crania from various localities on the coast of Peru he found 4 with ear exostoses; in 110 Calchaqui skulls of north-western Argentina there was none with such a formation. In view of his evidence he is strongly of the opinion that cranial deformation has no connection with the bony tumors.

The same year Von Luschan, in dealing with various defects and deformations in the external auditory meatus, particularly in deformed skulls from Peru and Argentina, touches also on the meatal hyperostoses and exostoses. He gives no new data, but expresses the opinion that these conditions cannot be attributed to head deformation, for on one hand they are absent from many of the most deformed skulls, and on the other they occur also in skulls that have no deformation. The real causes of these bony growths are uncertain; in individual cases they may perhaps originate in consequence of the constant drag produced by heavy ear pendants and great enlargement of the lobule.

erscheinen, dass wir in dieser besonderen, künstlich geschaffenen Raumveränderung und Beschränkung ein Irritamentum zu suchen haben, welches das wachsende Os tympanicum in seiner normalen Entwicklung derartig zu stören vermöchte, dass es, bei einer aus irgend welchen anderen Gründen vorhandenen Disposition zur Exostosenbildung, überhaupt an Stellen welche zur Ossification schritten, excessiv wucherte und somit Exostosen des äusseren Gehörgans erzeugte.” (P. 274.)

^o“Aus dem besonderen Zusammenwirken zweier Momente, der eigenartigen Verdrückung des äusseren Gehörgans bei den brachy- und hyperbrachycephalen Schädeln und einer gegebenen Neigung zu excessivem Knochenwachsthum überhaupt, wie sie durch die Exostosis multiplex zu Tage tritt, würde sich somit das so auffallend häufige Vorkommen von Exostosen des äusseren Gehörgans bei den alten Peruanern erklären lassen.” (P. 275.)

The largest series of American crania examined for tympanic exostoses before the present work is that of Russell (1900). It comprised in all the skulls of 1,369 American aborigines,⁷ which gave the following proportions of exostoses :

Ear Exostoses in American Aborigines

Crania	Exostoses in crania	Per-cent	Crania	Exostoses in crania	Per-cent
51 Eskimo.....	0	0	22 New Mexico (pueblos).....	0	0
64 Indians, New England.....	0	0	158 Indians, Calif....	2	1.2
58 Indians, Florida..	3	5.2	66 Indians, Pueblo and Plains....	2	3.0
456 Ohio and Tennessee (mounds).....	69	15.1	47 Indians, Mexican	4	8.5
			447 Indians, Peru....	24	5.4

Total no. of subjects, 1,369; total no. of skulls with ear exostoses, 104; percent, 7.6.

Russell's comments on the abnormalities are as follows :

There is a tendency in all races toward the formation of bony tumours or exostoses in the external auditory meatus. The tendency is increased in deformed crania, though it is now believed that such exostoses are not a necessary accompaniment of deformation; in support of this it will be noted that the small series of crania from New Mexico with pronounced occipital deformation exhibit not a single case of tympanic exostosis. . . . The exostoses varied in size from minute nodules to large tumorous growths and, in several instances, resulted in complete occlusion of the external auditory meatus.

Ranke (1900) found, among 21 skulls from Ancon, 3 (14 percent) with ear exostoses. He regarded these as examples of an "endemic disease common to the burial grounds of Ancon as well as those of old Peru in general."⁸

Moore (1900) reports that ear exostoses are "common in Hawaii", but gives no data or observations; and Meyer and Jablonowski (1901, p. 75) mention such growths in 2 among 24 crania from Easter Island.

Le Double and Lebourg (1903) report 9 cases of these growths in 46 skulls of American Indians (19.6 percent). Their causation is uncertain: they are evidently neither congenital "as was supposed by Velpeau", nor of pathological origin.

In 1904 Körner states that he found ear exostoses at Rostock in 16 cases among 2,162 patients with ear troubles, or 0.74 percent; along the

⁷ The printed table contains errors which have here been corrected. The material examined includes that reported on by Blake.

⁸ "Eine für das Totenfeld von Ancon, wie für alle altperuanischen Leichenstätten endemische Erkrankungsform."

seacoast of Germany he encountered 111 cases in 2,876 aural patients, or 3.86 percent.

One of the later treatises of anthropological interest on the auditory canal and its exostoses is a dissertation by Bachauer (1909). He made glue casts and measurements of the canal. Among the 33 Peruvian skulls of the München anthropological collection (including doubtless those reported upon by Ranke), he found 4 (12.1 percent) with exostoses. Bachauer takes up various questions in connection with the meatus. He finds that the only relation between the skull and the auditory canal is that in general large skulls have large canals, and small skulls smaller ones. He does not find that the dolichocephalic have a round, and the brachycephalic an oval, meatus, as was claimed by Ostmann. He also reaches the conclusion that race makes no difference in the shape of the lumen of the canal. But there is a decrease of the lumen in some deformed skulls. His wax casts comprised a series of deformed American and undeformed European skulls. He measured the longitudinal and transverse diameters at the orifice and found decreased lumen in 5 among 32 skulls from Pachacamac (15.6 percent). In three deformed skulls from that locality there were slitlike canals. Bachauer's main deduction is that the cause of the tympanic exostoses has not yet been found, but that their formation is no special characteristic of the old Peruvians.

In 1913, in my report on the results of my observations on the skeletal remains in Peru, I gave the following brief note on ear exostoses (Hrdlička, 1914):

A relatively large proportion of the pre-Columbian people of the more central parts of the Peruvian coast suffered, as shown by the skulls, from a greater or lesser occlusion of the external auditory canals by bony tumors. These are generally hard osteomata, from one to three in number, ranging in size from those like a minute drop to those of several millimeters in diameter, mostly rounded or pearl-shape, but occasionally irregular, frequently with enamel-like surface, and situated just within, or perhaps protruding slightly from the orifice of the osseous meatus. These little tumors, which are associated with no signs of any inflammatory nature, develop invariably from the tympanic ring and particularly from its extremities. They were in no case seen to coalesce, and though they may almost close the meatus they were never seen to do this entirely. Similar osteomata occur, though far less frequently, among the Whites; and they are found occasionally in the skull of a North American Indian.

Further attention to aural exostoses, in part from the anthropological standpoint, is given by Burton (1927), who has studied those parts of my Peruvian collections which are housed in the Museum of San Diego. Burton's examination of 26 deformed skulls from Peru showed 5 cases of exostosis in the canal and 1 in the middle

ear; 52 other Peruvian crania of the collection showed 5 with exostoses (in all 12.82 percent). Regrettably, the rest of the data are presented in a form that is difficult to understand, and there appear to be some bad printer's errors. To his interesting discussion as to the causation of these growths we shall return later.

In 1930 two important contributions to the subject of ear exostoses among the American aborigines are made independently by Oetteking in New York and Alexander in Vienna. Oetteking (1930) studied the skulls of the northwest coast of North America, Alexander (1930) mainly those of Channel Islands, California.

Oetteking's material is given in the table on page 11.*

In addition to the above Dr. Oetteking examined 43 skulls of the young, belonging to all the above series (including 10 Chinook), without finding any exostosis.

There is no discussion of the pathogeny of the tumors.

Alexander, on a visit to the United States, examined 550 Indian crania. His data are not given in as organized a way as would be desirable. There is no information as to how many specimens were in the different groups involved, and there was no sexing. The total number of skulls with ear exostoses was 30 (5.5 percent). A large majority of the skulls, and also of those with exostoses, were from California. The author adds an account of 21 (erroneously given as 22, nos. 3 and 15 being duplicates) cases of Austrian Whites with such growths, and goes into a detailed discussion of the whole subject.

In 1930, too, Moodie reports a case of ear exostoses in a California Indian; and in 1931 he mentions and illustrates, although with few details and no discussion, six cases in the Peruvian skulls of my San Diego collection, which doubtless had also been included in Burton's report.

The latest and among the most important contributions to the subject of ear exostoses from the anthropological point of view is that of Möller-Holst (1932). He examined 341 Chile-Bolivian skulls, of which 57 (16.7 percent) showed ear exostoses. Strangely, a larger proportion of these were in the undeformed crania (18 percent) than in the deformed (14.8 percent). In 250 skulls of German Whites there was but 1 case of exostoses. The author deals with the subject comprehensively and with much detail.

* Data in his memoir supplemented by Dr. Oetteking in correspondence and arranged by the present writer.

Exostoses in the Auditory Canals in Indians of the Northwest Coast, Adults

All skulls			Males					Females				
Series	Total number of skulls	Number and percentage of skulls with ear exostoses	Skulls examined	Skulls with ear exostoses	Percentage of skulls with exostoses	Ears with exostoses	Percentage of ears with exostoses	Skulls examined	Skulls with ear exostoses	Percentage of skulls with exostoses	Ears with exostoses	Percentage of ears with exostoses
Undeformed (misc. NW. coast)	112	... (2) 1.71	78	...	...	...	...	34	...	...	...	...
Cowichan (Vancouver Is.)	117	(3) 2.09	88	2	2.27	3	1.74	29	...	...	...	...
Koskimo (Vancouver Is.)	143	(23) 27.71	104	2	1.92	2	0.96	39	1	2.56	2	2.56
Chinook (Wash., Ore.)	83		58	19	32.75	34	20.48	25	4	16.00	7	14.00

SUMMARY

The data presented in the preceding pages together form a considerable mass of material of anthropological interest. To make them more easily graspable, they are abstracted in the following tables.

The statistical data on the White peoples are not as comprehensive or as uniform as might be desired, yet there is something of harmony. Ear exostoses in European and American Whites, taken as a whole, are scarce; among those with ear troubles they are found in from 0.4 to 1.5 percent of the cases, except along the German seacoast, where the percentage is apparently higher. Their racial and local frequencies within the White stem at large cannot as yet be estimated.

Added to the above observations on Whites may be those of 1 case of ear exostoses (among 12 skulls) in the Guanche; 1 in a Nubian; and 1 (among 516 skulls or 0.2 percent) in an old Egyptian.

Very different and more precise are the data on the American Indian. Here there are no reports on the living, all the observations having been made on skulls; and the skulls show many of the smaller ear exostoses that would give little if any trouble during life and hence would not come under the attention of the otologist, were he present, thus affecting the statistics. In other words, it is certain that the experience of an otologist with these tumors among the Indians would have differed considerably from that of the examiner of their crania. Nevertheless, even if only those ear exostoses be considered that must have caused distress, their frequency in general is above that in the white man. The records are as shown in tables on pages 13 and 14.

Condensing these two tables and leaving out duplications, we obtain:

Condensed Data on Ear Exostoses in the American Indian

Group	Skulls	Skulls with ear exostoses	Mean percent
Chinook, Flat-head, NW. Coast.	94	24	25.5
Tennessee (& Ohio).	459	71	15.5
Peru, Bolivia (& Chile).	approx. 1,433	149	10.4
California (chiefly).	816	38	4.7
Misc. N. & S. Amer. Indian.	1,004	54	5.4
New England Indian.	64	0	....
NW. Coast, misc., undefined.	112	0	....
Calchaqui.	110	0	....

Résumé of Data of Anthropological Interest on Ear Exostoses in Whites

Year	Author	People	No. of heads or skulls examined	Heads or skulls with ear exostoses		Individual ears or temporal bones		
				Number	Percent	Examined	With ear exostoses	Percent
1868	Toynbee.....	English.....	.....	.....	1,013	14	1.03
1874	Blake.....	American.....	1,000 cases with ear disease.....	?	.....	.....	.....
1878	Politzer.....	Austrian.....	over 1,000 skulls.....	0	.....	.....	.....
1889	Kessel.....	German.....	?	?	.....	.....	.....
1893	Hartmann.....	German.....	a little over 9,000 patients.....	14	.....	.....	.....
1894	Ostmann.....	European.....	1,054 skulls.....	0	.....	.....	.....
1895	Bezold.....	German.....	19,330 patients with ear troubles.....	116	.....	.....	.....
1904	Körner.....	German..... (Rostock)	2,162 ear patients.....	16	.....	.....	.....
1904	Körner.....	German..... (coast)	2,876 ear patients.....	111	.....	.....	.....
1909	Jackson.....	English.....	3,000 cases with ear disease.....	11	.....	.....	.....
1928	Martin.....	European.....	(no original data).....	.....	.....	.....	.....
1932	Möller-Holst.....	German.....	250 skulls.....	1	.....	.....	.....

Résumé of Data on Ear Exostoses in the American Indian

Year	Author	Group	Skulls examined	Skulls with ear exostoses	Percent	Year	Author	Group	Skulls examined	Skulls with ear exostoses	Percent
1864	Seligmann.....	Peru.....	6	5	.....	1900	Russell.....	New Engl. Indians.....	64	0	.....
1864	Welcker.....	Fox Ind.....	?	1	.....			Fla.....	58	3	5.2
1867-75	Davis.....	Peru.....	?	4	.....			Ohio & Tenn.....	456	69	15.1
1874	Wyman.....	Peru.....	330	8	2.4			Pueblos & Plains.....	88	2	2.3
1878	Carr.....	Tenn.....	67	9	13.4			Calif.....	158	2	1.2
1879	Turner.....	Peru.....	?	1	.....	1900	Ranke.....	Mexico.....	47	4	8.5
		Chinook.....	?	1	.....			Peru.....	447	24	5.4
1879	Flower.....	Flat-head Tenn.....	11 3	1 2	9.1 6.1	1903	Le Double & Lebourg	Peru.....	21	3	14.0
		Peru.....	147	9	6.1	1909	Jackson.....	"Amer. Indians"	46	9	19.6
1880	Blake.....	Tenn.....	195	36	18.5			"N. & S. Amer. Indians".....	450	25	5.5
		Calif.....	108	5	4.6	1909	Bachauer.....	Peru.....	33	4	12.1
1881	Studley.....	Coahuila.....	22	7	31.8	1927	Burton.....	Peru.....	78	10	12.8
1885	Virchow.....	Peru (Ancon) Peru.....	134 111	18 12	13.4 10.8	1930	Oetteking.....	NW Coast undefined.....	112	0	.....
1894	Ostmann.....	"Amer. Ind.".....	91	1	1.1			Cowichan.....	117	2	1.7
1894	Dorsey.....	Peru.....	86	6	7.0			Koskimo.....	143	3	2.1
1896	Ten Kate.....	Peru.....	50	4	8.0	1930	Alexander.....	Chinook.....	83	23	27.7
		Calchaqui.....	110	0	.....			Amer. Ind. (chiefly Calif.).....	550	30	5.5
					.....	1932	Möller-Holst.....	Chile, Bolivia.....	341	57	16.7

Ear Exostoses in Regions other than Europe and America

Asia			Polynesia			Melanesia			Australia			Africa (Negro)		
Skulls	Skulls with ear exostoses	Percent	Skulls	Skulls with ear exostoses	Percent	Skulls	Skulls with ear exostoses	Percent	Skulls	Skulls with ear exostoses	Percent	Skulls	Skulls with ear exostoses	Percent
?	Nepal 1	...	?	Marquesas Islands 3	...	20	Melanesians 2	10	107	1	0.94	267	0	...
491	"Asiatic" 0	0	?	Loyalty Islands 1	...	?	Fiji 2	...	?	1	...	?	1	...
			12	Tenimber Arch. 1	8.3					0				
			44	Chatham Islands 4	9.1									
			?	Hawaii 5	...									
			?	"common"	...									
Easter Island ^a —24—2—8.3														

^a Polynesian, but with probably some Melanesian admixture.

The maximum incidence of ear exostoses is not in Peru, but apparently among the tribes with fronto-occipital head deformation of the Columbia watershed, and in the Tennessee-Ohio mound and stone-grave region; also apparently in the old population that has left its skeletal remains in the caves of Coahuila, northeastern Mexico.

The data will receive further attention in the discussion of causation. For the present it is sufficient to note the fact that in America itself very marked differences exist, as to tribe and location, in the frequency of the growths under consideration.

There is but a single observation on a series of Eskimo skulls and that is negative—Russell in 54 specimens found no exostosis.

From regions other than Europe and America the data on ear exostoses are as yet very inadequate. There is little or nothing in this respect on the peoples of the densely populated areas of China, India, and Malaysia, of the rest of Asia or of Negro Africa, but there are indications that the abnormalities in question are relatively frequent among the Polynesians. The data are given in the table on page 15.

CLINICAL MATERIAL

In addition to the data tabulated in the preceding pages, there are scattered through medical literature of the last and present centuries reports of perhaps as many as 300 separate clinical cases of ear exostoses in white Europeans and Americans. A large majority of these are reported more or less defectively as to nationality, sex, age, and other details of importance, attention having been centered on the pathology and cure of the condition. Anthropologically, they add but little to the knowledge of the growths beyond showing further that they occur with no great rarity in England, France, Belgium, Germany, Italy, and other European countries, as well as in the United States.

Numerous as these reports are, they would not suffice to give a clear and full picture of the abnormalities. But here and there interesting points appear, and collectively there is much of value on the histology and especially on the etiology of these ear tumors.

The earliest comprehensive account of this nature is that of Joseph Toynbee (1850). He reports 12 cases of such "tumors", 10 (apparently) in males and 2 in females, mostly elderly people of British extraction. The exostoses consist of very hard and dense bone, are of slow growth, and develop frequently "unattended with any symptoms." He strongly suspects their connection with gouty diathesis and from a further standpoint of causation divides them into two classes—one "in which the disease appears associated with congestion

of the mucous membrane of the ear, as a result of rather free living" (and drinking); and the second associated with "disease in the cavities containing the expansion of the auditory nerve."

The first "thesis" devoted entirely to the subject of ear exostoses is by Delstanche (1878); and in the course of time this is followed by other such treatises by Schlomka (1891), Braunberger (1896), Sabroux (1901), and Bachauer (1909); to which may be added the comprehensive dissertations on the subject by Alexander (1930) and Möller-Holst (1932).

It would seem that a relatively limited condition that has received such prolonged and extensive attention should be well understood by this time; but, as will be shown later, this is still far from being true.

The records of over 200 cases of ear exostoses reported by aural surgeons are given in the next table. The stated nationality is usually that of the author, but the subjects, especially in such complexes as Austria or the United States of America doubtless included various other racial elements.

The data as to the sex, side, etc., do not always extend to the whole or an equal number of cases reported, which reduces their value. They need not be considered at this juncture; as far as they go they will be dealt with in subsequent chapters.

The table on page 18 has no pretense to completeness. There are records of additional cases, but some of these are little more than mere mentions, while with others the original report was unobtainable.

Bürkner (1884, pp. 92-93) summarized the statistical data on ear diseases published by 16 authors to 1884, but combined, regrettably, stenoses, exostoses, and atresiae into one group, and there is no way of separating the three. The figures had nevertheless some interest. In all there were 94 cases of the three above-named conditions, reported by 6 authors; and their combined frequency was, for Gruber 0.2; Lucae 0.2; Hedinger 0.3; Newark 0.3; Burkhardt-Merian 0.5; and Schwartze 0.2 percent of all cases with ear diseases.

What stands out from all the preceding data is the wide distribution of the incidence of ear exostoses, geographically, racially, and also in time. It is no recent or local affliction, but an old and widely generalized disorder. A few racial groups appear immune, but from none of these is there sufficient material to decide the question. In the remainder the frequency varies greatly, and this variance seems to follow racial or geographical affinities, but there appear no few exceptions to this, especially in the American Indian, where group conditions evidently prevail over the racial.

Ear Exostoses in the Living, From Reports of Aural Surgeons

Year	Author	Nation	All cases	Male	Female	Ages	Side			Number			Site					
							bilat.	right	left	1	2	3 or more	post. ant.	a.s.	p.s.	sup.	inf.	
1809	Autenrieth	Germany	1	1	1	40	1	1	1	1	1	1	1	1	1	1	1	1
1860	Toynbee	England	14	10	2	"mostly elderly"	4	3	1	6	5	1	4	4	1	1	1	1
1864	Welcker	Germany	4	rate"	1	17-65	1	2	1	2	1	1	1	1	1	1	1	1
1866	Roosa	U. S. A.	4	3	1	25-40	1	2	1	2	1	1(?)	3	1	1	1	1	1
1868	Bonnatont	France	4	3	1	25-40	1	2	1	2	1	1	3	1	1	1	1	1
1876	Dalby	England	14	8	6	..	6	8	..	..	..	..	..	..	..	..	..	..
1877	Cassells	England	?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1878	Delstanche	Belgium	25	5	3	{ 17(♀), 21, 23 } 23, 25, 30, 63	4	2	2	2	2	1	1	2	1	1	2	2
1878	Field	England	..	..	1	adult	..	..	1	1	..	..	..	..	..	..	..	..
1881	Hedinger	Germany	..	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..
1881	Ayres	England	4	4	..	22-30 (1?)	1	3	3	5	..	{ 1-pl } 3	3	1	1	1	1	1
1882	Masini	Italy	3	3	..	18, adult, 40	1	1	1	2	1	1	1	1	1	1	1	1
1885	Jacquemart	France	2	1	1	22	1	1	1	1	1	1	1	1	1	1	1	1
1888	Desarènes	France	2	1	1	♂12, ♀ adult	1	1	1	1	1	1	1	1	1	1	1	1
1889	Poltzer	Austria	2	2	..	adult	2	2	1	2	3	1	4	5	1	1	1	1
1889	Kessel	Germany	5	4	1	20-47	2	2	1	2	3	1	4	5	1	1	1	1
1889	Jacquemart	France	1	1	1	40	..	..	1	1	1	1	1	1	1	1	1	1
1890	Heiman	Germany	1	1	1	26	..	..	1	1	1	1	1	1	1	1	1	1
1891	Schlomka	Germany	5	4	1	24, 39, 47, 53, 67	2	1	2	2	3	1	6	5	1	1	1	1
1891	Roosa	U. S. A.	1	1	1	46	2	1	2	2	3	1	6	5	1	1	1	1
1893	Hartmann	Germany	14	..	..	..	..	..	1	1	1	1	1	1	1	1	1	1
1894	Mathewson	U. S. A.	1	..	..	adult	..	..	1	1	1	1	1	1	1	1	1	1
1894	Mathewson	U. S. A.	1	..	..	adult	..	..	1	1	1	1	1	1	1	1	1	1
1894	Hovell	Dutch Jew	1	1	1	16	..	..	1	1	1	1	1	1	1	1	1	1
1894	Taylor	England	1	1	1	16	..	..	1	1	1	1	1	1	1	1	1	1
1895	Green	U. S. A.	..	..	..	16-21	..	..	1	1	1	1	1	1	1	1	1	1
1895	Goldstein	U. S. A.	..	..	..	adult	..	..	1	1	1	1	1	1	1	1	1	1
1898	Lake	U. S. A.	2	2	1	"a girl", "adult",	..	..	1	1	1	1	1	1	1	1	1	1
1898	Alderton	U. S. A.	1	1	1	"elderly"	2	1	1	1	2	1	2	3	1	1	1	1
1899	Noquet	France	3	2	1	39, 43	2	1	1	1	2	1	2	3	1	1	1	1
1900	Moore	U. S. A.	2	2	1	"mature age"	1	1	1	1	2	1	2	3	1	1	1	1
1901	Stewart	England	1	1	1	45, 45, 46, adult	1	1	1	1	2	1	2	3	1	1	1	1
1901	Stabroux	France	4	4	1	9, 15	1	1	1	3	4	1	4	5	1	1	1	1
1904	Ferreri	Italy	2	(1?)	1	"child of 12", "boy of 10"	..	..	1	3	4	1	4	5	1	1	1	1
1909	West	England	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1909	Law	England	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1909	Law	England	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1909	Cheate	England	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1909	Jackson	England	11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1917	Urbancic	White	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1930	Alexander	Austria	21	17	3	9, 20-68	16	3	1	11	11	9	12	10	4	4	4	2
			214	91	..	..	..	..	..	..	..	..	..	..	..	..	..	..
			Approximately	76.9	21	3, 9, 10 12-68	40	21	14	46	27	13	42	34	6	5	10	..
				76.9	23.1		43.9	23.1	15.4	53.5	31.4	15	43.3	35.1	6.2	5.2	10.3	..

Also 16 unilaterals side?—17.6%

NEW OBSERVATIONS

In 1910 and again in 1913 the writer made trips to Peru. Owing to some fortunate circumstances and with the invaluable aid of the Peruvian authorities, he was able to make large skeletal collections which, aside from a mass of other parts of the skeleton, comprised approximately 4,000 skulls (Hrdlička, 1911, 1914). These proceeded mainly from the coasts but in an important degree also from the mountains. A portion of this material was used in 1915 in the preparation of the anthropological exhibit for the Panama-California Exposition and remains in the San Diego Museum; the rest is preserved in the National Museum at Washington.

Even in the field I was struck by the frequent presence in the outer half of the external auditory meatus of bony swellings and in some cases distinct tumors that more or less restricted or even almost closed the ear opening. In the report on the second expedition (Hrdlička, 1914), I briefly called attention to the fact that "a relatively large proportion of the pre-Columbian people of the more central parts of the Peruvian coast suffered from a greater or lesser occlusion of the external auditory canals by bony tumors." A small series of these crania with ear exostoses was exhibited and remained at San Diego, and another series was placed on exhibit in the Division of Physical Anthropology at the United States National Museum for demonstration to visiting surgeons.

In 1921-22, at my instigation, the series of Peruvian skulls in the United States National Museum was examined for the bony tumors in question by Dr. Beatrice Bickel. During these examinations and especially when an attempt was made to prepare the results for publication, it was found that the subject was more complex than at first anticipated and that some needed data were not obtained, which led to a second study of the whole series by Dr. Paul Van Natta, then Aid in the Division of Physical Anthropology of the Museum; and as the results of this second study differed somewhat from those of the first, a larger part of the collection was submitted to a third examination by myself. The results differed slightly from those of both previous examinations, but the differences in the three were seen now to be mostly only those in the precise appraisal of the various grades of the abnormality, the essentials remaining fairly constant.

Subsequently, finding the condition repeatedly also in other Indian and even in some non-American skulls, I extended the personal examination to a number of series of crania in the National Museum collections. Then other work intervened, and the publication of the results had to be postponed.

Meanwhile, as already noted in the first section of this memoir, the material left in San Diego received attention by a number of students from the west coast, two of whom, Burton and Moodie, reported on the ear exostoses of the skulls. Other publications on the growths appeared from time to time. From 1930 to 1932 three especially important studies in this line were published, namely those by Oetteking, Alexander, and Möller-Holst. Moreover, additions were received to our collections which promised to throw additional light on the peculiar disorder. These considerations led me to a determination to finish the survey of the subject, add as much as possible to the previous data, and attempt, should the facts warrant, to advance the understanding of the affliction under consideration. The results follow.

NEW MATERIAL

The total number of skulls examined for ear exostoses in this new study is 7,814. All these, with the exception of about one-third of the Peruvians, were sexed and examined by me personally.

The material is part of that of the Division of Physical Anthropology, United States National Museum, and the only portion of the specimens reported upon previously were those mentioned casually in my own publications. Only the larger series of our collections were made use of, and such as would give as far as possible a widespread racial as well as geographical and time distribution.

The abnormal bone formations were found to range without any line of separation from distinct localized "pearls"¹⁰ or tumefactions of bone in the external auditory canal to bony tumors that almost fill the distal part of the canal or even protrude outside of it. Only those cases were recorded where the growth presented distinct localized welting, excrescence, or tumor. In addition there were fairly numerous cases where a more or less evident trace of a tumefaction or a diffuse pathological thickening of the wall existed; these were not included in the records.

The earlier and again the late stages of ear exostoses present difficulties to the examiner. The initial tumescence, "pearl" or welt, may be ill defined; and one or two small swellings, welts or "pimples" or ridges, may accompany a larger growth which tends to preempt the attention or obstruct clear vision. Hence no two observers or even repeated examinations by the same student will give absolutely

¹⁰ The term "pearl" is particularly fitting, for many of the growths in their earlier stages very closely resemble developing pearls on their mother shell.

the same results as to the minor grades of the abnormalities. Considerable experience must be acquired by the student of these exostoses before his records can have real value.

The total new material and the gross results of the examination are shown in the following table.

Ear Exostoses in Different Racial Groups, New Observations

Adults ^a (except as specified otherwise)	Number of skulls examined	Number of skulls with ear exostoses	Percent of skulls with exostoses	Number of ears with exostoses	Percent of ears with exostoses
Egypt:					
XII D. Lisht.....	379	7	1.85	10	1.3
XX D.—III Cont. Kharga...	75	2	2.7	2	1.3
American:					
Eskimo.....	1,000	2	0.2	4	0.2
Indian Children ^b	335	1	....	1	....
Old Pueblo.....	500	12	2.4	19	1.9
North Dakota.....	29	2	6.9	2	3.45
Florida.....	395	35	8.9	53	6.7
California ^c	435	46	10.6	69	7.9
NE. States (St. Lawrence River to Maryland).....	112	13	11.6	19	8.5
Peru.....	3,651	522	14.3	855	11.7
Virginia.....	65	14	21.5	25	19.2
Louisiana ^d	61	15	24.6	26	21.3
Arkansas ^d	173	47	27.2	75	21.7
S. Dakota (All, Mowbridge, Arikara, misc.).....	109	30	27.5	48	22.0
S. Dakota (Mowbridge alone)	76	23	30.3	37	24.3
Kentucky.....	90	29	32.2	52	28.9
Polynesian:					
New Zealand.....	19	4	21.1	7	18.4
Hawaii.....	148	39	26.4	60	20.3
Asiatic:					
Chinese.....	77	....	....	....	....
Malaysian:					
Pagi-Pagi.....	10	....	....	....	....
Melanesian.....	39	....	....	....	....
African:					
Negro (African and American)	112	....	....	....	....

^a Including a very small proportion of subadults.

^b From age when fully developed tympanic bone is in place to eruption of a permanent second molar. A fair proportion of deformed, all three varieties of deformation.

^c Mainly of Channel Islands.

^d Mounds.

Examination of our Egyptian material, all of which was collected personally and is thoroughly identified, shows that although ear exostoses were rare, nevertheless they occurred in the Egyptians—at root a branch of the White stem—as far back as 2000 B. C.

There is no case of a tympanic exostosis in the 112 African and American Negro crania in our collection. It will be recalled that Ostmann, in 267 Negro skulls, also found no case of these exostoses. It would seem, therefore, that the true Negro was free of these formations.

No case of these tumors is found in our Melanesian and Malaysian skulls, but the series of specimens here are too small. Flower, it was seen, found one case of these exostoses in 1 of 7 Australian and in 1 of 20 Melanesian skulls. It appears, therefore, that the condition is not wholly absent either in Melanesia or Australia, though it probably is rare in these territories.

Especially interesting is the apparently complete absence of ear exostoses in the Chinese. No case in these people, so far as I could discover, is on record, and the valuable series of 77 adult male Cantonese skulls in our collection shows not a trace of bony ear tumors. Yet the Chinese belong fundamentally to the same yellow-brown human stem as do the American Indians, who show so many of these abnormalities, while on the other hand they are far apart from the African Negro, who similarly appears to be free from ear exostoses.

In the remaining groups of our table conditions differ greatly. At one end of the series stand the Eskimo, first cousins of the Indians, who in 1,000 skulls give but 2 with a moderate form of distinct localized tympanic tumefaction; at the other end are the Kentucky, South Dakota, Arkansas, Louisiana, and Virginia Indians, with the Hawaii and New Zealand Polynesians, among whom over one-fifth to one-third of the skulls show the neoplasms under consideration. The Arkansas and Louisiana Indians range themselves territorially with those of Tennessee and also Ohio, in whom both Blake and Russell found a high incidence of these growths; the Kentucky Indians show a slight similarity to those of Tennessee; the Dakotas are unconnected with any earlier or present groups reported on in this connection; our Polynesians harmonize with Welcker's and Davis' Marquesans, who also showed a high incidence of ear exostoses, and seemingly with the Polynesians in general.

From all the preceding it is plain that the highest frequency of the condition is found, on one hand, among the old aborigines of the North American continent, and on the other hand, in Polynesia. In North America ear exostoses were most frequent in portions of the north-central, south-central and central-eastern parts of the present territory of the United States, in the Columbia basin "flat-heads" (Oetteking), in some parts, at least, of Mexico (Studley: Coahuila); and in South America, in Peru. Peru, which was supposed to head all the Ameri-

can groups in the frequency of these growths, is seen to be barely in the middle of the American range of their frequencies.

Additional details of importance regarding the development and prevalence of the abnormalities under consideration on the American continent, and of their significance, will be dealt with in succeeding sections.

DETAILED DATA

AGE

Older observations.—The youngest subject in whom an exostosis in the external auditory canal has so far been observed, recorded by Field (1878a), was a girl of 3 years, in whom the bony growth followed the removal of a polyp. This being by far the earliest age at which the abnormality has been found, the case deserves to be quoted in full; the report reads:

M. W., a little girl aged 3, was brought to the hospital on July 25th. Her mother states that she had suffered from a severe attack of measles 12 months previously, and that she had since had an offensive discharge from the left ear. I had a few months since removed a polypus. About a fortnight ago, she noticed a hard substance in the ear, causing the child much uneasiness. When she came to the hospital, a small pedunculated osseous tumour about the shape of a pear was discovered, almost filling up the meatus.

The individually recorded cases in the young and up to about the age of puberty, that I was able to find in the literature, are as follows:

Field (1878a), in a girl of 3	Brindel (in Sabroux, 1901), in a boy of 13
Alexander (1930), in a boy of 9	Alexander (1930), in a girl of 13
Tod (1909), in a boy of 10	Kessel (1889), in a girl of 14
Krakauer (1891), in a girl of 12	Ferreri (1904), in a girl of 14
Garrigou-Désarènes (1888), in a boy of 12	Bezold (1895), in a boy of 14
Karewski (1892), in a girl of 13	Green (1879), in a boy of 14

It may be worthy of note that of the 12 subjects for whom both the individual ages and sex are given, 6 were males and 6 females, a relation which, as will be seen in the next section, does not hold later in life, when the exostoses are much more numerous in the males.

Bezold (1895, p. 48) mentions an isolated case in a boy of 14; and in addition West (1909) reports a case "in a child of 12", who was probably a girl, for the term "child" would scarcely be applied to a boy of that age.

The great rarity of ear exostoses in children appears most strikingly from the data published by Bezold (1885). Examinations by

aurists for ear troubles in 9,939 school children failed to show even a single case of the tumors. The detailed data were:

Reichard, Riga	1,055 children, no ear exostoses
Weil, Stuttgart	5,905 children, no ear exostoses
Bezold, Munich	1,918 children, no ear exostoses
Sexton, U. S. A.	570 children, no ear exostoses
Norrell, U. S. A.	491 children, no ear exostoses

Kessel (1889) believed that the growths appeared between the ages of 10 and 13, or later—most frequently about the age of puberty. Erhardt thought they originated during the period of the ossification of the canal; and Edward, of Berlin, thought similarly that these exostoses could originate only in the skeletal parts still in the process of formation—opinions opposed by De Rossi, Ferreri, and others.

Braunberger (1896) stated they developed both before and after the ossification period of the external meatus, though they are more common in advancing age. Lake (1898) thought the “hyperostoses often appeared latish in life.”

According to Bezold and Siebenmann (1908, p. 102) “they develop nearly always after puberty.” To which Bezold adds, “In 170 cases which I observed up to 1896 there was none below 15 years. Neither did I find a single case in public schools or deaf-mute institutions.” In another place, however, as noted above, he mentioned a case in a boy of 14.

Gray (1910) states that the bony growths in the ears are “seldom found in children.” Alexander (1930) failed to find these growths in children, even in those whose parents were badly affected by ear exostoses.

In contrast to this Marx (1926), who conceives a substantial distinction between hyperostoses and exostoses, regards as an essential mark of hyperostoses that they occur in early childhood, whereas the exostoses develop in the adult. Von Troeltsch’s (1873) cases “were predominantly in the middle-aged”; and Whitney (1886), in his Indian series, found them “as a rule in men past middle life.”

A most helpful record in this connection is that of Körner (1904, p. 105), who, although going into no details, gives a list by ages “of the hyperostosis and exostosis cases” observed by him in his private practice, “in 1,000 consecutive patients with ear diseases.” The data follow:

"Hyperostoses and Exostoses Cases" Observed by Körner

Age	Subjects	Subjects with exostoses and hyperostoses and percent in total number of growths	
		Number	Percent
0-5.....	81	0 =	0
6-10.....	113	2 =	1.6
11-15.....	116	6 =	4.8
16-20.....	115	11 =	8.8
21-25.....	78	13 =	10.4
26-30.....	77	17 =	13.6
31-35.....	74	12 =	9.6
36-40.....	74	16 =	12.8
41-45.....	68	13 =	10.4
46-50.....	61	7 =	5.6
51-55.....	38	8 =	6.4
56-60.....	45	10 =	8.0
61-65.....	29	4 =	3.2
66-70.....	19	5 =	4.0
Over 70.....	12	1 =	0.8
	1,000	125 =	100.0

To the above I am able to add data which I have culled from additional clinical reports, showing 101 cases where some information as to age was given. Of these, in 25 cases the subjects were merely marked as "adult", or "of mature age", or "elderly". The 77 subjects whose age was stated range as follows:

Age of Patients (White) With Ear Exostoses

Age	Subjects	Percentage of ages
Below 10.....	2	2.6
10-20.....	13	16.9
21-30.....	19	24.7
31-40.....	15	19.5
41-50.....	14	18.2
51-60.....	8	10.4
61-68.....	6	7.8
Above 68.....	..	....

The greatest frequencies of the bony growths in the external auditory canal are registered, it is seen, between the ages of 20 and 50. Their period of prevalence extends chiefly from 16 to 60. They are rare below 10 and but one had so far been recorded above 70, though the distribution in our table indicates that a few cases do probably occur above that age.

The condition or "disease", if it can be called such, is therefore, it is clear, dominantly one of the earlier to middle adult life, and has

very little if any connection with senility and its disorders—another point of importance.

It should be borne in mind, moreover, that the clinical age reports embodied in the above data are the ages at the time the subjects applied for treatment, and that in all the cases the bony growths in the ear began earlier. The data therefore show the ages at which the tumors reached development that caused the patient to apply for relief. Should we wish to learn the age at which the ear exostoses began, it would be necessary to shift the whole scale of ages in the direction of less years. How much to shift, on the average, cannot be estimated. In individual cases ear exostoses were known to the patients to have existed for many years before they gave sufficient trouble to lead the subject to the aural surgeon. The matter can only be settled, it would seem, by prolonged future attention to this point.

New observations.—Excluding the Eskimo, the specimens in which both meatus cannot be examined, and the very young, there are in the National Museum 335 skulls of Indian children between the ages when the tympanic portion is fully added to the bony ear and when there occurs the eruption of a permanent M_2 —in other words between about 2 and 12 years of age. The material, like that of the adults, is mainly pre-Columbian, and a good proportion of the skulls show one or another of the three kinds of deformation. A careful scrutiny of these specimens showed 334 without any trace of ear exostoses. The sole specimen showing the abnormality was a pronounced “flat-head” from Santo Domingo, with lateral permanent upper incisors and permanent upper molars about to erupt—hence about 8 to 9 years of age. In the left meatus of this skull is seen on the posterior wall, tympanic part, a small but distinct abnormal nodule, which in all probability would have later grown to a definite exostosis.

It may thus be concluded that, among the old American Indians at least, tympanic exostoses did not develop, or did so but exceedingly rarely, in childhood.

Even in the Indian adolescent of our collections, however, these growths are not very evident. They belong essentially to the earlier half or two-thirds of the adult life, though they not seldom begin before the adult stage is reached. Their maximum frequency and development in the Indian belong principally to the ages of about 30 to 60. They are infrequent in older subjects and, as in Whites, it is plain that they have little if any relation to senility and its pathology. All of these facts are of etiological importance.

SEX

Since Bonnafont (1868), all writers who have dealt with the subject agree that ear exostoses are considerably more common in men than in women. Thus Delstanche (1878, p. 14) says that they are "much more frequent in males," and practically the same words are used by Von Troeltsch (1881, p. 141). Whitney (1886, p. 442) found "the subjects were as a rule men"; for Kessel (1889) the growths were "decidedly more frequent in the males." Schlomka (1891, p. 16) and Sabroux (1901) express themselves exactly as do Delstanche and Von Troeltsch. For Braunberger (1896) it is "certain they are more common in males." There are many other expressions to the same effect.

More definite data on the subject, in living Europeans, are given by Körner and Bezold. The latter says (1908, p. 102): "The male sex is affected much more frequently than the female. My statistics show a proportion of 11 to 1, those of Körner of 3.5 to 1."

The individual clinical reports are frequently negligent as to sex, but from those in which sex is stated, the indications are very conclusive. Out of 89 instances that I was able to gather in which the sex was given, 70 of the individuals, or nearly four-fifths (78.7 percent), were males, and but 19, or a little over one-fifth (21.3 percent), were females. In the old craniological observations on non-European peoples sexing has been attempted in but a very few cases and that inadequately; but as far as the data go they show among those affected with ear exostoses a decided predominance of males.

New observations.—The new materials reported upon in this work have all been sexed on the basis of ample experience, with all possible care, and often with the aid of the rest of the skeleton, so that the records may safely be held reliable to within less than 5 percent of possible error. The results are given in the table on page 28.

The data show that:

In all the groups, Egyptian, American, and Polynesian, ear exostoses are more common in the males than in the females.

The total frequency of the growths in a group appears to have little if any influence on their relative frequency in the two sexes.

The proportion of occurrence in the two sexes differs considerably between some of the groups. Much of this difference is probably connected with the unequal and not always adequate number of specimens, but apparently there are also other reasons, the nature of which remains obscure.

In the two Polynesian groups the relative frequency of the growths in the females is higher than that in any of the American series.

The clinical records cannot be directly compared with our figures; they lack one of the essentials, which is the proportion in each sex of those with ear tumors to those without; but as the proportion of the two sexes in the White population at large is much the same, the relative values of the cases reported are probably nearly correct. They

Relative Frequency of Ear Exostoses in the Two Sexes

Group (in order of frequency of exostoses)	Total number of skulls examined	Total number of skulls with ear exostoses	Percentage of skulls with exostoses in:		Male to female (male = 100)
			Males	Females	
Egyptian.....	454	9	3.1	1.15	37.2
American:					
Eskimo.....	1,000	2	0.8	....	....
Old Pueblo.....	500	12	2.8	2.0	71.4
N. Dakota.....	29	2	11.1	....	....
Florida.....	395	35	13.7	3.3	24.1
California.....	435	46	15.2	5.7	37.5
NE. States.....	112	13	16.0	10.2	63.8
Peru.....	3,651	522	22.2	6.3	28.4
Virginia.....	65	14	28.6	13.3	46.5
Louisiana.....	61	15	46.4	6.1	13.1
Arkansas.....	173	47	38.6	16.7	43.3
S. Dakota, all.....	109	30	38.2	16.7	43.7
S. Dakota, Mowbridge.....	76	23	41.3	21.4	51.8
Kentucky.....	90	29	48.0	12.5	26.0
Polynesian:					
New Zealand.....	19	4	25.0	18.2	72.8
Hawaii.....	148	39	28.4	24.7	87.0

indicate that for every 100 White males with ear exostoses there are about 27 females with that affection. In most of the Indian groups and in both the Polynesian groups the proportion of females was decidedly higher, a fact for which there must be reasons as yet undetermined.

FREQUENCY OF EXOSTOSES IN THE TWO EARS

Our material permits us to show definitely the number of individual ears affected in the different groups, and the proportional involvement of the two ears in the affected skulls.

The next table gives for our series of groups the proportions of affected ears in relation to that of the affected skulls or individuals. It will be seen that, barring a few exceptions, in groups where the frequency of individuals or skulls with ear exostoses is smaller, the percentage of single ears free of the growths is larger than in those groups in which the proportion of individuals or skulls affected by

these abnormalities is larger. In other words, in general, the individuals or skulls that are more subject to ear exostoses will show not only absolutely but also relatively a larger proportion of ears involved than the groups where the growths are less common. Were some of our smaller series as large as are others, the figures would probably be more regular and even more convincing. The meaning of the phenomenon can only be that there must exist something like an oto-exostotic "inclination", which differs in quantity in different racial, geographical, or other groups; and that the larger the quantity of this x in a group, not only the more individuals, but also the larger percentage of individual ears, will become subject to the growths. The affection acts thus as an entity—perhaps more accurately a "diathesis",¹¹ a conception which will be found further strengthened when we come to consider the numbers, masses, and character of the abnormalities under discussion.

Relative Proportion of Skulls and Ears Affected by Ear Exostoses in the Different Groups

Group (in order of frequency of ear exostoses)	Skulls examined	Percentage of skulls with ear exostoses	Ears examined	Percentage of ears with exostoses	Percentage of ears affected vs. percentage of skulls
Egyptian	454	2.0	908	1.3	66.3
American:					
Eskimo	1,000	0.2	2,000	0.2	(100)
Old Pueblo	500	2.4	1,000	1.9	79.2
N. Dakota	29	6.9	58	3.45	50.0
Florida	395	8.9	790	6.7	75.3
California	435	10.6	870	7.9	74.5
NE. States	112	11.6	224	8.5	73.3
Peru	3,651	14.3	7,302	11.7	81.8
Virginia	65	21.5	130	19.2	89.3
Louisiana	61	24.6	122	21.3	86.6
Arkansas	173	27.2	346	21.7	79.8
S. Dakota, all	109	27.5	218	22.0	80.0
S. Dakota, Mowbridge	76	30.3	152	24.3	80.2
Kentucky	90	32.2	180	28.9	89.8
Polynesian:					
New Zealand	19	21.1	38	18.4	87.2
Hawaii	148	26.4	296	20.3	76.9

SIDE

Since the early history of ear exostoses, it has been known that such growths have a tendency to occur bilaterally, but opinions differed as to the frequency of such an occurrence.

¹¹ In the sense of "a constitutional predisposition or aptitude for some particular development" (Webster's New Int. Dict.).

Delstanche (1878, p. 10), stated that though the exostoses showed a tendency to occur on both sides, in his personal experience unilateral cases were "much more frequent". Schlomka (1891, p. 16) and Braunberger (1896) have also reached the conclusion that they occurred more frequently unilaterally than bilaterally. On the other hand, Von Troeltsch (1881, p. 141) saw them to be "predominantly bilateral"; Sabroux (1901, p. 35) says they were "very frequently bilateral"; and there are other statements of similar import.

Blake (1880) gives the first exact data on the subject. Of 231 old Tennessee and California Indian skulls, 38 had ear exostoses: in 14 (36.8 percent) these were bilateral; in 9 (23.7 percent) in the right ear only; and in 15 (39.5 percent) in the left ear only.

Attempts at statistical estimates in Whites were made by Körner (1894), who found the exostoses in 64 percent of cases bilaterally, in 36 percent unilaterally; and by Bezold (1895, p. 48) who found them in 54.4 percent of cases on both sides and in 45.6 percent on one side only. Bezold observed that occasionally, in cases originally unilateral, in time a development of the abnormality would also take place in the second ear.

As to the side in the unilateral cases, Ferreri (1904) thought the growths were more frequent on the left.

New observations.—The table that follows gives the involvement of the ears as to side in our material.

Side

Groups (in order of frequency of ear exostoses)	Skulls examined	Percentage of skulls with ear exostoses	Percentage of skulls with ear exostoses		
			Bilateral	Right ear only	Left ear only
Egyptian.....	454	2.0	33.3	22.2	44.5
American:			(100)	....	....
Eskimo.....	1,000	0.2	58.3	16.7	25.0
Old Pueblo.....	500	2.4	(Number inadequate)		
N. Dakota.....	29	6.9	51.4	28.6	20.0
Florida.....	395	8.9	50.0	23.9	26.1
California.....	435	10.6	46.2	15.4	38.5
NE. States.....	112	11.6	63.6	16.1	20.3
Peru.....	3,651	14.3	78.6	7.2	14.3
Virginia.....	65	21.5	73.3	13.3	13.3
Louisiana.....	61	24.6	63.8	19.2	17.0
Arkansas.....	173	27.2	60.0	20.0	20.0
S. Dakota, all.....	109	27.5	60.9	17.4	21.7
S. Dakota, Mowbridge.....	76	30.3	79.3	13.8	6.9
Kentucky.....	90	32.2			
Polynesian:					
New Zealand.....	19	21.1	75.0	....	25.0
Hawaii.....	148	26.4	53.8	15.4	30.8

The data on page 30 show the following conditions:

1. In general, in a group the larger the number of individuals affected by ear exostoses, the more commonly both ears are involved.
2. The frequency of bilateral as compared to unilateral involvement varies from 33 to 79 percent in the different series of our material.
3. When but one side is involved, there is a perceptibly greater tendency for the abnormalities to develop in the left ear. In the 14 groups of our crania, in 9 the involvement was more frequent on the left side, in 3 on the right side, and in 2 groups it was equal on the two sides.

The proportions of bilateral involvement in our series agree fairly closely with those of Bezold (54.4 percent) and Körner (64 percent) on European Whites. Through all this the affliction again impresses one as something of a pathological entity.

As it is probable that some proportion, at least, of the individuals whose skulls enter into these series, if they had lived longer, would have developed the condition bilaterally, it may be assumed that the general tendency for the tympanic exostoses is to involve both auditory canals; but they evidently tend to start more frequently on the left side. Why this should be so is not apparent, but it is probably connected with nervous and vascular factors.

The very apparent tendency toward a bilateral involvement should be an important factor in the study of the deeper causes of these formations.

NUMBER

Ear exostoses may be single or multiple. Delstanche (1878) encountered up to three in one ear. Von Troeltsch saw "frequently several in one ear, arising from different parts of the wall." Sabroux (1901, p. 35), from the data he gathered, believed them to be "ordinarily single", though there might be two or even three in one ear. For Kerrison (1913, p. 125) they were "multiple oftener than single."

Blake (1880) and Körner (1894, p. 107) alone give some statistics on the point. In Blake's 39 cases of ear exostoses in Tennessee and California Indians, 54 of the 78 ears showed the growths: in 38 ears (70.4 percent) they were single, in 12 (22.2 percent) double, in 3 (5.6 percent) triple, and in 1 (1.8 percent) multiple. In 41 ears Körner found the exostoses 32 times (78 percent) single, 8 times (19.5 percent) double and once (2.7 percent) triple. The two records are remarkably harmonious.

Aside from Blake's there are no data on this subject in the published reports of a more anthropological nature. Among the clinical records

in the literature I was able to find 84 cases, or rather ears, in which the number of exostoses was given. The results follow:

Number of Exostoses in Individual Ears of White Subjects Recorded in Otolological Literature

Number of records on individual ears	Exostoses		
	Single	Double	Triple or more
84	44	27	13
	52.4%	32.1%	15.5%

It seems plain from the above data, small in number and imperfect as they are, that among the Whites, in over one-half to two-thirds of the ears affected by exostoses in the external meatus which come to the attention of the aural surgeons, there is but one of these growths, and in the remaining number there are two or over.

New observations.—A much more satisfactory record can be presented in connection with the new observations that are given in this work, though on different racial groups:

Number of Exostoses in Individual Ears Affected with Such Growths

Group	Skulls	Skulls with ear exostoses	Percentage of exostoses in individual ears			
			1	2	3	Over 3
Egyptian.....	454	9	83.3	8.3	....	8.3
American:						
Eskimo.....	1,000	2	(100)	....	....	....
Old Pueblo.....	500	12	100	....	....	....
N. Dakota.....	29	2	(100)	....	....	....
Florida.....	395	35	71.7	24.4	2.0	2.0
California.....	435	46	73.7	17.5	7.5	1.2
NE. States.....	112	13	73.7	26.3	....	....
Peru.....	3,651	522	46.3	38.6	14.6	0.4
Virginia.....	65	14	52.0	36.0	4.0	8.0
Louisiana.....	61	15	73.2	26.8	....	....
Arkansas.....	173	47	73.3	25.3	1.4	....
S. Dakota, all.....	109	30	75.0	16.7	....	8.3
S. Dakota, Mowbridge	76	23	81.1	16.2	....	2.7
Kentucky.....	90	29	57.7	26.9	15.4	....
Polynesian:						
New Zealand.....	19	4	(42.9)	(14.3)	(14.3)	(28.5)
Hawaii.....	148	39	56.9	36.7	4.9	1.5

It will be seen that in all the larger groups a single outgrowth in a meatus is the most frequent condition. In our Pueblos, curiously, it is the universal, and in our old Egyptians a nearly universal, condition. But in most of the other groups two exostoses per meatus are also fairly frequent; three are scarce, and more than three are decided rarities.

The single tumefaction-exostosis is, as a rule, the initial stage, but a second enlargement, generally from the opposite side of the tympanic portion, will soon follow, the third and perhaps additional growths developing later.

In no less than 6 of the 12 Indian series the percentage of single tumors is practically identical.

In three of the remaining groups, Peru, Virginia, and Kentucky, and in both Polynesian groups, the proportion of cases with two or more growths is exceptionally high.

The Peru and the Kentucky material especially shows many ears with three exostoses.

Two notes of caution are here necessary: 1, In some specimens with one ear exostosis, had the subject survived to older age there might have taken place a development of additional growths; and 2, where the canal is nearly filled by one, two, or three exostoses, other growths, smaller and more posterior, cannot be seen and thus escape enumeration. This means that the proportions of cases with more than one exostosis would be somewhat higher were we dealing with those who lived their full span of life; and that the proportions of two and especially those of three or more growths are in reality in some measure higher than those given in the records; but the excesses in either case could hardly be very material.

The chief meaning the above results convey is once more that the ear affection under consideration appears in the form of an entity or "diathesis", which manifests itself practically identically in a large proportion of different geographic or tribal groups of the same race, but which may also, through some peculiar causes, differ substantially in other groups of the same people.

LOCATION

As in other respects, so in this also there are in the history of ear exostoses some variants of experience and hence of opinion.

According to Toynebee (1860), ear exostoses may develop in any part of the length of the tube; but the part from which they most commonly originate is about the middle third of the passage. . . . Occasionally the posterior wall affords the point of origin to the tumour, and then it not unfrequently resembles a simple bulging of the wall. In other cases, a similar tumour is also developed from the anterior part, and the two protuberances meet and lie in contact in the middle, leaving an inferior and superior triangular space at the place of the original opening of the tube. . . . The tumour may grow from the upper surface of the tube. . . . Two or more tumours, again, extend sometimes from various parts of the circumference of the meatus, and converging towards the center, fill up nearly the whole cavity.

Delstanche (1878) says that the growths may develop from any point of the meatus, but arise most frequently posteriorly. For Blake (1880), most of them are on the posterior wall; for Ayres (1881), they are in any portion of the canal but most frequent posteriorly; Von Troeltsch (1881, p. 141) states they "occur as well at the beginning of the bony canal as close to the drum . . . by far the most often from the posterior and superior, less often from the anterior wall."

R. Virchow, and after him Hartmann, Ostmann, Körner, and Marx, held that the abnormal bony growths in the external auditory canal originated generally (or even invariably) from the borders of the tympanic bone, where they lay on and fused with the squamous portion of the temporal; some of these authors, however, had observed also occasional exostoses in other parts of the canal. Moos (cited by Goldstein, 1898), in his cases, observed that they arise "invariably from the upper wall of the canal, almost at its outer end"; in Jacquemart's (1889) practice they were "encountered most commonly at the inferior part of the meatus."

Among additional statements, some of which merely repeat others, the following may be quoted. Schlomka (1891, p. 16): "As to their origin, these exostoses arise most often from the postero-superior wall of the auditory canal . . . more seldom from the anterior, most rarely from the lower portion of the same." Sabroux (1901, p. 34) says that they develop anteriorly and posteriorly as well as superiorly and inferiorly, "but it is at the union of the cartilaginous with the bony part (of the meatus), or again quite close to the drum, that we observe them most often." Ferreri (1904): "Most frequent posteriorly and superiorly." Kessel (1889, p. 285): "As far as the place of origin is concerned, the globular exostoses arise from the posterior and superior wall, the cylindrical ones extend along the floor of the meatus parallel to its axis, while the osteophytes occur preferably on the superior part of the inner portion of the canal." Kerrison (1913, p. 125): "Oftenest on the anterior and posterior walls. . . . When one growth only is present, the anterior wall near the attachment of the drum membrane, is the most common site." Dahlström (1923, p. 213): "Most of the exostoses were found approximately on the boundary between the cartilaginous and the bony parts." Burton (1927): "By far the larger number of aural exostoses are found along the suture lines between the canal and the rest of the temporal bone." Oetteking (1930, p. 249): "The pea-shaped restricted to marginal area of meatus; more or less pedunculated anterior or posterior; the crest-shaped is elongated and extends from without inward."

For Möller-Holst (1932, p. 96), who had the advantage of observing numerous cases in skulls, "the exostoses of the auditory canal occur in the outer, middle, and inner portions of the canal. They are located on the tympanic bone in different places, mostly on the boundary of this bone and the squama or pars mastoidea. They seldom proceed from the squama." In his material, "they occurred with about equal frequency anteriorly and posteriorly in the tympanic part; one-third of the cases showed them anteriorly, one-third posteriorly, and the last third both anteriorly and posteriorly."

Older records.—The only actual record on the location of ear exostoses within the meatus is that of Blake (1880). In 45 Indian skulls with such growths, from Tennessee, California, and Arkansas, out of a total of 82 exostoses 55 (66.3 percent) were posterior, 24 (28.9 percent) anterior, 3 (3.6 percent) antero-superior, and 1 (1.2 percent) postero-inferior.

New observations.—The location of the exostoses was noted in all of our material. It was as shown in the table on page 36.

Notwithstanding some significant differences, there is a remarkable basic agreement in the figures, and also between that part of them that embraces the bulk of the American Indian material and those of Blake on the same race.

It may now definitely be said that ear exostoses in the American Indian (with a few exceptions), regardless of the amount of total involvement by the growths, will be in something over 60 percent (of all the exostoses) posterior, in from 20 to 40 percent anterior to antero-superior, and in a small percentage—and that in but some of the groups—postero-inferior or antero-inferior. Superior (squamous part) outgrowths occurred in but three of the series, inferior outgrowths in but one and that only in a single instance.

Some observers would perhaps be inclined to class some of the cases included in "posterior" as postero-inferior or postero-superior, but that would not alter the main significance of the above showing. This is that, in general, in the American Indian, approximately two-thirds of the ear exostoses arose from the posterior end or portion of what was originally the tympanic ring and later developed into the tympanic bone; that nearly one-third of the growths arose from the anterior end of the ring and subsequent bone; and that in but a few groups was there apparently any tendency toward a development of bony excrescences from the squamous portion of the meatus—though the incidence and proportions as given in the table for this item would probably be augmented somewhat if an examination of the whole squamous part were always possible; and that the floor of the meatus

Place of Origin of the Ear Exostoses within the Meatus

Group	Number of skulls examined	Number of skulls with exostoses	Location of exostoses, in percentage of total number of the growths									
			Posterior	Postero-superior	Postero-inferior	Anterior	Antero-superior	Antero-inferior	Superior	Inferior		
Egyptian.....	454	9	82.4	...	...	17.6	...	...	...	...	...	...
American:												
Eskimo.....	1,000	2	100	...	...	...	...	...	...	...	...	...
Old Pueblo.....	500	12	100	...	...	...	...	...	...	...	...	...
N. Dakota.....	29	2	(100)	...	...	...	...	...	...	...	...	...
Florida.....	395	35	64.3	2.9	1.4	7.1	24.3	...	...	...	...	...
California.....	435	46	66.0	...	1.1	7.4	25.5	...	...	...	...	...
NE. States.....	112	13	62.5	...	...	37.5	...	...	...	...	...	...
Peru.....	3,651	522	42.7	...	1.0	30.9	25.3	0.1	...	...	...	...
Virginia.....	65	14	57.1	...	...	23.8	14.3	4.8	...	...	...	...
Louisiana.....	61	15	71.9	...	6.3	...	21.9	...	...	...	...	...
Arkansas.....	173	47	65.6	...	2.1	15.6	14.6	2.1	...	...	...	...
S. Dakota, all.....	109	30	61.7	...	1.5	17.6	5.9	8.8	2.9	...	1.5	...
S. Dakota, Mowbridge.....	76	23	74.5	...	...	14.9	6.4	...	...	...	4.3	...
Kentucky.....	90	29	62.2	...	...	15.9	20.7	...	...	...	1.2	...
Polynesian:												
New Zealand.....	19	4	53.3	...	...	20.0	26.7	...	...	...	...	...
Hawaii.....	148	39	52.4	...	...	19.0	23.8	...	...	...	...	...

is practically never primarily involved by these abnormalities, though it may be secondarily involved when the posterior or anterior exostoses are large and diffuse.

In the old Egyptians of 4,000 years ago there is the same predominance of posterior growths, with a smaller proportion of anterior, and no other.

In the Polynesians conditions differ but slightly from those in the Americans: there are somewhat less of posterior and correspondingly more of anterior and antero-superior exostoses.

The data demonstrate once more that, although there are some group differences in the location of ear exostoses, this location discloses certain general tendencies, which in their turn support the conception of the process of these growths as a definite and separate abnormal entity.

Observation along this line on large numbers of specimens leaves a strong impression of basic definiteness and rule, both as to location and mode of development, which is radically opposed to any incidental or purely local origin of these formations.

SIZE

In size the ear exostoses vary, according to Wyman (1874) from "a pin's head to that of the whole caliber of the canal"; according to Whitney (1886), "from a simple thickening all stages can be traced, up to the formation of round osseous growths as large as peas, which in one or two cases have completely blocked up the opening"; according to Russell (1900), from "minute nodule to large tumorous growths". Sabroux (1901) says that their volume varies much—from a simple protrusion on the walls of the canal to a complete obliteration of the same. For Gray (1910) their size ranges from "a pinhead to that of a bean". Dahlström (1923) states that they "seldom reach such a size that they would completely close the meatus." Möller-Holst (1932) says that "the size varies from that of a pinhead to exostoses that involve nearly one whole wall of the meatus; while in height they range from very low to those that project up to 7 mm." There are additional statements on the point, but they merely repeat more or less what has been given here.

New observations.—From our observations, unimpeded by any soft parts or wax or discharges, it is possible to state as follows: The growths differ from small distinct abnormal bulgings or little circumscribed exostoses to bony tumors that almost occlude the meatus, or even protrude beyond it. In no instance has an absolute occlusion of the auditory canal been seen, but when in life the parts were covered

with skin the closure in some of the cases must have been about complete. Large growths are frequently accompanied by smaller ones. The circumscribed exostoses never coalesce, and they never become fused with the wall they reach in their growth.

An attempt was made to record the exostoses found as to size. Such a procedure is difficult and calls not only for extensive experience but also for a clear notion as to the range of variation of the growths. With these conditions satisfied, it is possible to arrive at a rational classification which, although incapable of mathematical accuracy, is nevertheless really useful for conveying a fair picture of the conditions.

The whole range in size of the growths was divided into small, moderate to medium, and large. The "small" ranged from that which could be distinctly diagnosed as a new growth to those grades where the formation began to be too much developed to be still readily included in that class; the "moderate to medium" were those from the upper boundary of the "small" to such as would occlude up to a half of the canal; and the "large" were those growths that occluded more than half of the meatus. The results obtained are not without interest:

Size of the Ear Exostoses

Group	Number of skulls examined	Percentage of skulls with ear exostoses	Size of the bony growths		
			Small	Moderate to medium	Large
Egyptian.....	454	2.0	Percent 76.5	Percent 23.5	Percent ...
American:					
Eskimo.....	1,000	0.2	25.0	75.0	...
Old Pueblo.....	500	2.4	100.0	...	...
N. Dakota.....	29	6.0	50.0	50.0	...
Florida.....	395	8.0	67.2	25.7	7.1
California.....	435	10.6	78.8	18.1	3.2
NE. States.....	112	11.6	75.0	25.0	...
Peru.....	3,651	14.3	50.9	42.5	6.6
Virginia.....	65	21.5	52.4	40.5	7.1
Louisiana.....	61	24.6	78.1	18.7	3.1
Arkansas.....	173	27.2	65.7	28.1	6.2
S. Dakota, all.....	109	27.5	60.3	39.7	...
S. Dakota, Mowbridge.....	76	30.3	55.1	44.9	...
Kentucky.....	90	32.2	45.1	50.0	4.9
Polynesian:					
New Zealand.....	19	21.1	86.7	13.3	...
Hawaii.....	148	26.4	96.7	3.3	...

There are some very perceptible and significant differences in the above figures. In the old Egyptians, the Pueblos, and the two Poly-

nesian groups, in the two Dakotas and in the northeastern American States, there were no exostoses that could be recorded as "large". In the Egyptians, the Pueblos, and the Hawaiians, in particular, notwithstanding their widely differing total involvement by the growths, the exostoses were all or almost all small. The greatest collective "massiness" of the abnormal formations occurred in Kentucky, Virginia, Arkansas, Florida, and Peru—again under widely differing total involvement.

The causes of the above differences are not clear. If it were practicable to divide the basic causes of these exostoses into hereditary and those checking, or again favoring or exciting, their development and growth in the predisposed individual—as may be correct—then it could be conceived that the differences in their total bulk in a group were due proportionately to the checking or favoring factors. Another influence that enters into the subject is that of age. The growths need time for their development to a large size. Of two groups equally subject to the exostoses the younger would presumably show less mass of the growths. It is probable that the mean age of the affected skulls is not the same in all the groups. But age alone could not possibly account for all the differences encountered.

One item is clear from the results shown in the preceding table, and that is that the numerical involvement by ear exostoses in different groups does not always go hand in hand with the collective massiness of the growths.

SHAPES

Ear exostoses occur in many shapes, and these merge with each other so much that any definite classification appears impossible. Blake (1880) believed that he could recognize two main forms, the "rounded" and the "flattened". Von Troeltsch (1881) divided the better differentiated ones into broad-based and pedunculated. Kessel (1889, p. 285) states they are "multiform", but fall into three classes, namely, hyperostoses, periostoses, and exostoses; under the latter "are understood more or less circumscribed tumors that grow especially in one direction and stand either vertically to or parallel with the axis of the canal. One can observe rounded, cylindrical, and conical exostoses"—but there are also transitional and peculiar forms; there are, too, spinelike growths which have been called "osteophytes". For Schlomka (1891, p. 16), who doubtless in part follows Kessel, "one can speak of rounded, cylindrical, or conical exostoses; but there are many combinations of these forms", and some of the growths may assume the form of ossified polyps. Sabroux (1901,

p. 35) says that their implantation is various, ranging from large diffuse to one or even more than one "pedicules". Körner (1904, p. 106) believed that "the globular growths tended to be located more outwardly than the small buttonlike exostoses, to arise from the postero-superior wall of the canal, to be larger than the other excrescences—pea to cherry size—and to lead readily to the complete closure of the meatus." Möller-Holst (1932, p. 96) says: "As to the shape, one can distinguish flat, broadly based, semiglobular, globular, and pedunculated exostoses. All the forms connect through intermediary grades."

New observations.—In our examinations it was found that the ear exostoses show a variety of forms which merge into each other, present no distinct separate classes, and can only be subdivided roughly or arbitrarily. They range on one hand from what can clearly be recognized as an abnormal localized tumefaction or bulge on the posterior or anterior tympanic wall to large irregular massy growths with adventitious smaller elevations; from slight oblong ridges directed along the axis of the canal to redundant more or less conflating welts; from a recognizable swelling of the postero-superior or antero-superior terminal part of the tympanic ring or bone, to masses that almost occlude the auditory canal; and from little pearl-like exostoses to more or less buttonlike or pedunculated and irregular tumors, some of which nearly occlude and some even protrude from the meatus. On the other hand, there were observed no slender spines, or sharp osteophytic growths, and no forms that could properly be called "cylindrical".

SYMMETRY

There are repeated statements in the literature on ear exostoses that these growths in some cases occur symmetrically in the two ears of the same individual. Thus Dalby (1876) states that "not infrequently both meatus are affected similarly, not only in respect to the presence of these tumors, but also as to their size and number"; and they may also "increase synchronously" in the two canals. For Delstanche (1878, p. 10) "most often, in case the tumors are bilateral, their point of insertion corresponds exactly in the two canals, and they possess also a certain analogy of form and even of size." Ayres (1881) says, "There is seemingly a good deal of uniformity in their development"; and similarly Kessel (1889, p. 286) states, "as to the bilateral cases, it may be remarked that they occasionally appear in the same form and in the same locations and therefore symmetrically"; and for Schlomka (1891, p. 16) the bilateral outgrowths "are occasionally

entirely symmetric, both as to form and location." Noquet (1899) in one case saw perfect symmetry on the two sides—the same aspect, volume, point of origin; Urbantschitsch had one case with two exostoses in each meatus, exactly alike. Sabroux alone (1901, p. 35) considers them as "very rarely implanted symmetrically in the two auditory canals." For Körner (1904, p. 107) they "develop mostly symmetrically"; and also for Möller-Holst (1932, p. 96), "they in part develop very symmetrically."

New observations.—No statistical data have been attempted in this connection, for it was learned that a tendency toward symmetry, where both external auditory canals are affected by exostoses, is the general rule. The likeness extends most to the location of the growths, less to their number and size, and least to the details of their shape. Even where the growths must be recorded as unilateral, there is frequently a trace of a commencing tumefaction in the corresponding locality of the other meatus.

This general tendency of the growths toward symmetry on the two sides connects them clearly, in the view of the writer, with the central neuro-vascular system and is another element of importance in the etiology of these formations.

RATE OF GROWTH

An inquiry into this subject is possible only to the clinician. There are a number of notes on the subject in otological literature.

Toynbee (1860) learned that the development of these tumors may frequently be very gradual and "unattended by any symptoms calculated to attract the attention of the patient." Dalby (1876) found that ear exostoses "may remain without perceptible change for many years."

In the observation of Von Troeltsch (1881), their growth was generally very slow; Braunberger (1896) stated that it was "slow and painless." Kessel (1889, p. 288) noted that, although usually slow, their growth at times was rather rapid. "It was most accelerated toward the time of puberty; older age retards growth. The growth is sometimes uneven; it can cease for a time and then recommence." In Stewart's (1901) experience, although such an occurrence was "extremely rare", yet on occasion these exostoses could take on a rapid growth suddenly.

A summary of all the clinical observations on the rate of growth of ear exostoses is that their early stages are slow, symptomless, and usually ignored even by the subject; that many apparently stop all growth after reaching a smaller or larger size; but that under exciting

conditions, evident or not, there may set in a relatively rapid enlargement, which soon is attended by distressing symptoms that bring the subject to the aural surgeon.

An interesting further fact is that after an operation and removal of an ear exostosis, in a majority of cases the subject remains free from the growth, but in some cases there is a recurrence of the bony tumor. In the absence of both infection and malignancy the latter event implies, it would seem, a special neuro-vascular influence.

SUBDIVISION

Since Toynbee (1860), repeated but not very successful efforts have been made at a classification of ear exostoses, either on the basis of causation, of the form of the tumors, or of their structure.

The morphological classification alone needs to be dealt with in this section. It begins with Cassells (1877), who divides the growths into two categories, namely, the hyperostoses and the exostoses, which he believes to be separate abnormalities and of totally different origin. This clinically convenient subdivision, notwithstanding voices to the contrary and its demonstrable basic inaccuracy, has become generalized in otology and will probably stay there. Von Troeltsch (1881, p. 144) states that hyperostoses are not clearly separable from exostoses, yet he uses the two terms, applying the first to "a generalized hyperplasia of the walls" of the meatus. Virchow, though in general admitting the subdivision, appears at times uncertain; he speaks (1889) of a "hyperostosis" in a Tanimbar skull which closely resembles the "exostoses" of the Peruvians.

Kessel (1889) follows Cassells, but adds two more forms and gives the following somewhat arbitrary definitions: Hyperostoses, involving the whole extent of the canal; exostoses, more or less circumscribed growths; periostoses, ringlike bony growths; and osteophytes, spinous growths.

Pritchard (1891) attempts to divide ear exostoses into: 1, multiple, uniformly smooth and rounded; 2, multiple, irregular in shape; and 3, single, polypoid.

Hartmann (1896, p. 44) has this to say:

Now as it happens that of late years both hyperostoses and exostoses have been described indifferently under the title of exostoses, although they are plainly two different processes; the descriptions of cases vary a great deal, depending on whether the author has had his mind more intent on exostosis or on hyperostosis. That there is an essential difference between the two, is also supported by Virchow, who, with his enormous experience with exostoses, remarked, during the discussion of a paper which I had read in the Berlin Medical Society: "I agree with the reader, particularly in one point which made

itself plain to me many years ago during my ethnological investigations of skulls from the northern portions of the Pacific coasts. I refer to the more diffuse hyperostosis which he has exhibited in his first case. That, I should not call an exostosis at all. Diffuse hyperostosis is quite different from a genuine exostosis. Inasmuch as exostoses have a very typical situation, this interpretation is very plain."

Hyperostosis of the external auditory meatus always limits itself to the pars tympanica, whilst the adjacent squamous portion of the bone has no bony protuberance. . . . The entire pars tympanica may become hyperostotic.

For Lake (1898) hyperostosis is distinct from exostosis, being "a more or less uniform bony stricture of the external meatus." Sabroux (1901, p. 13) distinguishes between exostoses and osteomata, believing the two to differ anatomo-pathologically; but gives no satisfactory rule for differentiating the two.

Körner (1904, pp. 106-7) thus imperfectly distinguishes the two forms:

Of the exostoses, the button- to semiglobular forms are found near the antero-superior border of the drum, in the vicinity of the location, still open at birth, of the original tympanic ring. They remain mostly very small. . . . The hyperostoses are found as a rule in the outer part of the bony meatus. In accord with the differing participation of the tympanic bone in the formation of the lower portions of the bony meatus, they reach up to the middle, seldom to the upper third of the lumen of the canal. They develop usually synchronously on the anterior and the posterior wall, seldom also on the floor of the meatus, in such a manner that the remaining opening of the canal becomes pear-shaped. . . . After what was said it seems that the frequently mentioned occurrence of multiple exostoses in one ear is really to be assumed as a combination of ex- and hyperostoses; only the small exostoses at the upper border of the drum do occasionally occur in a multiple number. . . .

Bezold and Siebenmann (1908, p. 102) offer a somewhat peculiar concept of the hyperostoses and exostoses and decide against speaking of them separately:

We call *exostoses* small round bony growths which are usually found as little white circumscribed elevations in groups of two or more on both sutures of the deepest part of the os tympanicum to the horizontal part of the scale of the temporal bone. One protuberance is usually directly in front, another close behind the short process of the hammer in the drum membrane. A third one often protrudes between the two. *Hyperostoses* present themselves more in the form of diffuse bulgings of the anterior lower, and sometimes also posterior lower wall. A crosscut through the meatus has consequently the shape of a pear with the point downward. We shall speak about exostoses and hyperostoses together, as they are found not infrequently in the same ear.

Jackson (1909) divides the neoplasms merely into: 1, those that entirely block the meatus; 2, those that do so partially; and 3, those that scarcely affect it, causing merely some narrowing.

Ballenger (1914, p. 661) attempts, though hardly successfully, to give precise definitions: "An *exostosis* is a bony tumor growing from the wall of the meatus, and may be either sessile or pedunculated. *Hyperostosis* is a diffuse thickening of the bony tissue, or a true hyperplasia."

Ferreri (1904) opposes the division into hyperostoses and exostoses as artificial. But Gray (1910, p. 137) accepts Cassell's classification, defining ear exostoses as growths "which are circumscribed and even occasionally pedunculated; and hyperostoses, in which a general diffuse thickening of the bony walls takes place."

Manasse (cited by Möller-Holst, 1917, p. 71) says that the hyperostoses are broadly based thickenings, the exostoses showing a globular development; and the same definitions are given by Bauer and Stein (1926). For McKenzie (1920, p. 457) "osteomata in the meatus may be sessile (hyperostosis) or pedunculated (exostosis)."

Bauer, Stein, Kaufmann (cited by Alexander) designate the circumscribed protruding bony growths as exostoses, the more diffuse ones as hyperostoses. "Thereby", says Alexander, "the principal distinction between exostosis and hyperostosis falls; the difference lies simply in the development. The separation of exostoses and hyperostoses of the external auditory canal is not easily possible when they occur at the same time in the same ear passage." Alexander then classifies the growths according to location, into:

1. Exostoses that proceed from the outer border of the os tympanicum.
2. Exostoses that proceed from the inner border of the os tympanicum.
3. Exostoses that arise from the body of the os tympanicum.
4. The flat but slightly protruding exostoses of the inner part of the canal, coming mostly from the terminal line of the os tympanicum.

He also classifies the growths pathognomically, of which more later.

Oetteking (1930) separates hyperostoses and exostoses, but says that "there may be transitional forms", though in shape rather than structure.

Finally Möller-Holst (1932, p. 73, 101, 102) expresses himself thus:

Under hyperostoses Kessel and Ostmann understand general thickenings of the tympanic bone; Kaufmann diffuse bone increase in mass, but also circumscribed growths; Hartmann and Virchow flat exostoses; Manasse broadly based thickenings; Marx diffuse malformations which are to be counted among the hyperplasias and which originate already in childhood; Alexander a structural variation, not an abnormality (*Missbildung*), which when more strongly developed are to be counted with the tumors. Zuckerkandl's exostoses also, are designated by Alexander as hyperostoses. Under exostoses are generally understood localized bony outgrowths.

For Kaufmann, Möller-Holst says, exostoses and hyperostoses are but form-differences. "Marx, too, knows no boundaries between circumscribed exostoses and diffuse hyperostoses, and no more does Alexander, who uses the two terms for the same growths." Möller-Holst's own view is that, though there exist all kinds of transitions between the bony growths in the ears in their form as well as their structure, yet from the clinical point of view there is a justification for subdivisions of the formations on the basis of location, shape, and size. "Speaking generally, therefore, a so-called bony polyp of the meatus may anatomico-pathologically be an exostosis or a hyperostosis"—which last statement is not very clear.

New observations.—It is plain from the above that a generally valid classification of the abnormal bony ear growths has not been realized and in fact, appears to be unrealizable; but that clinically there is a prevalent sense of two or rather three forms—the diffuse or broad-based irregular tumefactions; the circumscribed, occasionally pedunculated tumors, capable of a rapid growth and, together with their soft coverings, of causing an occlusion of the whole canal; and small indolent rarely troublesome "ceiling" growths in the meatus.

The extensive examinations reported in this monograph lead to the conclusion that, aside from the small, more or less pearlike exostoses—or probably better osteomata—arising from the superior or squamous part of the meatus, there is no line of demarcation that would permit any valid subdivision of the growths into hyperostoses and exostoses, or in any other manner. There are many cases where a clear characterization of the growth by one or the other of the above main terms, hyperostosis and exostosis, is impracticable—it is more or less both. There are other more differentiated cases in which at the base the growth would deserve the name of diffuse hyperostosis, but above this is definitely a more or less rounded exostosis. There are cases where what is evidently the same growth, in the same location, will in one of the ears of the same skull show the form of a pronounced exostosis, in the other that of some grade of hyperostosis or an intermediary condition. And there are no few instances in which both or all three of these forms (hyperostoses, exostosis, and intermediary) may be seen in the same ear. The more or less diffuse hyperostosis of the posterior or anterior wall of the meatus is in many cases in all probability but an earlier stage of an exostosis.

Thus otology, for its practical purposes, will doubtless keep its conventional classification of the bony growths of the external auditory canal into hyperostoses, exostoses, and osteomata of the roof; but those who use this classification should be aware of the fact that,

except perhaps for the rare osteomata of the roof, it is merely a conventional and convenient subdivision, without substantial anatomical or pathological foundation.

STRUCTURE

A number of authors who dealt with ear exostoses report the results of a histological examination of these growths. The results show differences; some are more or less cancellous and some are compact tumors, but between the two there is no line of demarcation—they connect by intermediary grades. Thus histology, too, fails to afford any definite basis for the differentiation of these neoplasms into distinct categories. About all that can legitimately be said is that the small, pearlike and the smooth, rounded exostoses are generally the more compact, the tumefactions and the large masses prevalently the more cancellous.

The structure of ear exostoses received attention from the very first report of these cases, that of Autenrieth (1809). The growth was "formed of areolar bone tissue."

Contrary to this, in Toynebee's experience the tumors were compact. In his Textbook (1860) we read:

As far as my opportunities have permitted examination, these tumours . . . appear to consist of extremely hard and dense bone. In one case, where a portion of the bone was denuded of membrane, it appeared shiny, white and polished, like ivory. In another, where, under the misapprehension of the body being a polyp, caustic had been applied, the bone was exposed and found to be extremely hard and devoid of sensibility. In a third instance, where I observed the membrane to be absent, there was a thin layer of cartilage on the surface, beneath which the bone was very hard.

Delstanche (1878) distinguishes "cellular" and "eburnated" structure of ear exostoses. He says (p. 8): "Thus some—the cellular exostoses—are formed by areolar bony tissue which is enveloped by a thin layer of compact bone; others—the eburnated exostoses—are completely formed by compact tissue of much density." Schwartz (q. by Delstanche) "is of the opinion that the spongy and compact states of the exostoses represent merely different phases of the development of the neoplasms, and that exostoses that were at first cancellous can pass into the state of eburnation; and he believes also in the possibility of their transformation in the reverse sense. This opinion is also partaken of by Virchow and Nélaton."

Individual cases were studied histologically by Hedinger, Cocks, Kuhn, Eulenstein, and others. The reports are sometimes rather involved, but all agree on one hand in the complete absence of anything

that would suggest malignity, and on the other in the lack of a substantial basis for any definite subdivision of the growths into different classes.

A case of a pedunculated exostosis operated upon and studied by Politzer (1902, p. 210), "showed here and there very compact lamellae (eburnation) with spaces that contained but few vessels."

Another pedunculated exostosis was removed and studied by Tod (1909, p. 77) who reports briefly as follows: "On making a section the ossification was seen to be proceeding from the centre." Other exostoses "were very hard, with a very thin layer of skin over them."

A number of detailed histological examinations of ear exostoses are reported by Dahlström (1923, pp. 215-216), and notes on the subject may be found in Kessel, Schlomka, Ferreri, Gray, Oetteking, and other authors, but there is nothing to afford any definite aid in the attempt at a classification of these growths.

Marx (1926, p. 502) thus summarizes the results of the histological studies of ear exostoses up to his time:

They consist of compact bone without distinct medullary spaces, but often with strikingly marked vascular canals. In substance the "exostosis eburnea" and the "exostosis spongiosa" are not different, but it is to be accepted that one form passes into the other (Weber, Virchow, Schwartze), and that occasionally also mixed forms are encountered.

Finally, Möller-Holst (1932, pp. 69, 100) states:

Some exostoses consist only of cancellous bone and will therefore be designated as *exostosis spongiosa*, others are covered with a compact layer and are called *exostosis eburnea*. Histological examinations by the clinicians have shown that between the two extremes (the compact and the spongy exostoses) occur all transitions.

Remarks.—The only conclusion that can be drawn from the histological evidence regarding the bony growths in the ears is that they all together constitute but one abnormal complex, which offers numerous individual differences, grades, and variations.

NATURE

What, in the opinion of those who have dealt with the condition, is the nature, pathologically, of ear exostoses? There are numerous opinions on this subject, but in general they are based on limited individual observations, and that mostly clinical, which do not permit of a sufficient perspective and grasp. However, it is interesting to survey these opinions.

Roosa (1866) concluded that ear exostoses "were morbid growths consequent on local irritation."

For Von Troeltsch (1881) the "exostoses" were pathognomically close to tumors, the "hyperostoses" close to diffuse osteophytic growths.

Hedinger (1881) diagnosed his case as "ostoid metamorphosis of inflammatory proliferation of papillary and connective tissue, with lime deposits"—no regular bone formation.

Moos (1881) regarded his cases as simple hyperplasias arising from irritative processes at a time when the tympanic ring fuses with the adjacent parts of the temporal; Roosa, about the same time, viewed them as "hyperplasias of the periosteum and the underlying bone"; Politzer (1893) as "partial hyperplasias of development and ossification."

Steinbrügge (1891) terms the outgrowths "periosteal osteomata." Virchow (1893) considers them as "plainly products of pathological nature . . . examples of disturbed development, which probably begins in and proceeds from the end parts of the annulus tympanicus", and says later, "The localization of the exostoses of the auditory canal implies that they, as the exostoses of other parts of the skeleton, may be conceived as excessive bone growths on places which are advancing toward ossification."

Whitney puts them, *ab origine*, under "cartilaginous exostoses."

Braunberger (1896, p. 6) thought that "if we want to give these exostoses an anatomically and physiologically substantiated position in ear pathology, we must range them with connective tissue tumors in the ectodermal part of the sound-conducting apparatus of the ear."

Ranke (1900) believed that the growths "were examples of an endemic disease common to the burial grounds of Ancon as well as those of old Peru in general."

Sabroux (1901, p. 13) says, "Exostoses of the auditory canal are tumors formed by an abnormal and circumscribed production of bony tissue on the surface of the canal." They are "benign tumors, harmful only by mechanical obstruction."

Mayer (1923, 1924) attaches these exostoses (as also otosclerosis) to the "hamartomata" or defect-developments (*Fehlbildungen*), and refers them to a defective condition of the periosteal connective tissue.

For Marx (1926, p. 500), "exostoses of the auditory canal represent circumscribed bony neoplasms and are to be counted with the tumors, in distinction from the more diffuse hyperostoses, that belong to the hyperplasias. A sharp division of the two is, however, not always possible, as evidently there are transitional forms and as circumscribed exostoses may also occur in a meatus narrowed through hyperostosis."

Alexander (1930) regards both hyperostoses and exostoses—separable only by their form—when slight as variations, when large as tumors.

Remarks.—It must be clear from the above that the pathognomy of ear exostoses is a subject that is as yet by no means as elucidated as might be desired. The relative rarity of the condition in the living, its clinical disadvantages, the want in many cases of the assistance of an expert histo-pathologist, all constitute serious difficulties in this field. Perhaps the extensive observations that form the basis of this report may help to throw some light on the matter; this will be dealt with in the terminal discussion.

ETIOLOGY

The causation of ear exostoses, being of especial importance to otology, has received considerable attention; nevertheless, here also much still remains obscure. The subject has naturally a direct connection with that of pathognomy of the growths.

A general review of the observations and opinions recorded in this part of the field shows that attention has been concentrated mainly on the local or exciting agencies and on the possible connection of the exostoses with certain systemic conditions or diseases. Nevertheless, there are also a number of valuable observations on the heredity of the growths. It will be well to take up separately the various etiological factors involved.

TRUE CAUSES "UNKNOWN"

A large majority of the authors who deal more adequately with the etiology of ear exostoses acknowledge more or less openly that the true or basic causes of this class of disorders are unknown or uncertain.

Statements such as "nothing positive", "still dark as to the causes", "true causes unknown", and others of similar import may be found in Turner, Blake, Garrigou-Désarènes, Ferreri, Lake, and many others. Hedinger (1881), "pathogenesis entirely unknown"; Whitney (1886, p. 41), "various explanations have been offered for the occurrence of the growth in this situation, but none of these is entirely satisfactory"; Kessel (1889), "causes still but little known"; Goldstein (1898), "etiology often shrouded in mystery"; Politzer (1902, p. 210), "the causes of these exostoses are, in the majority of cases, not ascertainable." Le Double and Lebourg (1903), "causation uncertain"; Bachauer (1909), "cause not yet found"; Burton (1927),

"causes still largely speculative"; Möller-Holst (1932), "subject in many points not satisfactorily cleared."

Notwithstanding this general pessimistic attitude, there are many beliefs and theories as to the causation of the tumors. They will be reviewed in the following sections.

"SPONTANEOUS", NUTRITIVE

There are a number of remarks in otological writings to the effect that an exostosis in the meatus commenced spontaneously without an apparent reason. As late as 1930 Alexander says that some "originate spontaneously, as an abnormality."

Dupuytren (q. by Sabroux, 1901) suggested a nutritive disturbance. He believed that they depended on a modification in the nutrition of the bone, on some sort of aberration in the distribution of the bone juices, comparing the tumors to the outgrowths which develop as a result of irregularity in distribution of sap.

Masini (1882) believed also in disturbed nutrition. He thought the growths "may be comprehended as exaggerated nutritive 'lavosio'."

CONGENITAL

A number of authors have advanced the idea that some of the ear exostoses may be "congenital", though none have taken the trouble to state precisely what they meant by that term. In some cases it probably stands loosely for "hereditary".

Thus Dalby (1876) says, "that small bony enlargements in the external auditory canal are sometimes congenital I feel tolerably confident." Delstanche (1878), a little more explicit, believes that the exostoses "may develop both before and after the ossification of the canal." For Roosa (1892) "there may be congenital cases." Velpeau (q. by Le Double) believed some to be "congenital." For Goldstein (1898) exostoses in American Indians belong apparently to "congenital" growths. Sabroux (1901, p. 24) accepts, though rather loosely, the "congenital" nature of some of these growths: "we call therefore congenital all exostoses whose origin is unknown and which seem to be transmitted by heredity; exostoses whose presence coincides with the development of some congenital tumors or malformations; and finally all those exostoses that characterize one race more than another."

In Bezold and Siebenmann's textbook (1908, p. 102) we read on this subject as follows: "The exostoses in the bony meatus which Virchow found in many Mexican [should be Peruvian] skulls and which he

explained as a peculiarity of the race, must be considered as congenital deformities.”

Fürst (q. by Möller-Holst, 1932, p. 73) regarded the exostoses as possibly congenital, and Green (*ibid.*) held that some of the growths could be of fetal origin.

All ideas of congenitality are, on the other hand, opposed strongly by Kessel (1889, p. 286), who states: “In the literature of the subject there are also met with opinions that the exostoses in the auditory canal may occur congenitally. In my estimate this assumption rests on a gross error, for from developmental studies it is known that in the newborn there is as yet no bony meatus and that the same comes into existence only during the first years of life. . . . The exostoses are therefore later manifestations. . . .” Le Double and Lebourg (1903) express the view that the growths “evidently are not congenital”; and Körner (1904) states unequivocally that they do not occur congenitally.

New observations.—An examination of numerous skulls of fetuses, newborn, and infants has shown me not the slightest trace of what could be regarded as a hyperostosis or exostosis of the tympanic ring, or on the roof of what was becoming the external meatus. As Kessel pointed out, there is no bony canal until well after birth, in early childhood.

Judging from the incomplete developmental stage of the parts up to and for a period after birth, and from the absolutely negative results of our examinations, which included infant skulls of groups that were greatly affected by ear exostoses in later life, it may safely be said, I think, that the growths in question do not occur congenitally. The term “congenital” should henceforth be excluded from the literature of ear exostoses.

DEVELOPMENTAL

Aside from causes inherent in the organism and derived either from some constitutional fault or from heredity, a number of students of ear exostoses connect them with “developmental” conditions of the external auditory canal. Just what is meant by this is mostly not clear, and even where an attempt is made at explanation, no proof of the correctness of the view is given in any instance.

Virchow (q. by Möller-Holst, 1932, p. 73) believed that some of the exostoses originated in the fetal stage from the tympanic ring as a result of a pathological irritation. Much the same view was held by Moos. Green, too, believed that some of the growths could develop in fetal life. For Heiman (1890) congenital ear exostoses were “due

to hyperplasia during the period of development and ossification of the external auditory canal."

Hartmann (1893; 1896, p. 43) held that ear exostoses "must be cases of anomalies of development, because of the simultaneous appearance on both sides, the limitation of the anomaly to pars tympanica, and the perfectly uniform consistency of the rest of the bone." And further (pp. 45-46):

All of these structures are to be regarded as anomalies of formation, which begin with the development of the external meatus and come to light with the advancing of the pars tympanica. . . .

If I were to offer proof that these alterations were simply anomalies of development and had nothing to do with inflammatory or morbid processes, I should emphasize: the absence of alterations which could possibly be referred to previous inflammation; the perfectly uniform condition of the bone, which can in no way be distinguished from the neighboring bone, and especially from that of the squamous portion; the limitation of the hyperostosis to the pars tympanica; the uniform occurrence on both sides; the stationary condition of the tumor in adults; and finally the hereditary influence so often observed.

Lake (1898) opposes Hartmann's opinions. But J. Gruber (1897, p. 212) believes similarly "that the development of ear exostoses stands in connection with the growth of the tympanic ring and is to be conceived as an excess product of this." And for Politzer (1902, p. 210), in some cases the origin of the growths may be attributed to "partial hyperplasia during the stages of development and ossification of the bony auditory meatus." According to his view, "those bilateral osseous neoplasms which develop without symptoms belong to this class, especially if they are located symmetrically in both meatuses and have a corresponding form. They are usually found in the middle and inner sections of the osseous meatus. They are sessile or pedunculated, and seldom attain such a size that they completely fill the auditory canal."

Ballenger (1914, p. 161), too, subscribes to these opinions. He says: "They may be due to developmental causes, particularly in those cases wherein the middle and the inner section of the osseous meatus on each side is the seat of the growth. When due to faulty development, the growths are usually small."

Since the above, the "developmental" origin of ear exostoses received noteworthy further support by Burton (1927). To this observer,

it seems logical to believe that the exciting agent, whatever its form, acts equally upon the entire canal but is responded to only by those points which are especially susceptible to the stimulus. Which are these points? In the vast

majority of cases reported only those areas responded to this stimulation, whatever it was, which during the development grew most rapidly. These places are the two ends of the annulus. By far the larger number of aural exostoses are found along the suture lines between the canal and the rest of the temporal bone. Why? The author believes that an adequate explanation is to be found in his theory that these susceptible areas have retained their early potentiality of more rapid development and response to any stimulus of production.

For Alexander (1930) the "deeper causes of ear exostoses lie in the temporal bone, which is formed of parts that ossify in cartilage and parts formed from periosteal ossification; also the persistence of cartilaginous points in the petrosium, and the lateness of the close of the postembryonal growth, create a disposition to variation in the bone and pathological growths."

Critical remarks.—Although the theory of a "developmental" origin of some, at least, of the ear exostoses has received a considerable backing, yet most of this appears of the order of "follow the leader". And neither the leader nor those who followed have furnished the slightest material evidence that would bear out their contention, or even make it possible.

The discussion under "Congenital Origin" applies also here. There are no observations on record of a fetal, or even later, involvement by the growths up to Field's child of 3 years, and even that case is unique. The bony parts that are to form the external meatus and from which eventually exostoses may arise, are still largely deficient in fetal life and are still far from complete at birth. And irritative ear troubles, that could excite the formation of the outgrowths, are not known of before birth.

INBORN TENDENCY

Wholly different from congenitality is the case of the causes comprised under the term "inborn tendency". Here is something worthy of earnest attention.

The suggestion that there may be behind ear exostoses an inborn tendency toward their production has been expressed by a number of writers on the subject, though one would vainly search for any comprehensive exposition of the idea. Thus Nélaton speaks of a "prédisposition générale de l'économie", and Delstanche (1878), who quotes him, admits this as among the causes. Masini (1882) names "imminent predisposition", and Ostmann (1894) mentions "inborn tendency" as among the causes of the exostoses. For Russell (1900) there is a "tendency in all races towards the formation of bony tumors

or exostoses in the external auditory meatus." A noteworthy statement on the subject is that of Gray (1910):

The other general aspect of the problem is that the majority of individuals never do suffer from exostoses, no matter how badly or from whatever cause their general health become affected, or whether they suffer from some local disease of the ear, such as suppuration, middle ear catarrh, etc., or not. Now it appears to the writer that, viewed from this point of view, the logical conclusion to be drawn is that the cause of exostoses, that is the condition without which the disease cannot occur, is to be found in the organ of hearing itself, and, further, that this condition exists in the organ of hearing of certain individuals, and in these individuals only. From this point of view, which I believe to be the correct one, exostosis is idiopathic. That is to say, the disease occurs in people who have an inborn tendency to it, and that this is the only constant factor in the etiology. No doubt disturbances, either locally in the ears or constitutionally in the bodies of these individuals, may precipitate the onset of the disease, but no particular one of these disturbances need be present and in many cases they may all be absent. The single constant factor is the innate tendency to the disease and the fact that hereditary influences are evident in many cases is strongly in support of this view.

Burton (1927) supports Gray's (and others') view of the presence of an "innate tendency" toward these developments, and would call this "atavism", though evidently with a different shade of meaning from that ordinarily applied to this term. For Möller-Holst (1932, p. 102) a causative connection of atavism is wholly unfounded.

A few authors approach the conception of a "racial influence". Thus Darnach (q. by Alexander, 1930) regards the inclination of the American Indian to ear exostoses as a racial peculiarity (character), something like that of the African Negro toward keloid formations. Möller-Holst (1932) is skeptical and would at most admit a "race-peculiarity" (Rasseneigenthümlichkeit).

Remarks.—The above and some additional statements of this nature range from hesitating suggestions to firm convictions. They show that the more obvious agencies of the disorder did not fully satisfy these observers. They felt more or less vaguely, or have become definitely convinced, that some innate predisposition, individual or racial, lay in the background of the etiology of the growths under consideration. But not one of them has attempted to pin down and critically analyze the hazy factor.

HEREDITY

The subjects of "congenitality", "predisposition", and "inborn tendency", considered above, lead inevitably to that of heredity of ear exostoses, and here otology furnishes a line of definite valuable observations.

As early as 1878, Schwartze reports that he had observed hereditary connections, and Delstanche regards "hereditary predisposition" as among "the best determined causes" of the bony growths in the meatus.

According to Blake (1880, p. 88):

there is one other possible influence which may have a bearing upon the occurrence of these growths, and which is at least worthy of consideration in any future investigations which may be made, and that is, hereditary tendency. Of the more marked cases—that is, cases exhibiting excessive growth without evidence of other aural lesion—I have found, in aural practice, that the majority have occurred in certain families, in the male members of successive generations, the most marked instance being in the three successive generations of one family.

Masini (1882) found positive evidence of heredity of ear exostoses in one case, and similarly did Boyer, Kirchner, Politzer, and Moore. Kessel (1889, p. 288) states that he can confirm the heredity of the growths out of his own clinical experience. There exists here, he says "a constitution-anomaly which leads to certain disturbances in the genesis of the skeleton, without the possibility of a conclusion as yet as to just what this anomaly consists of."

Braunberger (1896) affirms that in individual cases heredity is ascertainable. Hartmann (1897, p. 43) has not only seen evidences of heredity of ear exostoses in his own practice, but a review of the literature on the subject has shown him "the frequent occurrence of hereditary influence in similar cases"; Körner (1904, p. 102) says, "There exists nevertheless in not a few families an hereditary disposition to these bony new growths"; and in Bezold and Siebenmann (1908, p. 102) we read, "This anomaly is often found in several members of the same family."

Gray (1910) states that: "The single constant factor is the innate tendency to the disease and the fact that hereditary influences are evident in many cases is strongly in support of this view." For Ballenger (1914, p. 662), "there are some cases in which heredity seems to be a factor in the production of these growths, as the same condition may be traced through a few generations." O. G. Kessel (1924) declares heredity alone to be the effective cause of the growths, other factors being of but secondary importance. Burton (1927), as already noted, calls the growths "atavisms", which implies inheritance, and asserts that heredity is among the best substantiated of the causes of the abnormalities. For Alexander (1930), ear exostoses are "often hereditary".

Convincing as the above statements are, they are supplemented by the sustaining evidence of actual observations on the heredity of the abnormalities. The reported cases, as far as it was possible to gather them, are as follows:

Reports of Cases of Evident Inheritance of Ear Exostoses

- Blake (1880, 1888): In two families father and son successively affected.
- Masini (1882): In one case, adult male, mother "deaf" through occlusion of both ears when about 40.
- Boyer (q. by Hartmann, 1897, p. 43): Treated a woman whose father, brother, three sisters, two nephews, and all of her own children were affected by ear "hyperostoses."
- Kirchner (1883): Observed a man with bilateral ear exostoses, in whose son he later found a similar condition.
- Kessel (1889, p. 288): Like Blake, saw in two families bony growths in ears of a father and a son.
- Moore (1900): Had two cases, in two brothers, in one in the right, in the other in the left ear.
- Körner (1904, p. 102): Treated, I, a father, 63, with bilateral marked hyperostoses; in his first son, 26, the same; in the second son, 20, the same; in his daughter, 22, a hyperostosis in the right ear; II, father, 55, bilateral marked hyperostosis; son, 7, hyperostosis in the left ear; III, man, 42, bilateral marked hyperostoses . . . brother 38, the same; sister, 30, meatus normal; their cousin, 19, in right ear a completely occluding, coffee-bean-size exostosis.
- Kessel (1924): Presents a heredity-tree of three generations of a family with ear exostoses.
- Alexander (1930): Had three male patients with ear exostoses, the father of each of whom was affected by similar growth; another male whose brother and sister were effected; and still another male with "ear troubles" in a brother and three children of another brother.

Discussion.—In view of the above data, it cannot be doubted that direct heredity plays a part in the etiology of ear exostoses. But there is no light as yet on the problems of how large and important this part is, whether it is generalized or restricted to individual families, whether it is progressive or regressive, and how it originates. Also, nearly all that is said relates to direct inheritance in families and not to heredity in a wider sense. The subject will receive due attention in our final chapter.

An item that calls for some consideration in this place is that of inbreeding. Inbreeding as a cause of ear exostoses was brought up recently (1932) by Möller-Holst, but without comment or any attempt at an explanation. Inbreeding is known to be capable of accentuating and spreading different pathological conditions. In limited localities, in small human groups, and especially in single families, it might have

played a part in multiplying the cases of ear exostoses. But inbreeding means essentially intensified heredity. It could augment but hardly create the exostoses. As these abnormalities are so widespread over the earth, inbreeding, if it was their cause, would have to be equally generalized, which of course it is not. Harmful inbreeding is rare in any race of men. It did not exist in America, where exogamy was the rule. It did exist in Egypt, but only in the Pharaohs and perhaps in the highest families. It took place only very exceptionally in whites. More closely inbred communities, whether in the Old World or the New, have never been reported as especially subject to ear exostoses. In fact, the more closely the subject of inbreeding is examined the more it eludes as a possible cause of ear exostoses.

SOCIAL STATUS: OCCUPATION

There are but a few references to social or occupational causes of ear exostoses, but these few are suggestive. Von Troeltsch (1881, p. 142) states that his cases predominated in those of middle years "who liked to eat well and drink." Bezold in 24 years of hospital and private practice found ear exostoses in 116 patients and says (1895, p. 49): "In only a few instances have I found the exostoses in the dispensary patients; my observations come almost all from private practice. The occurrence of the exostoses is therefore overwhelmingly a disease of the better situated." And the same is reasserted in Bezold and Siebenmann (1908, p. 102).

Körner (1904), in dispensary practice at Rostock, found ear exostoses in but 1.1 percent of his ear patients—a relative rarity in the poor. For Tod (1909) the growths appeared more frequently in the "more favorably circumstanced than in the labouring class." Moodie (1930) mentions that the exostoses are more frequent "among the sedentary groups than among the more active", although he does not state the basis for this conclusion. In Möller-Holst (1932, p. 69) we find the following statement, though it is perhaps not original: "Usually [the ear exostoses] will, curiously, be found almost exclusively among the well-to-do and but seldom in the poor."

Remarks.—Both the social and the occupational factors are of such breadth and complexity, as well as potency, that some influence by them on any pathological or abnormal process may safely be assumed. Such influence may be of direct or indirect nature, primary or secondary. Given the existence of a widespread oto-exostotic diathesis, it is conceivable that its manifestations might be favored or hindered by what is embraced in the term "social status", or occupation. Either

of these complex agencies, in other words, might act as a contributory, exciting, modifying, or checking cause of the abnormalities under consideration.

CLIMATE

The climate of England has been blamed. Law (1909, p. 77) thought ear exostoses were "more frequent in the South, and more so among individuals who have lived in hot climates." Alexander (1930) regards climate as possibly influential in "releasing" the growths. Möller-Holst (1932, p. 69) says—though apparently not as a result of personal observation—that "it is also an interesting fact that the development of exostoses in the external auditory canal occurs more frequently in people who had had a prolonged stay in the tropics"; yet on another page (102) he states that this view is "unfounded".

Remarks.—Our materials hardly sustain the claim for climate as one of the causes of ear exostoses. Our northernmost large group, the Eskimo, is nearly free from the growths; but so is one of the most southern groups, the Egyptians, and so are even more, apparently, the essentially hot-climate African Negroes. The exostoses are frequent along the coasts in Peru, but so they are in the highlands of Peru and Bolivia. The old tribes of the Channel Islands in California and those of Florida, who were equally at least as "oceanic" or litoral as the Peruvians, show much less incidence of these formations. This is particularly noteworthy in Florida, whose old natives belonged largely to the same physical type as those of Louisiana and Arkansas, and where moreover there was a prevalent tendency toward a superabundance of bone formation, as shown frequently by all parts of the skull as well as the skeleton. The greatest involvement by the exostoses is found in tribes of Dakota, Kentucky, Virginia, Tennessee, and Arkansas—all inland regions but differing considerably in climatic conditions. And there is the considerably greater frequency of the growths in the Polynesians than in the Melanesians, with whom the climate is very similar.

From the above it seems that for the present the only safe conclusion to be drawn from the geographical distribution of tympanic exostoses is that their frequency differs very considerably in different territories, but that this is largely, if not entirely regardless of climate or other geographic factors.

FOOD, DRINK, HABITS

Stimulating food and drink.—Toynbee (1860), aside from other considerations, says: "The disease in question may be divided into

two classes: I, appears with congestion of the mucous membrane of the ear. Most of the patients who have consulted me on account of it were in the habit of partaking freely of stimulating food and beverages." Hedinger (1881), on the basis of about 40 cases, found it necessary to deny abuse of liquor as an etiological factor. Heiman (1890) mentions alcohol, but the question is "hard to decide." According to Alexander (1930), food has possibly also "a releasing effect on the exostoses." Möller-Holst (1932, p. 102) says "effect of nutrition is not determinable."

Habits.—Habits in the main imply occupations. With the possible exception of those of sea divers (see under Salt Water), and that of carrying heavy ear pendants (see under Mechanical) no attempts have thus far been made to connect occupational or other habits with ear exostoses.

CONSTITUTIONAL DERANGEMENTS

GOUT, ARTHRITIC DIATHESIS

In dealing with the obscure etiology of ear exostoses it was inevitable that much thought should be given to the possible connection of these abnormalities with those constitutional derangements or diseases that are known to be the cause of osteoblastic disturbances. The foremost of such conditions are the arthritic or gouty diathesis, and syphilis.

The view that rheumatic or arthritic diathesis and resulting localized osteitis or periostitis were the causes of ear exostoses was suggested as early as 1856 by Rau, but was especially fathered by Toynbee (1860), who believed that "it is principally in individuals of rheumatic or gouty temperament that one encounters these bony tumors"; and "they appear to be the result of a rheumatic or gouty diathesis."

Roosa (1866, p. 428), is the first to raise a partial objection—some influence of rheumatic dyscrasia cannot be denied, but must not be overestimated. For Delstanche (1878) the influence of rheumatic or gouty diathesis is not well established. Von Troeltsch (1881) did not see arthritic signs in his cases. For Dalby (1885) the views of Toynbee and similar views are "fallacious"; for Kessel (1889), ascribing the growths to rheumatic or gouty diathesis is untenable.

Virchow (1889, p. 395) is uncertain—"there exists a certain relation between these formations and arthritis deformans"; and in 1893 he is still in doubt—there is "possibly some connection." Jacquemart (1889, p. 192), however, returns to the old view and believes ear exostoses result "from the species of plethora which characterizes arthritism; are found principally in individuals of rheumatic and

gouty temperament." Pritchard (1891), speaking of ear exostoses of certain kinds, says "as far as my own observations go, I am inclined to the belief that they are usually of gouty or rheumatic origin." Alderton (1898) saw in his case "a local gouty manifestation of the constitutional diathesis." For Politzer (1902) gout was one of the causes of the tumors; for Tod (1909) one of the chief causes; and Noquet (1899) saw a case of bilateral ear exostoses in a gouty subject. Sabroux (1901, p. 27) sums up the situation as follows: "Aside from the syphilitic diathesis, we must mention in the etiology of these conditions, arthritism and herpetism, diatheses which are nearly equivalent and closely related if we consider their effects, and finally the gouty diathesis."

For Ballenger (1914, p. 662), gout is doubtful as a direct cause; "it is more probable that the gouty diathesis causes an inflammatory process of the skin and the periosteum, which finally undergoes a retrograde change and becomes the seat of lime deposits."

Remarks.—Arthritic, gouty or rheumatic diathesis is a subject still far from being well understood. It is not even definitely known whether all the conditions comprised under these terms are merely so many differing manifestations of one basic diathesis, as it seems to the writer, or whether they belong to two or more related yet distinct constitutional derangements. They do not, except perhaps on very rare occasions, affect the external auditory canal. They cause irregular osseous deposits in or about the joints, but never pedunculated or circumscribed bony tumors. And they affect mainly those above middle age, whereas exostoses are predominantly an affliction of the earlier part of adult life. A very large proportion of the rheumatic, arthritic, or gouty, moreover never develop ear exostoses. Where then is the connection between the two conditions?

That ear exostoses may exist or develop in "gouty" subjects need not be questioned; that a gouty condition of the system may possibly in some cases act favorably on their development could readily be admitted, though proof should be furnished; that an arthritic diathesis could be the sole cause of an ear exostosis is unexplainable and is opposed by the mass of evidence presented by the extensive skeletal materials at our disposal.

The Eskimo offer perhaps the best refutation of a causal connection between arthritis and ear exostoses. Arthritis is frequent and at times severe in these people, leading to marked joint deposits and marginal exostoses—ear hyperostoses and exostoses are practically absent. On the other hand, in our Kentucky, South Dakota, and Virginia groups, where ear exostoses are most common, arthritic conditions are no more frequent than usual in American material.

SYPHILIS

Syphilis has been blamed for so many pathological conditions of which the causes were difficult to detect that no surprise need be felt that ear exostoses, too, have been attributed to the disease.

The first to believe he saw a direct connection between the two is Triquet (1857, q. by Sabroux), who says "the presence of these bony tumors is not encountered except in subjects manifestly affected by syphilitic infection." Roosa (1866, p. 428) believes that, as with gout, "the influence of syphilis may not be denied, but must not be overestimated". Gruber (1870) thinks syphilis acts in part as a cause; so also, more or less similarly, do Politzer, Jacquemart, Fournier, Noquet, Menière, Krakauer, and Sabroux.

To the above stand opposed Von Troeltsch, Delstanche, Schwartz, Erhardt, and Hedinger. Von Troeltsch (1881, p. 142) says categorically—"connection with syphilis is utterly undemonstrable". Hedinger (1881), as a result of his observations on about 40 cases of ear exostoses, "must exclude syphilis as an etiological factor". For Kessel (1889), ascribing them to syphilis is untenable. According to Duplay (q. by Sabroux, 1901, p. 25), "nothing authorizes us to connect these exostoses with syphilis."

Sabroux (1901, p. 24), though on the basis mainly of the opinions of others, inclines to the view that syphilis is concerned in the genesis of the congenital ear tumors; while in the acquired forms, "syphilis is quite certainly the most common agency that influences their development. . . . In hereditary syphilis we have the congenital exostoses; in the acquired we encounter the exostoses as one of the tertiary manifestations of the disease." And for Ballenger (1914, p. 662), "Syphilis is undoubtedly a cause of the growths, although not in a very large number of cases."

Yet for Bezold and Siebenmann (1908, p. 102) "there is no proof of a special diathesis for this disease such as lues."

There are other statements on the two sides of the question, but no proofs. More recent textbooks and authors in otology tend to be cautious.

Remarks.—Not one single case in the great collection of prehistoric American material that passed through our hands in connection with this study, has shown any evidence of syphilis. Nor was there seen any trace of the disease in any of the Polynesian or other skulls that were found to be affected with ear exostoses.

In the 14 post-Columbian to recent Indian, Eskimo, and White skulls with extensive tertiary syphilitic lesions, in the United States National Museum collections, not one shows even a small ear exostosis.

Whether syphilis, acquired or inherited, may in some way favor the appearance or growth of ear exostoses cannot be decided from my sources. But these do show beyond question that ear exostoses may exist, and that to a far greater extent than in White people, without a trace of syphilis being present; and that on the other hand a whole series of skulls with most pronounced syphilitic involvement may exist with not a vestige of ear exostoses.

LOCAL IRRITATIONS AND INFLAMMATIONS

Of all the possible causes of ear exostoses, none in otological literature receives as much attention as ear irritations and inflammations. The irritations are secondary, due particularly to injuries and discharges, and act by setting up an inflammation. The inflammations may be of any intensity, acute or chronic, localized or generalized. They range from mild focal periostitis or osteitis to serious involvements of the meatus, and to otitis media. All were, and largely still are, believed to be more or less directly influential in favoring the development of the bony growths in the meatus, directly or through their irritating discharges.

Wilde (1855, p. 241) concluded that ear exostoses were the results of chronic osteitis and periostitis in the meatus. Rau (1856) expressed the same opinion. For Toynbee (1860), one class of the growths was due to "congestion of ear lining", secondary to a diseased condition of the ear. Roosa (1866, p. 428) saw in their production a process "substantially an irritative one, often even inflammatory"; "irritation and probably periostitis due to chronic otorrhoea." Similarly for Dalby (1876) they were "at times called into existence by an irritation . . . by the irritating influence of a discharge".

Delstanche (1878, pp. 17, 65) enumerates "among the most potent causes" of ear exostoses, "chronic phlegmasia (inflammation), primary or secondary, of the walls of the meatus . . . inflammation of bone and periosteum . . . inflammation of irritation, spontaneous or traumatic". Similarly, the chief or one of the chief causes of the growths is, in the opinion of Hedinger (1881), "hypertrophic inflammation of the lining membrane, with subsequent osseous metamorphosis of the new-formed connective tissue." For Masini (1882, p. 616), continued local irritation (as in otorrhoea) is a cause of the growths. Moos, Kessel, Politzer, Pritchard, Jacquemart, Heiman, Kuhn, Jackson, Sabroux, Ballenger, Michailowskij, and others express themselves in a more or less similar manner.

For Roosa (1892) the growths are "in general caused by local irritation." Politzer (1902) sees as their basis hypertrophic inflammation of the lining of the canal, with ossification of the new tissue. Virchow (1893) feels that they "owe their inception to a pathological irritation restricted to the pars tympanica." For Green (1896) they are "in most cases, in all probability, the results of a circumscribed periostitis." For Goldstein (1898) "the most tangible and comprehensible cause, yet one not often met with, is that of the long-standing direct irritation and chronic inflammatory condition of the walls of the external auditory canal." McKenzie (1920, p. 458) holds that "exostoses of the meatus seem to be the result of some long-continued irritation, such as chronic suppuration of the middle ear, or eczema of the meatal wall." For Michailowskij (1924, 1926) the chief cause of ear exostoses is chronic *otitis media* and long-lasting dermatitis of the auditory canal. Ballenger (1914, p. 661) tries thus to explain the process: "Chronic suppuration of the middle ear may excite a secondary inflammation of the membranous canal, and cause a fibrous or connective tissue thickening, which, after a long period of time, may be metamorphosed into osseous tissue."

Many other authors, however, express doubt. Field (1878), although acknowledging the influence of inflammatory conditions, nevertheless points out that there is a "rare form of exostosis of ivory consistency, partaking of the nature of a new growth, and quite independent of inflammatory changes." Kessel (1889, p. 287) and after him Schlomka (1891, p. 15) acknowledge that the exostoses occur most frequently in those with chronic ear discharges, and that the discharge causes irritation is beyond doubt; but often it is very hard to decide which was the first condition, for it can be shown that the exostoses are capable of arousing inflammation. Bezold (1895, p. 50) found that "suppurative processes of the middle ear, as accompaniments of exostoses, belong to the great rarities."

Körner (1904, pp. 102-104) feels that the causation of the hyperostoses and exostoses of the meatus by other ear affections is a possibility only in very isolated instances and definitely proved in none; but "there is a rare variety of the exostoses that appears only in consequence of chronic suppuration. These are small buttonlike, fairly pedunculated growths that develop from the postero-superior border of the meatus, close in front of or behind the suprameatal spine and which therefore do not belong, as do the ordinary exostoses, to the tympanic part, but to the squamous portion of the temporal bone." Gray (1910, p. 137) cautions that "judgment must be reserved in this matter"—a large number of the growths are without any symptoms.

Burton (1927) is skeptical as to the influence of otic discharges: "If the exciting agent be some form of chronic irritation and the potentialities of all four walls be equal, we are surely entitled to postulate that the floor, being the most dependent part, would be the wall receiving the maximum stimulation, and hence should be the area most frequently productive of these overgrowths. But the floor is hardly ever involved in the process. It follows therefore that we are justified in premising etiological factors other than chronic irritation. . . ." O. Mayer (q. by Alexander, 1930) does not believe that ear exostoses arise from a primary local inflammation. Möller-Holst's material (1932, p. 102) "fails to show connection with otitis media"; and he has also failed to find, in the mummies with ear exostoses, inflammatory processes in the soft parts.

Discussion.—As with most other alleged causes of ear exostoses, the question remains undecided.

There is no question but that in a large majority of the clinical cases the growths were found accompanied by otorrhoea and in some by marked otitis media. But there were also observed cases without any discharge or otitis, and a great many patients with otorrhoea or otitis media develop no ear exostoses.

A number of the aural surgeons reporting on the condition mention that for long periods the growths caused no trouble to the patient. In general the subject is unaware of the hyperostosis or exostosis until it reaches such a size that it begins to be accompanied by a discharge or interferes with the hearing. But when conditions reach such a stage, a determination of which was first, the bony growth or the discharge and inflammation, is impossible.

The fact that the growths almost never develop from the floor of the meatus, which is most exposed to ear discharges, need not have much significance, for in all probability, owing to differences in innervation and blood supply, not all parts of the tympanic bone are equally prone to the development of exostoses, and at night the discharges bathe also the lateral parts of the meatus.

Theoretically, it cannot but be acknowledged that any cause inducing nerve irritation and reactive prolonged hyperaemia of the meatus would be capable, where a "predisposition" to ear exostoses existed in the parts, of arousing or favoring their development. Where the predisposition does not exist or is held in check in some way, there would, in all probability, be no exostoses. Irritations and inflammations may thus be admitted as among the possible exciting causes of ear exostoses, but hardly as the basic causes of such growths.

The Indian and other material that passed through my hands sustains the view that the fundamental causes of ear exostoses are quite different from mere irritation or inflammation. Most of the specimens with such growths in our collections show no detectable inflammatory changes. Nor are the growths themselves, in a large majority of cases, such as would suggest inflammation. They and the parts about them show nothing like the periostitic bone deposits or osteitic indurations that are so well marked elsewhere in the skull or skeleton where inflammatory processes affected the bone. Our material suggests strongly that, in general, otorrhoea and other otic derangements may not precede but rather follow ear hyperostoses and exostoses, after these have begun to reach an obstructive stage.

SALT WATER

Connected with the preceding category of causes, yet having some individuality of its own, is the irritation of the ear by water and more particularly salt water. A number of authors incline to regard this as a cause of ear exostoses in some instances.

Thus in Field's (1878) cases, two of his four patients attributed their ear troubles, which proved to be exostoses, to repeated and prolonged sea bathing. For Körner (1894) exposure to sea water "was influential"—he found them more than five times as common along the seacoast of Germany as in the interior. Moore (1900, p. 786) reported that ear exostoses were "very common in the Hawaiian Islands, where great fondness for aquatic sports is supposed to be a cause." Tod (1909) blamed "gout and the morning tub." For Law (1909, p. 77) "a causative factor seemed to be the pouring of water into the ears, especially carelessly sponging while holding the head on one side"; and for Jackson (1909) it was "local irritation, principally by sea water." Jackson thought irritation by salt water to be a more frequent cause of ear exostoses than any other. McKenzie (1920, p. 458) says, "they are very common in people who indulge freely in sea-bathing and diving."

For Heiman (1890) the case is "hard to decide." In a case of Lake (1898) the subject "had never had a sea bath." And for Möller-Holst (1932, p. 102) the claim, with some others, is "so unfounded that no discussion of it is necessary."

Remarks.—Some efforts were made to connect the frequency of ear exostoses in the Peruvians and the Channel Islands Californians with sea bathing. It was not known then that the abnormalities would be found to be even much more frequent in some of the inland tribes; that they also occurred in parts of Peru where no one bathed; that they

were rare in the Egyptians who were great water lovers; and that the Malays and the boys of some other maritime groups, including certain Whites, were great swimmers and divers without being particularly troubled with ear exostoses.

Notwithstanding the above, sea water is undoubtedly capable of causing chronic ear troubles, and these may conceivably act, where there is a tendency to the exostoses, as exciting or favoring causes.

ABSCESSSES, FURUNCLES

Cassells (1877) regarded some ear exostoses as secondary to a subperiosteal abscess of the mastoid.

Jacquemart (1889, p. 193) states that after a cure of an ear furuncle or abscess, it is not surprising to see a development of one of these tumors; and Sabroux (1901, p. 29) makes the same assertion.

POLYPS

From evidence adduced by others, Kessel (1889, p. 289) is satisfied that ear polyps may ossify and thus turn into bony tumors. Pritchard (1891) attests that the origin of ear exostoses in some cases may be traced "even to the actual ossification of the polypi." Sabroux (1901, p. 31) quotes Klotz, Bezold, Patterson, Cassells, Hedinger, and Cook as having seen bony tissue in ear polyps, seemingly parting from the bony part of the canal and developing preferentially into the implantation of the tumor (Politzer). Tod (1909) reports a case where a single exostosis developed "from the floor of the auditory canal" 2 years after the removal of a polyp from that ear. Dahlström (1923, p. 216) reports that ossification of ear polyps had been observed by Cocks and Noltenius.

Remarks.—These cases, if correctly reported, would seem to differ substantially from ear exostoses.

MECHANICAL CAUSES AND TRAUMATISM

The first to call attention to the probable influence of mechanical causes on the development of the ear exostoses was Seligmann (1864), who advanced the theory that in ancient Peru the growths were due to the mechanical irritation produced in the Incaic youth, about the time of puberty, by loading the ears with heavy ornaments. This idea is met with also here and there in later authors, and even Virchow (1889, p. 395) inclines to the view that such may have been the cause of the growths in some cases. Blake (1880) found it suggestive that most of the growths occurred in the posterior wall of the meatus, "the wall most exposed to violence."

Politzer believed traumatism might be a cause of ear exostosis, through consequent localized periostitis. Jacquemart (1889, p. 193) claims that even in cases of arthritic or syphilitic diathesis which predisposed to the bony growths in the ears, "it is ordinarily by traumatism that the process commences." More or less similar views are advanced by Heiman (1891), "L. B. of Hamburg", and other authors.

Wagenhäuser (q. by Schlonka, 1891, p. 14) reports a case in which, following a fracture of the anterior wall of the meatus resulting from the kick of a horse, 3 months after the healing of the wound there showed on the site of the injury in the canal two small rounded exostoses.

Contrary to these opinions and reports Kessel (1889) declares that "should one think of mechanical irritation, he will be disappointed. We see foreign bodies remain in the auditory canal for whole decennia, without causing exostosis."

Sabroux (1901, pp. 24, 28) tends to restore the belief in such causes; he says:

A purely *mechanical* cause may also determine deformations of the auditory canal and thereby bring about the production of exostoses. Such an agency might be the compression of the external ear by the umbilical cord when this is coiled about the head. . . . An *injury* of the meatus, however slight, may become the starting point of an exostosis, particularly in those predisposed to such growths through syphilitic, rheumatic, or gouty diathesis; and the same applies to severe traumatisms.

Körner (1904, p. 104) says that "also fractures of the temporal bone, which pass through the auditory canal, may lead to the development of hyperostoses or exostoses in the canal. I have seen two such cases. In both the new bone formation assumed the form of a dull cone and was located on the floor of the canal quite far out toward the mouth of the meatus."

Ballenger (1914, p. 661) holds equally that "traumatic fracture of the walls of the meatus, whereby a circumscribed periostitis is excited, may finally result in the formation of a bony mass or tumor."

Möller-Holst (1932, p. 102) objects to the presumed influence of ear pendants.

There are still other references to the subject of traumatism in otological literature, but they add nothing further.

From the above it appears certain that traumatism of the meatus may in some cases act as the exciting causes for the development of bony growths in the canal. On the other hand no substantial support

is given to the idea that heavy ear pendants might induce the development of these growths, though conceivably in rare cases some exciting influence may exist even in this connection.

HEAD DEFORMATION

Students of ear exostoses who gave attention more especially to American cranial materials, where artificial deformation is frequent, have mostly been inclined to attribute to these deformations more or less influence in the causation of the abnormalities; but there were also those who opposed the view.

There are three main forms of head deformation. One is the simple occipital flattening produced by the unaided or aided pressure of the back of the head on a resistant base. This form assumed its greatest development and vogue among the Pueblos, but it was also present in Florida and elsewhere.

The next form is the "circular" or "Aymara" deformation, produced by a band applied about the head from over the forehead to under the bulge of the occiput. This caused the curious more or less truncated skulls known best from the highlands of Peru and Bolivia, but common also in Vancouver Island, in parts of Argentina, and in other localities.

The third form of head deformation is the fronto-occipital or "flat-head" compression. This was produced by the direct application of pressure to the forehead by means of planks or bags, and occasionally a pad or other appliance for counterpressure to the lower part of the occiput. It prevailed in the Columbia basin, in the southeastern United States, in Mexico and Yucatan, in northern South America, and in Peru. It was also present in Hawaii.

The presumed influence on the development of ear exostoses of artificial skull deformation, ranges itself with the mechanical causes. About the best expression on the subject is that of Whitney (1886, pp. 441-442). He says:

If now the flattened skulls are examined it will be found generally that the meatus is narrowed from before backwards and the lips are often slightly thickened and raised up; . . . There is no absolute demonstration possible that it is the narrowing of the meatus from posterior pressure in early youth that gives a vicious twist to the tympanic ring and places it in a condition favorable to give rise to such outgrowths in after years. All that can be said is that it occurs more frequently in such heads than in those that are normal or flattened by anterior pressure which does not apparently affect the shape of the meatus. And further the similarly flattened heads of the ancient Peruvians show also a large percent affected with hyperostoses. It is not claimed that this deformity is the sole cause, but that it simply increases a tendency which is universal.

For Ostmann (1894), too, the cause of the tympanic exostoses among the American aborigines is largely connected with the deformations of the skull, through its effect on the meatus, which sets up irritation that will lead to exostoses, especially when any other tendency toward such formation exists; with Whitney, he recognizes in the American materials two main causes—"inborn tendency, with head deformation." Goldstein (1898) inclines to a similar opinion; Russell (1900) believes the tendency to bony tumors in the meatus "is increased in deformed crania"; and there are other suggestions of this nature.

On the other hand Turner, as early as 1879, though he found exostoses in a deformed Peruvian and a flat-head Chinook, states that "there was nothing in the two skulls to indicate that the growths may have been induced by the artificial deformation." For Virchow (1893) head deformation was without effect on the production of these growths; for Ten Kate (1896) head deformation had "no connection with ear tumors"; and for Von Luschan (1896) ear exostoses "cannot be attributed to head deformation."

It is plain from the above that the influence of artificial skull deformation on the production of ear exostoses is still problematical.

However, with the observations already on record and the extensive materials that form the basis of this study, it should be possible to throw more definite light on the matter. Let us see how the principal American data on ear exostoses will range themselves in relation to head deformation.

The lessons of the table on page 70 are not as conclusive as might be desired, yet they are not valueless. The records show that undeformed American Indian skulls may be practically free from ear exostoses, may be involved slightly to moderately, as in the Californians, or may present a very marked involvement, as in the Coahuilas. An absence of cranial deformation is therefore no index of freedom from the growths.

There appear in the table several other points worthy of notice. The Argentine Calchaqui, though generally affected by more or less of occipital cradle-board flattening—artificial but very gradual and probably unaided deformation—are, in the available series, free from ear exostoses; and the Vancouver Islanders, all of whose skulls show the artificial circular or Aymara shaping, which in some cases is known to reach very marked degrees on the island, show the growths relatively but very rarely. On the other hand the Chinooks, all of whose heads are deformed by more or less pronounced fronto-occipital flattening, present a very high proportion of the abnormalities.

Older Data on American Indians

Author	Territory	Deformation	Number of skulls examined	Number of skulls with ear exostoses	Percentage of skulls with exostoses
Oetteking....	NW. Coast, misc.	none.....	112	....	....
Ten Kate....	Calchaqui.....	generally occipital flattening	110	....	....
Russell.....	California.....	none.....	158	2	1.2
Oetteking....	Vancouver Island	all deformed, circular..	260	5	1.9
Russell.....	Peru.....	most deformed, fronto-occipital & circular	447	24	5.4
Alexander....	Amer. Indian, chiefly California	in general, no deformation	550	30	5.5
Virchow.....	Ancon.....	most deformed, fronto-occip.	134	18	13.4
Russell.....	Tennessee & Ohio	most deformed, fronto-occip.	456	69	15.1
Möller-Holst	Chile-Bolivia....	most deformed, fronto-occip.	341	57	16.7
Oetteking....	Chinook.....	all deformed, fronto-occip.	83	23	27.7
Studley.....	Coahuila.....	none.....	22	7	31.8

New observations.—In the next table are given the results of our own series. The indications from these data are hardly better than—in fact, not very different from—those that preceded, but there are confirmations which can hardly be without importance.

In the first place it is now definitely seen that undeformed groups may range widely in the incidence of ear exostoses. This can only mean that the syndrome of these growths exists independently of cranial deformation.

The second synergistic result is that shown by the old Pueblos. A large majority of the skulls of this large group are deformed by the occipital cradleboard compression. In some cases this compression seems to have been aided, is very pronounced, and the whole skull has been affected as a result. Yet this group shows a remarkably low proportion of cases of the abnormal ear growths. It thus ranges itself with

the Calchaqui, who present the same variety of deformation. These results are further strengthened by Hooton, who failed to find any noteworthy involvement in his large Pueblo series from old Pecos. All this justifies the conclusion that the simple occipital cradleboard compression does not favor—and may possibly even check in some way—the development of ear exostoses.

On the other hand the fronto-occipital artificial deformation, produced by the direct and forcible application of pressure over the forehead with a counter pressure on the back of the head, must be viewed with the increasing suspicion that it aids in some way in the appearance of the growths under consideration.

New Data

Author	Territory	Deformation	Number of skulls examined	Number of skulls with ear exostoses	Percentage of skulls with exostoses
Hrdlička	American:				
	Eskimo.....		1,000	2	0.2
	Old Pueblo.....	nearly all deformed, occipital flattening	500	12	2.4
	N. Dakota.....		29	2	6.9
	Florida.....	about 10 percent deformed, fronto-occipital	395	35	8.9
	California.....		435	46	10.6
	NE. States.....		112	13	11.6
	Peru.....	most deformed—mainly fronto-occipital—some circular	3,651	522	14.3
	Virginia.....		65	14	21.5
	Louisiana.....	frequent deformation, fronto-occipital	61	15	24.6
	Arkansas.....	occasional deformation, fronto-occipital	173	47	27.2
	S. Dakota, all.....		109	30	27.5
	S. Dak., Mowbridge		76	23	30.3
	Kentucky.....	only a few deformed, occipital or fronto-occipital	90	29	32.2
	Polynesian:				
	New Zealand.....		19	4	21.1
	Hawaii.....	most undeformed—occasional fronto-occipital	148	39	26.4

This matter may perhaps be more conclusively tested in another way. In six of our series exact records were made of the three main kinds

of deformed skulls (fronto-occipital, circular, and simple occipital), and their aural exostoses. The results came out thus:

Frequency of Ear Exostoses in Undeformed and Deformed Skulls of the Same People, and in the Three Varieties of Deformed

Territory	Percent of skulls with ear exostoses in—			
	Undeformed	Occipital flattening	Circular or "Aymara"	Fronto-occipital or "flat-head"
Peru.....	6.7	14.4 ^a	3.7	18.0
Pueblos.....	2.0	2.5	d. absent	d. absent
Louisiana.....	21.7	deformation absent	absent	26.3
Arkansas.....	21.6	absent	absent	31.8
Florida.....	8.7	absent	absent	12.5
Hawaii.....	23.5	absent	absent	28.3

^a Most, if not all, of these Peruvian skulls are really cases of artificial "flat-head" deformation, but the pressure on the forehead was not sufficient to cause a permanent well-marked flattening of the frontal bone.

In this table, it will be noted, it is possible to compare directly the percentages of specimens with exostoses in each category of the undeformed and deformed skulls, within the same ethnic series. The results are convincing. In every instance where both undeformed and "flat-head" skulls existed in some quantities, the proportion of ear exostoses is distinctly higher in the flat-heads. The fronto-occipital deformation, therefore, it may now for the first time be said positively, favors somewhat the development of the growths.

The simple occipital or cradleboard flattening has evidently but small if any influence on the exostoses; and the circular or Aymara artificial deformation seemingly shows more of a checking than a stimulating effect on the growths.

Just how the flat-head deformation may favor or excite the development of ear exostoses is not clear. Many of these cases of deformation are not of extreme grades, and the skulls that are most deformed do not by any means always show the abnormal ear growths; the occurrence of the latter, in other words, is not directly proportionate to the grade of the distortion.

Where the occiput has been much flattened in these cases—pressed forward—a considerable stress has undoubtedly been transmitted to the parts composing the external bony ear. But much the same com-

pression of the back of the head with similar effects on the ear occurs in some of the cases of the simple occipital flattening, without resulting in tympanic exostoses.

It seems that it is the forcible frontal compression which is mainly to blame. The stresses within the skull produced by the fronto-occipital forcing are certainly greater than those in simple occipital compression. The shape of the external auditory canal is certainly affected in many of these cases. But just how this could give rise to the exostoses is not clear, especially as such growths do not appear to develop earlier in the flat-heads than they do in other crania. Much evidently remains to be learned in these connections.

The simple fact that definitely emerges from our data is that the fronto-occipital head deformation in the newborn of a group is as a rule attended with an increased frequency of development of ear exostoses later in life in that group. The size, forms, and locations of the growths remain apparently unaffected. As to the cause for the increase in frequency, it could be conceived that where artificial head flattening was practiced for a long period of time and favored the development of ear exostoses, the tendency toward these became more and more "alive", and perhaps also the abnormalities became multiplied through direct heredity in families, thus increasing their frequency in the group, even in the undeformed heads. There is probably a kernel of truth in this, though for the present the idea must remain in the category of speculation.

MISCELLANEOUS CAUSES

As in other cases where the causation of a condition is obscure, so with ear exostoses, the students of the subject in the course of time have advanced about the whole gamut of theories that could well be made in this connection. Aside from those dealt with in the previous pages may be mentioned the following:

INBREEDING

Möller-Holst (1932) believes that the pathological ear exostoses, as well as the normal thickening of the tympanic bone such as found in the Eskimo, have arisen through inbreeding (see p. 56).

CONSTITUTIONAL DISEASES (OTHER THAN SYPHILIS AND ARTHRITIS)

Heiman (1890) regarded scrofula as favoring a development of ear exostoses, but only indirectly, through its favoring inflammatory conditions in the auditory canal. There are a few other weak references

to such a possible connection in the earlier literature. Alexander (1930, p. 456) believes some of the growths to "be connected with general constitutional diseases", but does not specify or go further into the subject.

INNERVATION

Toynbee's (1860) class II of ear exostoses "showed symptoms indicative of diseases in the cavities containing the expansion of the auditory nerve."

CONNECTION WITH EXOSTOSES OF INNER EAR, OR OF OTHER PARTS OF THE SKELETON

A connection of meatal exostoses with those of the inner ear was noted by Toynbee, Gruber, Schmaltz. Virchow (1889) saw that in two of his cases the skeleton showed also other exostoses, which suggested a possible connection. Krakauer (1891) was inclined to believe that there was a connection between meatal exostoses and multiple exostoses of the skull. Ostmann (1894) believed the ear exostoses to be due in part to "a tendency to excessive bone production, such as manifested through multiple exostoses."

OTOSCLEROSIS

Burton (1927) attempts to identify the process leading to ear exostoses with otosclerosis. Bezold (1895, p. 50) states that "sclerotic processes in the middle ear do not infrequently coexist with the exostoses."

MASTOID

Rafin and Rougier (q. by Sabroux, p. 22) cite a case of advanced obliteration of the auditory canal by exostoses, in which the mastoids were more developed than the average; Knapp (1898) looked upon some of the ear exostoses—because they are so often posterior—as probably due to primary affections of the mastoid.

MASTICATION

Burton (1927) raises a point which, curiously, has been neglected by other authors. This is the influence upon the meatus of the activity of the lower jaw. He believes "irritation to the aural canal due to mastication to be a contributory factor of aural exostosis." The excess of the growths in the male he attributes to the same factor. But Möller-Holst (1932, p. 102) says the idea of the effect of mastication cannot be sustained.

VESTIGIAL

Whitney (1895) believed "these exostoses must be considered as formed from remnants of fetal cartilage."

NO PATHOLOGY

For Le Double and Lebourg (1903), finally, who examined the ear exostoses in a series of American Indian skulls, the growths were "evidently not of pathological origin."

GENERAL DISCUSSION

Including the records presented in this work, there are few if any pathological conditions of the human skeleton that could command as vast an amount of material as that of ear exostoses, not only clinically, but also, and in much larger measure, racially. This amplexness of material enables the student to see the subject in a much more complete and satisfactory manner than has hitherto been possible. Let us survey briefly what the facts, as far as revealed, indicate.

UNITY OF COMPLEX

About the most important result of the studies is the realization that the subject of ear exostoses, notwithstanding its many variations, represents not a mixture of diverse conditions, but in substance a large unit, a special unit-complex, in the field of human derangements.

While there is a possibility that some of the smaller growths from the deep portion of the roof of the ear, and now and then perhaps an ossification in a polyp, or a hypertrophy following a serious injury, may be formations apart, the great bulk of exostoses in the external meatus constitutes a single human pathological complex-entity. Regardless of any secondary subdivisions of the growths, some of which may be useful, the overwhelming testimony of the evidence is that there is involved but one process—a realization that should facilitate the eventual comprehension of its causes.

RESTRICTION TO MAN

According to all indications the affliction of ear exostoses is purely human—no such growth has ever been observed in the anthropoid apes, any other primates, or any other living forms provided with an external bony meatus. It is apparently one of the penalties of the human estate.

GENERALIZATION IN MAN

Aside from the fact that ear exostoses are limited to the human family, the next major realization is that of the generalization of the tendency to these growths over many if not all the human races. So far the formations have been found in all branches of the human family from which large cranial collections are available. They have not yet been reported in a Negro skull, in that of a Chinese, nor in those of a few other groups, but the numbers of specimens in no one of these cases has been adequate. When sufficient material is available, there are indications that the growths will be found absent in no human aggregate.

VARIED FREQUENCY

Though a tendency toward ear exostoses is probably a pan-human condition, the incidence of the growths varies greatly in different races and groups, and even in different localities. This may be due to differences in the tendency, or to the quantity or effectiveness in a given group or locality of the exciting causes; or both these factors together. The most afflicted, in the order named, are some of the American Indians, the Polynesians, and probably some groups of the Whites; the least affected are the African Negro, possibly the Chinese, and the Eskimo. There is no racial concordance in this and no plain significance, except perhaps as to the African Negro, who in general represents one of the least advanced groups, so far as the brain and head are concerned.

The very marked difference in the incidence of ear exostoses among the American Indians and probably also among the Whites indicates that in some groups and localities the agencies that master the normal status have been further weakened, or that conditions favoring the production of the growths are more potent or common. The term "racial inclination" must be understood in this manner.

GENERAL SIMILARITY

A survey of large and varied series of osteological material reveals: 1, that in general, ear exostoses display, regardless of race or place, essential similarity; and 2, that there is often distinguishable more or less of group or place peculiarities. Thus in one tribe or locality large growth may be frequent; in another, equally involved, they may be scarce. There are also group differences in the exostoses according to their location, in their predominant forms, and in other respects.

It may be said that each more important racial or geographical unit of people will present its own characteristic picture of ear exostoses, though the fundamentals remain much the same. The differences may be of but little import, but now and then are rather striking. All characteristic group differences in these respects must necessarily be connected, on one hand, with the neuro-vascular background of the growths, and on the other hand, with the status of the normal bony structures involved.

NATURE OF THE PROCESS

The syndrome of ear exostosis cannot be regarded as a "disease". Although secondarily it may become pathological and incidentally even fatal, yet in general the outgrowths are quite innocuous, and mostly not even known of, until they grow so large as to become an obstruction or lead to the development of inflammatory conditions. There seems to be no possibility that any bacterial agency is involved in their production, and they are in no sense malignant.

If we exclude all microorganisms and all malignancy, then there remain, it would seem, but two classes of possible causes, the first comprising such "poisons" in the lymph and blood as would be capable of arousing bone tissue to localized bone overgrowths and outgrowths, and the other consisting of derangements of the trophic nerve control of the parts concerned.

"Poisonous", i. e., harmful, substances circulating in the body liquids are certainly present in many individuals, particularly in the later years of life, when the liver, kidneys, and other organs no longer suffice for their neutralization and elimination, and particularly in various pathological conditions and diseases during which poisonous products come into the blood and lymph from pathogenic bacteria.

Granted a "predisposition" to outgrowths in the tympanic bone and the squamous part of the bony meatus, some such poisons as those just mentioned could readily be conceived as the initiators of the exostoses. What many otologists suspected in connection with syphilis, gout, and other constitutional troubles as causes of ear exostoses, was not really these conditions themselves as much as their poisonous products. Mineral as well as organic poisons, such as lead, mercury, alcohol, etc., may also enter the system in other ways. That some such substances may be capable of inciting abnormal osteogenesis where the ground for this is favorable may provisionally be admitted. That any special one or ones can excite the bony growths in the ears, would need an unequivocal demonstration through experiment. That any and all are generally powerless to produce such bony

outgrowths is shown by the very many whose blood and lymph are known to carry such poisons for years, without any effect on the ears. Moreover, such poisons, when present, reach all parts of the osscous system, yet produce nothing resembling the hyperostoses and exostoses of the ear. The case for the internal poisons therefore is not a strong one.

There remains the factor termed conveniently "predisposition". This predisposition must be something limited to the external meatus, for barring rare exceptions, no such bony growths appear elsewhere on the skeleton. But what is the "predisposition"? It can hardly be anything in the mechanics or the structure of the bone—if it were, there would probably be other examples of such a condition and its results elsewhere. There is no evidence that the tympanic bone is unfinished or proliferating in spots. Yet the fault, essentially, can only be with the meatus, or with what controls its structure and being.

If the condition of ear exostoses is, as it appears to be, of the nature of an osteogenic derangement, then it would be reasonable to regard it as the result of a disturbed or weakened trophic control of the parts affected. The development of every part of the body is under a very definite and heredity-bound neuro-vascular control. In the apes and lower forms such control of the external bony meatus is evidently thoroughly established and fully adequate. In man this control appears to be disturbed and no longer wholly sufficient; and with, or even without, sufficient exciting causes abnormal bony growths in the ears are the result. Such a disturbance or weakening could possibly be an accompaniment of the unprecedentedly great and rapid evolution of the human head. Such radical change must have disturbed pre-existing trophic controls, and a full reaccommodation has not yet been reached, at least not in most of the human groups.

Another, though related, way would be to look upon the deranged neuro-vascular control of the external aural canal as an expression of degeneration. Degeneration may be defined as a generalized, progressive groupal insufficiency of the organism to sustain the developmental level reached by an organ. Such insufficiency can again only be based on inadequacy of the trophic nerve centers. It differs diametrically from the inadequacy of accommodation in that it tends to augment with time, whereas the latter tends to diminish, unless the evolutionary changes that caused it keep on advancing.

Can the osteogenic disturbance which results in ear exostoses be regarded as a process referable to a pan-human greater or lesser degenerative condition of the tympanic bone or the external meatus?

Normal, that is, primarily devolutionary and not pathological, organic degeneration follows, as a rule, the reduced use of an organ. Examples of it may be observed in human teeth, appendix, the fifth toe, and other parts that in the course of time have become less active and important than formerly. The changes comprise diminution in size, loss of regularity of shape, diminished vital resistance, and a tendency toward elimination of the part. Has the human ear, or at least the external auditory canal, become less useful and necessary to man than it has been in the lower primates and other animals? The changes here, too, aside from the outgrowths, include diminutions in size (lumen), distortions in shape, and occasionally a more or less complete elimination.¹²

Is the underlying process of ear exostoses, then, a degeneration, or merely a disturbed accommodation—a slowly regressive, or but a somewhat inadequate central control of the neuro-vascular system of the parts involved, with the bony abnormalities as secondary manifestations? It may be best not to attempt any answer to this question before the rest of the available facts on the subject can be considered.

ANTIQUITY

It is not known, and will probably never be determined, when in the existence of man the abnormality of ear exostoses made its first appearance. No case of the growths has as yet been reported in early (geologically ancient) man, and none even from the Neolithic period, though that does not necessarily mean that they were absent.

The oldest skulls in which ear exostoses have been encountered so far are the seven skulls with such outgrowths found by me in the Egyptians of the beginnings of the XII Dynasty, or close to 4,000 years ago. These specimens came from the deep rock-tombs at Lisht and belonged to the higher classes of the people.

The four next oldest specimens with ear exostoses are the skull of an Egyptian (date?) reported by Ostmann (1894), that of an early Christian Nubian Egyptian mentioned by Wood Jones (1910), and the two Egyptian crania found by me in the collection from the Kharga Oasis. Possibly quite as old, or nearly so, are some of the prehistoric American Indian skulls with the growths. Most of the American specimens of such a nature are pre-Columbian; others are post-Columbian but of a period before there was any appreciable influence by the white man. The Hawaiian and New Zealand crania of our

¹² See the writer's "Seven prehistoric American skulls with complete absence of the external auditory meatus." *Amer. Journ. Phys. Anthropol.*, vol. 17, no. 3, 1933.

series are probably all pre-White. The European and American Whites recorded in this connection are all recent, as are also the Chinese, the African Negro, and the Melanesians.

Thus the time in which ear exostoses are known to have existed extends back about 2,000 years before the Christian era. But the frequency of the condition in the prehistoric American skulls is a sure index that the beginnings of the affection are much older—which is about all that can safely be said on the subject for the present.

An even more important question than that of antiquity is that of progression. Have ear exostoses, or have they not, been becoming, however slowly, more frequent? A reliable answer to this query would go far toward the solution of the problem as to whether or not the process is of a degenerative nature; but such an answer is not yet possible.

AGE

Ear exostoses, the data have shown, are encountered from childhood to old age, but the maximum frequency of their development ranges from adolescence to middle age. With no known exception, they begin to form only after the parts they involve have reached full development, and this development, as seen in the affected skulls, barring an occasional diminution in the lumen of the meatus has as a rule been quite normal. This regular normalcy of structure and the delayed manifestation of the growths speak against the basic cause of the abnormalities being of a degenerative nature.

SEX

Ear exostoses are decidedly more frequent in males than they are in females. This phenomenon, moreover, is common to all races, all human subdivisions. What is the meaning of this marked and generalized sex difference?

It would be easy to draw heredity into the picture and speculate on its sex dominance and other effects, especially since there is conclusive evidence that hereditary transmission often does have a part in the spread of these growths. But this method of thinking, with our present knowledge, would lead only to a maze of uncertainties.

Yet heredity in the wider sense is involved in the problem. The pan-human extension of that something in the system that predisposes to ear exostoses can only be sustained as time goes on through heredity; and this generalized deeper heredity apparently finds its effectiveness everywhere enhanced in the males. The females on the whole

are more infantile, less differentiated, organically more conservative; the males more advanced morphologically, less set, more variable. For these reasons the effects of any evolutionary belatedness in accommodation of parts could confidently be expected to show more in the males. This seems likely to be the explanation of the sex difference in the incidence of the abnormal conditions under consideration. There may be assumed, in general, a somewhat greater control of the normal conditions of the tympanic bone and the external meatus as a whole in the females.

An interesting fact in this connection is that according to prolonged observations by otologists, ear troubles and diseases in general are more common in the males than in the females. There is however one notable exception and that is atresia or congenital defect of the external meatus; this serious agenetic defect is considerably more common in the females, particularly in certain human races.¹³

SOCIAL STATUS

A number of authors, it has been seen, have voiced the opinion that, among the Whites at least, ear exostoses occur predominantly in the well-to-do classes. If this is so—and there is no voice to the contrary—the question would arise, what is there in the wealthier class that favors the abnormalities?

Here is a promising line of inquiry, but the foundations for it need to be strengthened. All that may be said now is that being “well-to-do” means, on one hand, usually more leisure and what this carries with it, on the other hand, a greater preservation of the weaker—which, together, may conceivably lead in time to some weakenings or derangements of the basic neuro-vascular controls of different parts of the organism.

SIDE

In materially over one-half of the cases of ear exostoses, on the average, the affliction is bilateral and frequently more or less symmetrical. This points strongly to the conclusion that the basic cause of the growths lies centrally in the nervous system. That not all cases are bilateral is due probably to developmental differences of the bones of the meatus in the two ears. It is well known that no two bones are exactly equal, macroscopically and microscopically, on the two sides.

In the unilateral cases, there is perceptible a general tendency for the exostoses to be more frequent in the left ear. In clinical experience

¹³ See the writer's report on the condition, *Amer. Journ. Phys. Anthrop.*, vol. 17, no. 3, 1933.

with ear troubles as a whole, according to extensive statistics, "the left ear becomes diseased more often than the right", in the proportion of about 5 to 4 (Bürkner, 1883, p. 103). The significance of this eludes us for the present.⁴⁴ In this connection it must not be forgotten that not a few one-side cases tend with time to become bilateral.

CONSTITUTIONAL DISEASES, LOCAL PATHOLOGICAL CONDITIONS, TRAUMATISMS, IRRITATIONS

None of these conditions is associated with ear exostoses, except on more or less infrequent occasions. Examinations of osseous materials show that in cases where gout, arthritis, or syphilis have run unchecked to their limits, there are generally no ear exostoses. These diseases, as well as most of the local irritative conditions affecting the external meatus, can occupy no more than a secondary place in the etiology of the abnormal growths. They can probably all be accepted as occasional exciting, but not as the original, causes, except perhaps in the case of certain traumatismes of the bones composing the meatus. The real, the predisposing, cause is different: it is deeper and is generalized over most if not all human groups.

THE GENERAL CAUSE

On the basis of the extensive materials reported in this work and after all preceding considerations of the etiology of ear exostoses, both by other authors and the writer, it seems possible now to approach certain generalizations that hitherto were impossible.

Let us fix our minds once more on the essential facts of the subject under consideration. These are: an apparently complete absence of the process in animals, including the primates; a generalized predisposition to it in recent and present man; the absence or rarity of developmental defects; the predominance of the manifestations from the post-pubertal to presenile time of life; the excess of involvement in the males; the marked tendency of the growths to bilaterality and even symmetry; and their ascertained occasional direct inheritability.

All this, as seen in previous discussion, points to the conclusions that ear exostoses constitute a special complex or entity belonging not in the field of diseases but in that of abnormalities, and that they must be directly connected with neuro-vascular derangements, which

⁴⁴ Here again, curiously, the serious defect of ear atresia forms an exception, being considerably more common, especially in the American Indian, on the right side.

may be excited locally by different agencies, but which have their seat in the trophic nervous centers that control the bony structures of the external auditory canal.

There remains to be considered the general cause of the neurocentric derangement and insufficiency. It was seen that two possible agencies suggested themselves in this connection. One of these is degeneracy, the other incomplete or disturbed evolutionary adjustment.

The disgenic character of the ear growths would seem to point to a degenerative cause affecting the aural apparatus—they tend to lead to loss of hearing, local troubles, and indirectly, in rare cases, even to death. Another item that might conceivably support the view of a degenerative cause of ear exostoses is the fact, long known in otology (see Bürkner, 1883, p. 103), that “the disposition to ear troubles (in general) rises from birth to the 40th year and thence diminishes with age”, which might be viewed as evidence of a degenerative condition regarding the ear and which bears a close relation to the age incidence of the ear growths. The much greater prevalence of ear exostoses in the males than in the females, in all the human groups known to show the abnormalities, might be viewed as a further support for the idea of a basic degenerative cause, for the males as the less stable or conservative sex might be expected to make just such a showing.

But there are serious difficulties in the way of the hypothesis of degeneration. The most potent are: There is no evidence that the human ear is falling into disuse and hence would be starting on the way to degeneration and restriction or elimination; ear exostoses affect not the organ of hearing proper, but the relatively much less important bony passage that leads to the hearing apparatus itself; the exostoses as a rule are not accompanied by congenital defects in the parts involved; they are associated with few and followed by very few, if any, changes that could possibly be looked upon as of degenerative nature of either the ear as a whole or of the meatus; once successfully removed by the surgeon they generally leave a sound ear with normal function and but rarely recur; the process of the production of these growths is in substance an excess of production rather than any expression of structural weakness or defective vitality such as usually result from degenerative causes; and although they may be transmitted to the progeny, the ear exostoses recur as such and not, so far as known, in the form of any congenital defects of the meatus.

It appears from the above that there is more that speaks against than for a degenerative cause in the background of ear exostoses.

There remains to be considered the central neurotrophic maladjustment. It is plain that all structures in the body must be formed and

maintained under the direction of special nervous centers, which as yet are known but very imperfectly but the existence and regulatory function of which are necessary, and which are called the trophic centers. They are highly important parts of the central government of each individual organism. They act upon the blood and lymph supply and doubtless also in other effective ways. The tissues themselves can have no architectonic individuality; they are but so much living material from which, under the strongly hereditarily fixed specific influence of the nervous centers, there are built different structures. Nor does the function of these centers end with the finish of the construction, just as the function of the government of a city cannot end with the completion of its streets and houses. There is a perpetual guardianship under the continued power of heredity, and there are perpetual changes, for heredity is not fully discharged or satisfied with the completion of the structures—it is a lifetime factor. And here, I feel, lies the clue to the problem that confronts us in our study of ear exostoses.

It may safely be regarded as axiomatic that as long as both the heredity and the nervous apparatus that subserves it in connection with any given part of the organism are normal, that part will, unless in some way injured, remain normal. If in the absence of a chemical, mechanical, or bacterial injury a part behaves abnormally, it is an unquestionable proof that at that point and to that extent there is either a weakening or derangement of the hereditary control, or of its proper transmission. The something we call heredity must not be conceived as any special power acting within and upon an organism—it can in the end consist only of a specific organization within and between the molecules of the cells of the nervous centers. Such organization is as a rule deeply fixed and not readily influenced. It may however be affected by deep-acting causes. Just what such causes are and how they may act, except in case of destructive bacterial or other poisons, is still but little known.

What from the above discussion can help us toward an understanding of the basic cause of ear exostoses? Can it be a weakened or temporarily disturbed heredity, or does the cause lie in a faulty or temporarily disturbed mechanism of nervous transmission of the hereditary control?

Both the above conditions are possible, but the wide prevalence of ear exostoses in the human family, and their manifestations as to age, sex, and side, seem to speak against derangements of nerve transmission.

This leaves as the most probable basic cause of ear exostoses a weakening or derangement of the normal hereditary control of the tympanic bone and parts adjacent. With this conclusion we must rest for the present, for while it was possible to proceed thus far by the use of logic, a further delving into the subject, until there have accumulated additional reliable data, would entail pure speculation.

Only one thought, already touched upon, may here be permissible, but that must not be taken for an assertion. It concerns man's astoundingly rapid evolution and changes—geologically and morphologically. Within some 500,000 years man's progress, especially as concerns his brain and head, has far outstripped that of all the rest of creation. This rapid progress and differentiation, with a spread to all regions and exposure to a multitude of new factors, has prevented in many respects a full adjustment of all parts, a full harmonization and stability in all regions. There is a possibility that the central trophic control of the external meatal region, in the greatly enlarged, altered and still altering skull, has not regained the full life-long adequacy that it possessed before. This would mark the abnormality under consideration as an incidental condition, one that might disappear in the natural course of events, if further skull changes affecting the part stopped and if direct inheritance of the abnormality did not meanwhile become rooted. Should this conception prove to be true, then the process of ear exostoses could be defined as that of irregular outgrowths of bone in the external bony auditory canal and principally from its tympanic part, due primarily to evolutionarily-weakened normal neuro-vascular control of the parts.

One other item demands a brief consideration in these connections. It is that of a possible disturbing, and hence causative, influence of the sex hormones. As seen, ear exostoses develop most frequently during the period of major sexual activity. Also they are more common in the male, in whom the sex activity is more intense. This attractive "clue", however, proves disappointing. Perhaps no race, particularly as regards the males, is more active sexually than the Negro—yet ear exostoses are very rare if not absent. There are so many such incongruities, racial and individual, that this promising lead must be abandoned.

SUMMARY

Ear exostoses are neither a constitutional, nor infectious, nor malignant disease. They do not even properly deserve the name of disease, being but secondarily pathological and that mainly through obstruction or pressure. They are abnormalities rather than a disease.

Ear exostoses are localized hyperplasias, or outgrowths, from essentially the tympanic part, but occasionally also from the squamous portion, of the external bony meatus.

They arise generally from what were the free upper ends of the tympanic ring. Their development belongs chiefly to the later adolescent period and the earlier half of the adult period.

A "predisposition" to ear exostoses is now probably universal in man, but in some races or groups the formation of the abnormalities, owing perhaps to direct hereditary effects, is much more frequent than in others.

Males are considerably more subject to the growths than females, the well-to-do (in Whites at least) more than the poor. The affection is most frequently bilateral, and where one-sided, it occurs somewhat more commonly in the left than in the right ear.

Structurally, the growths range from cancellous to compact, without any definite segregation. Though macroscopically the bone is often more or less aberrant, its elements are normal and remain viable. There is never any breaking down or necrosis, nor a complete calcification.

The causes are systemic or "predisposing", and exciting. The paramount systemic cause appears to be a deranged neuro-vascular control of the parts involved, chiefly the tympanic bone, during what corresponds to the sexually more active part of life; but on critical consideration it becomes apparent that no connection of the exostoses with sex activity can be ascertained.

What causes the peculiar time-limited neuro-vascular derangement that predisposes or leads to ear exostoses cannot yet be definitely established, but it appears to be something in the hereditary endowment of the trophic nervous centers that control the normal status of the external bony meatus. A deranged accommodation of evolutionary nature suggests itself, rather than degeneracy, as a plausible explanation.

The exciting cause of ear exostoses, where the predisposition to these exists, may be anything mechanical or chemical that produces prolonged irritation, with consequent hyperaemia to inflammation, of any part of the bony meatus.

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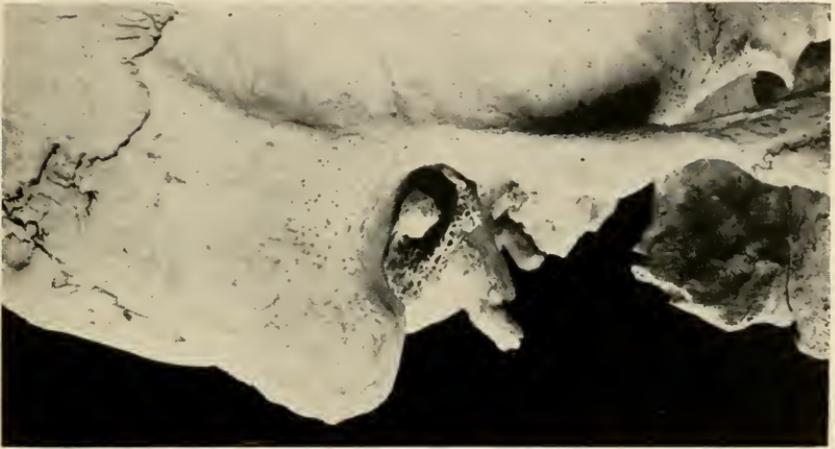
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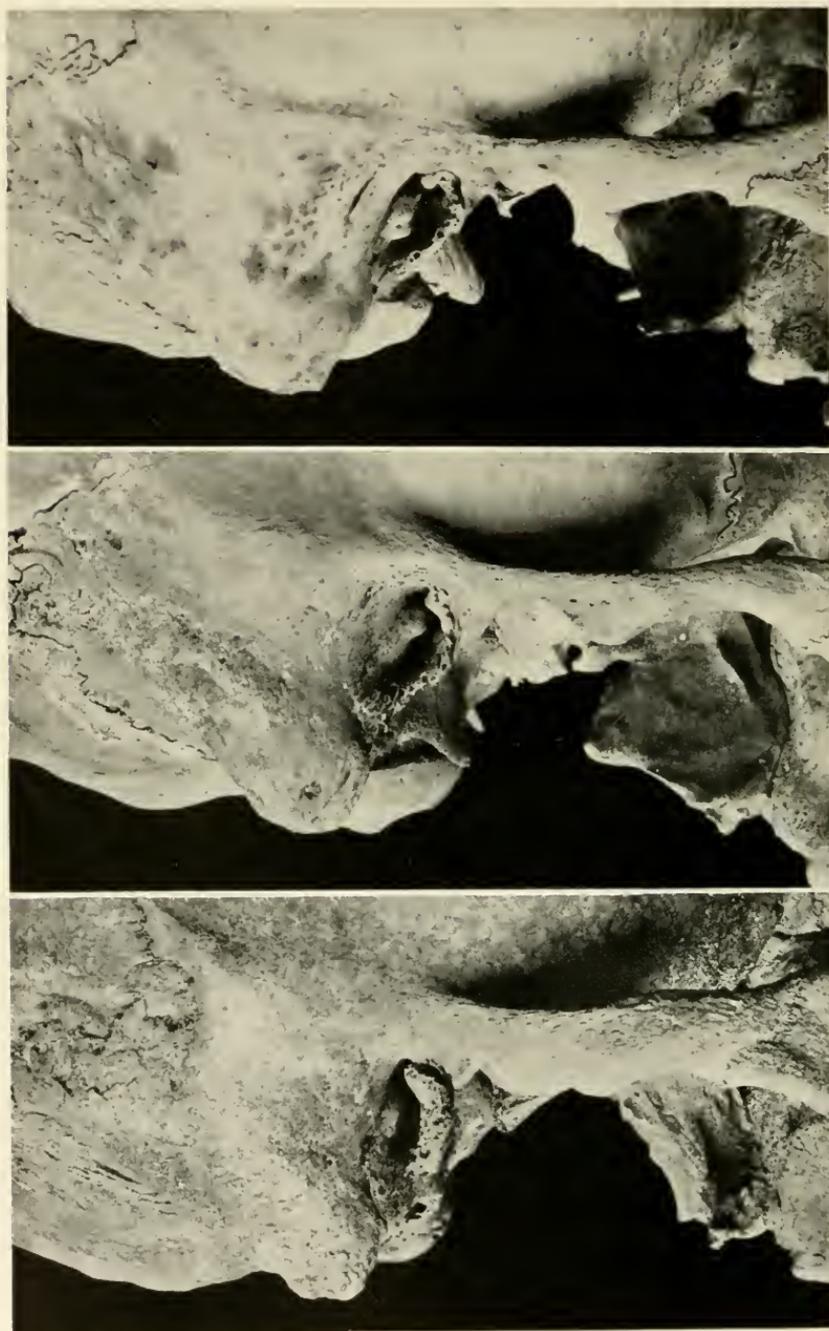
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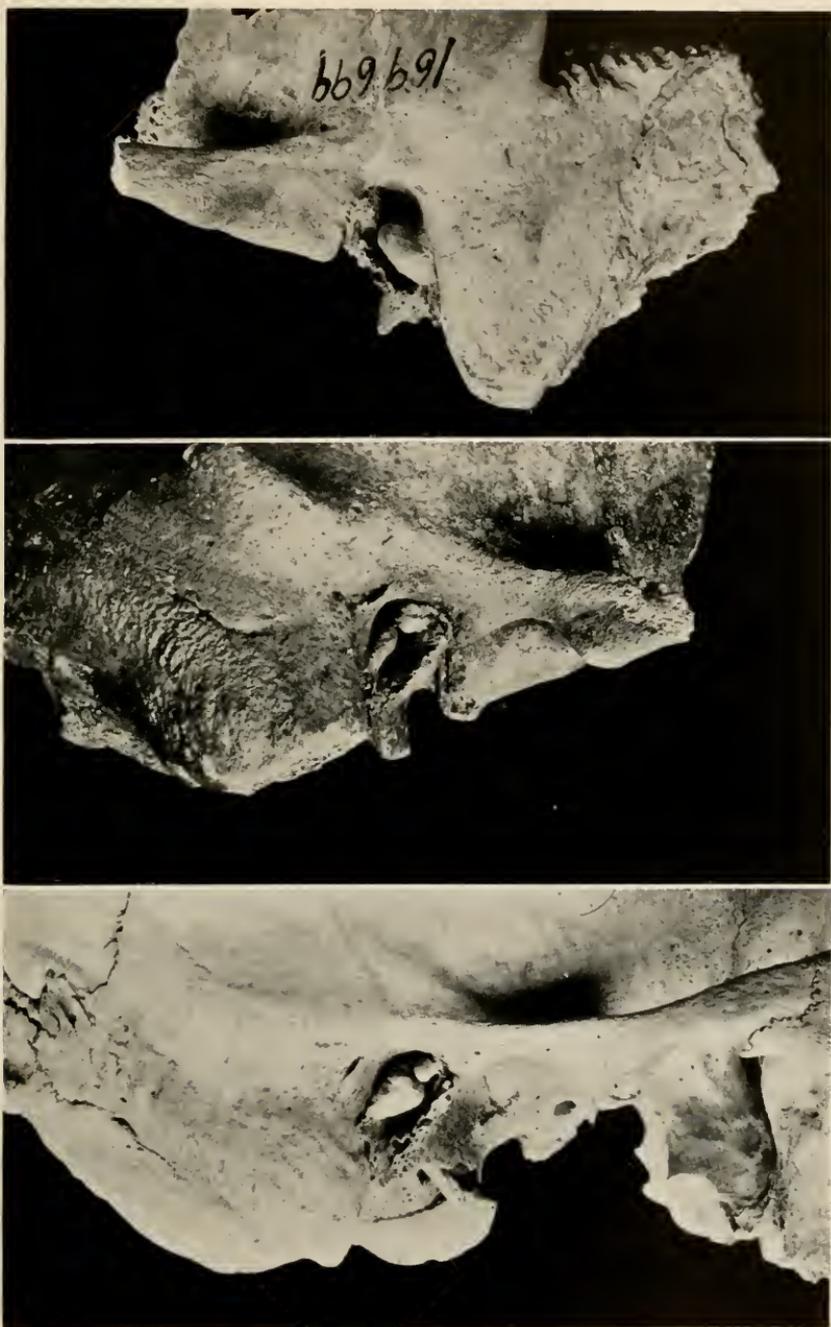
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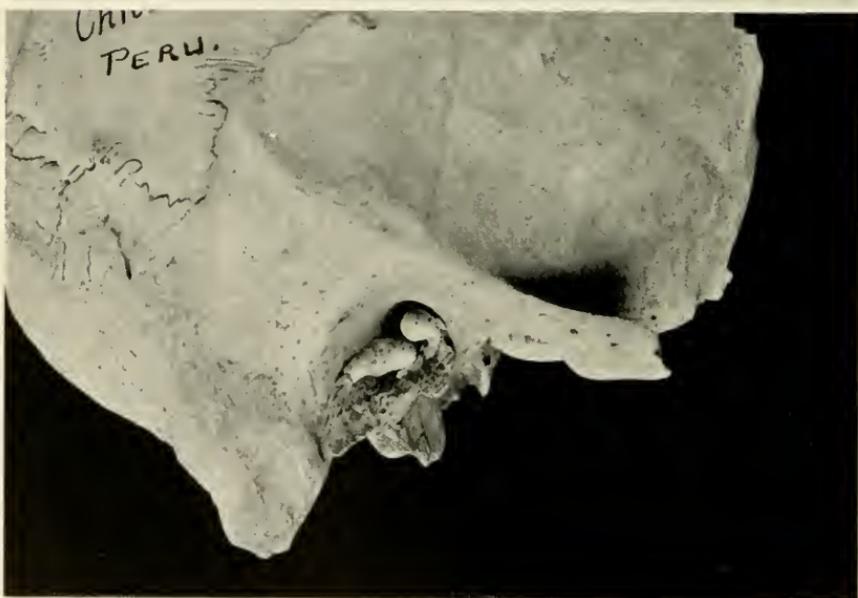
THREE PRE-COLUMBIAN SKULLS FROM PERU, EACH WITH A LARGE POSTERIOR EAR EXOSTOSIS, WITH VARIOUS BASE ATTACHMENTS



THREE PRE-COLUMBIAN SKULLS FROM PERU, WITH IRREGULAR POSTERIOR AND ANTERIOR (OR A-S) EAR EXOSTOSES



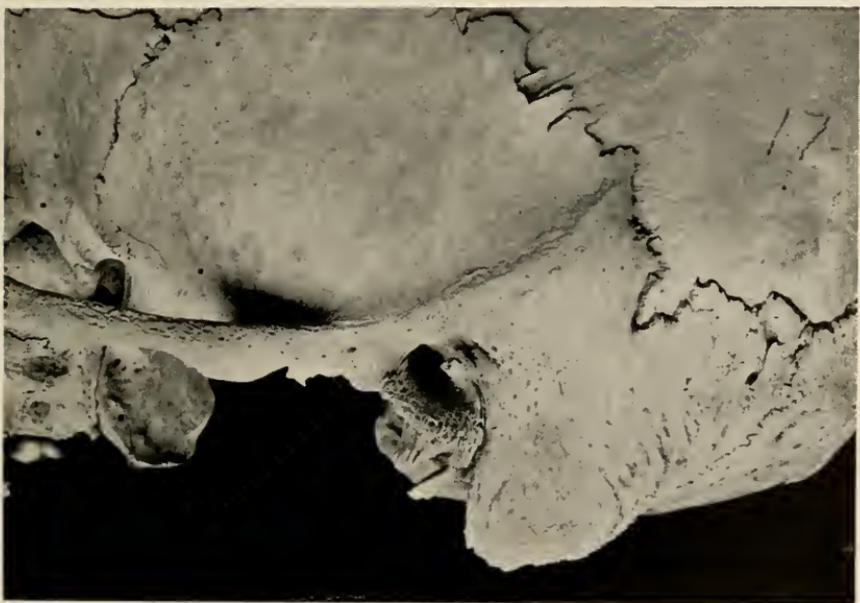
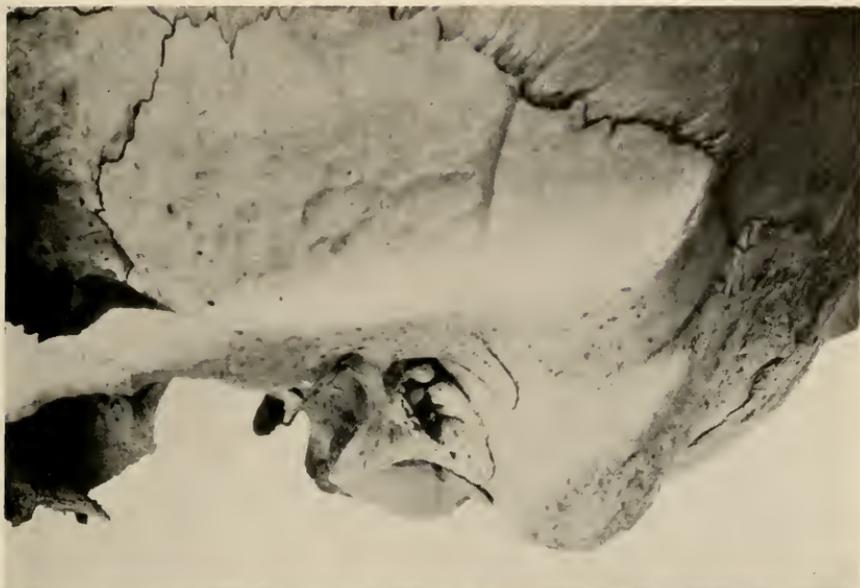
THREE PROBABLY PRE-COLUMBIAN INDIAN SKULLS, UPPER FROM VIRGINIA, LOWER TWO PERU, WITH DOUBLE (POSTERIOR AND ANTERIOR) EAR EXOSTOSES, OF VARIOUS SHAPES



TWO PREHISTORIC SKULLS FROM PERU WITH EAR EXOSTOSES

UPPER: A VERY LARGE POSTERIOR (OR P-I) WITH A SMALL ANTERO-SUPERIOR GROWTH

LOWER: TWO LARGE GROWTHS, POSTERIOR AND ANTERIOR, WITH SECONDARY SMALL GROWTHS ANTERIORLY



UPPER: PRE-COLUMBIAN INDIAN SKULL, PERU, WITH TRIPLE EAR EXOSTOSIS

LOWER: THE SAME, WITH A 5 MM-HIGH EXOSTOSIS OUTSIDE ABOVE THE MEATUS, OF SEPARATE ORIGIN AND SIGNIFICANCE. SMALL INTRAMEATAL EXOSTOSIS IN EACH EAR

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