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FOR THE ADVANCEMENT OF MEDICINE.

LECTURE X.

A CLINICAL STUDY OF THE SKULL.

BY

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X. "A Clinical Study of the Skull." By Dr. HARRISON ALLEN. Delivered May 29, 1889. Published March, 1890. 8vo., 79 pp. with 8 cuts.

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SMITHSONIAN INSTITUTION,

WASHINGTON, *March*, 1890.

INTRODUCTION.

It would be difficult to mention a single phase of the manifold expressions that belong to disease in which the study of the face and brain cannot enter; but to the laryngologist and to the neurologist many portions of the head must be of especial interest. The laryngologist can examine the mouth, nose, and the pharynx; the neurologist the surfaces of the crown, which afford him guides to the peculiarities of the interior of the skull. Since much which pertains to both of these branches of medicine is of comparatively recent growth, a study of the osteology of the head cannot fail at the present time to be useful.

An accurate impression of the superficial characters of the skull can be received from examination of the living subject. Reliance must be made upon these characters in fixing the relations of the soft parts; hence the ranges of variation in these characters should be known, and as full a knowledge as possible be obtained by study of the cranium. In the paper herewith submitted an attempt is made to treat of these relations and ranges of variation. The author's interest, at first, was confined to the diseased conditions of the facial region and of the vault of the pharynx, but the interest gradually widened and soon embraced the normal anatomy of the entire head.

The method recommended by him is as follows: First, to study carefully a character as detected in the living subject, then to examine all crania available and endeavor to ascertain in what guise the same structure may re-appear, and subsequently to formulate such descriptions as can be deduced from the data; second, to bring together the material gleaned while examining crania, which appears to be of interest, to illustrate the nutritive processes at work

in forming or maintaining the different parts of the skull each to the others.

Many of the characters obtained in this manner are of necessity minute; so, indeed, are the distinctions upon which the anthropologist relies. The obliquity of the palpebral fissure, the color of the iris, the distribution of the hair, or the characters furnished by the individual hair may be mentioned in this connection.

The significance which can be attached to the study of variation either in the study of race grade, or in the large question of evolution of organic forms, is of course conceded. The last named cannot be determined until extended series of data have been collected. If, according to Engel (*Untersuchungen über Schädelformen*, p. 121), uncultivated primitive races exhibit few variations in the composition of the skull as compared with the more advanced, we may be prepared to accept Retzius' dictum that individual differences become greater in proportion to the higher intellectual development of a nation. Preservation of such facts as the disposition of the minute plates and processes of the interior of the nasal chambers and of the base of the skull, the description of suture changes, of the depressions made by small veins, and of the minor deviations in size of paired structures may have an outcome as interesting as those derived by discovery of structures which exist on a larger scale.

The lack of fixation of characters should not of necessity diminish their value. Beginnings of characters are always facile and indeterminate. This is nature's process.

The effects of diseased action, although their manifestations be apparently insignificant, are also worthy of study from the standpoint of the biologist as well as that of the pathologist. When produced from other than traumatic causes, these effects have distinct value. They may indicate modifications of the processes of life, which are of the same kind as those furnished by the anatomy of normal parts.

The extent to which variation in normal anatomy is an exciting cause of disease is difficult to determine. All things remaining the same, it may be said that the most variable parts are seen in the regions which are in extremes of specialization, as in the nasal chambers of man, and that these chambers are degenerate as compared to many mammals where the range of variation is small. The pre-disposition of nasal disease in man cannot be rationally dissociated from the proneness of the parts which enter into the composition of the nose to vary. If this statement can be depended upon, the publication of all details of structure in the nasal chamber becomes essential.

This essay is a contribution to the morphological study of diseased action. The writer trusts that increasing interest may be awakened in the proposition that medicine for the most part is a science based on biology. The study of biology should not be the preparatory work of the trio only, but should be the subject of unceasing assiduity in every phase of medical research. The study of anatomical variation in the human frame is a phase of biology, and it is held in this connection to be a subject as important as any other which may claim the attention of the student of etiology of disease.

The materials upon which the essay is based were found in the collections of the Academy of Natural Sciences of Philadelphia and of the College of Physicians of Philadelphia. The letter C, in absence of other signs, will indicate that a specimen so named is to be found in the College of Physicians (Hyrtl Collection); the remainder are in the Academy. (The last named are often indicated by the letters A. N. S.)

The determination of percentage of frequency of any anatomical peculiarities has not been attempted. The writer has been content to give the numbers and nationalities of the specimens referred to.

The entire number of specimens of crania in the Academy is 1,750, and in the College of Physicians 156.

The following exhibit the arrangement of the subject-matter of the essay :

The malar bone.

The lower jaw.

The norma-basilaris.

The basi-cranial angle.

The posterula.

The nasal chambers.

The vertex—its sutures, eminences, depressions, general shape, etc.

Remarks on the sutures other than those of the vertex.

The foramina.

The grooves caused by blood vessels.

The cranial ridges, processes, etc.

LECTURE X.

Delivered May 29, 1889.

A CLINICAL STUDY OF THE SKULL.

BY HARRISON ALLEN, M. D.

THE MALAR BONE AND THE ZYGOMATIC ARCH.

The malar bone is one of the most conspicuous of the superficial characters of the face. At the outer and lower margin of the orbit the external surface, as well as the posterior and zygomatic borders, can be separately distinguished. The bone as it enters into the composition of the lower border of the orbit is discussed elsewhere.

The consideration of the external surface will be undertaken at this place. The chief points to consider are, first, its inequality, and, second, its obliquity.

1st. The inequality of the surface is simple in character. It is comprised in the lower part, this being at times raised so as to form a rounded projected eminence. It is less pronounced in the negro than in the Caucasian, and is entirely absent in the child. When the cranium is examined the inequality is seen to answer to distinct differences in texture of the superficies—differences varying in individuals, but never entirely absent.

Throughout the series of examinations made with this object in view—*viz.*, of determining the variations in the upper and lower part of the bone—it was found that from simple differences in superficial texture it was an easy transition to the detection of differences in the deeper texture of the two parts; that thence to attempts at the for-

mation of suture-lines which extended along the boundaries of the parts to a groove along the entire length of the bone on the posterior surface; and that finally the observer was led to the study of specimens which showed the separation of the bone by a perfect, open suture. The details of the description adopted will appear in the reverse order of the appearances as given above.

The existence of a suture in the malar bone has been occasionally noted in the skulls of various races. J. B. Davis,¹ in 1872, contributed a short note on the subject, of which the following is an epitome: The author refers to the presence of the suture in nine skulls of Asiatics and negroes. The suture is often met with in the skulls of the Dyaks of Borneo. It is rarely met with in modern skulls, but more frequently in the skulls of ancient Europe. Prof. Wenzel Gruber² subsequently enumerated twenty-one examples and gave the literature of the subject.

The collection of the Academy of Natural Sciences contains ten undescribed examples of a distinct bone occupying the lower part of the malar, or lying at the malo-squamosal suture. Seven skulls were found which exhibited these peculiarities. No. 1255, Ostrogoth, showed a separate malar bone on one side. No. 1442, Peruvian, exhibited a separate malar ossicle at the malo-zygomatic suture, on both right and left side of the skull. No. 1690, Peruvian, a distinct transverse suture crossed the malar bone of the right side. No. 83 (Atacames), Peruvian, a transverse suture was seen on the left side; a less distinct one on the right side. No. 1305, Peruvian, a small ossicle was seen at the malo-zygomatic suture on both sides of the skull. No. 753, Seminole, and 540, Pawnee, a similar ossicle was noted on the right side. No. 460, Malay, exhibited an imperfect division of one of the malar bones into two parts. This specimen is not enumerated with the foregoing. In the United

¹ Journal of Anthropological Institute, vol. 1, p. clvi.

² Das Zweigetheilte Joehbeine. Vienna, 1873.

States Army Museum (No. 309, Chickasaw) the malar bone was double on both sides.¹

Four examples were seen in which a suture began at the malo-zygomatic suture, and, advancing forward, was lost a short distance from the posterior end of the bone. These were No. 1424, Peru, on both right and left sides; No. 1506, *ibid*, on the right side, and No. 1434, *ibid*, on both right and left sides.

In a single example, No. 1369, *ibid*, a skull of an old female, a foramen perforated the right malar bone a little in advance of the malo-zygomatic suture and appeared to be in the line of the transverse suture, though no trace of the line could be discerned either in front or back of the opening.

Thus twelve examples can be cited, all of American origin, which exhibit transverse malar sutures more or less complete as seen from both the inner and outer surface of the bone, and two in which the bone was double.

But when the inner side of the malar bone is examined a much larger number of skulls exhibit the transverse suture. No attempt was made to ascertain the entire number of examples last named. While a search was instituted, with another object in view, the inner surface of the malar bone was at the same time examined, and out of the entire number examined, it was detected in fifty-one crania. In eight of these it existed on both right and left sides.

The distribution of selected examples among the races was as follows: North American Indians, one each of Chinook,² Lenape,³ Menominee,⁴ Naas,⁵ Shawnee,⁶ California Indians,⁷ one unnamed;⁸ Peruvians, ten;⁹ Anglo-American, one;¹⁰ Mexicans, three;¹¹ negro, one;¹² Egyptians, five;¹³ Circassians,¹⁴ Roman,¹⁵ Arabian,¹⁶ Nubian,¹⁷ one each.

¹ I have since seen an additional example in a skull (No. 53) in the anatomical collection of the University of Pennsylvania.

² 462. ³ 40. ⁴ 44. ⁵ 213. ⁶ 1210. ⁷ 1683. ⁸ 204.

⁹ Nos. 567, 1704, 1298, 1303, 1025, 941, 447, 11, 891, 1426. ¹⁰ No. 17.

¹¹ 1005, 1004, 1515. ¹² 548. ¹³ 997, 778, 799, 814, 768.

¹⁴ No. 762. ¹⁵ No. 248. ¹⁶ No. 776. ¹⁷ No. 829.

In all of these specimens a delicate line could be traced forward from the posterior to the antero-inferior portion of the bone. It was of precisely the same character in the examples in which the outer suture was distinct.

The inner surface of the malar bone will not infrequently exhibit a concavity below the line of the suture. This concavity is distinct even in specimens in which the suture is nowhere evident. Such a peculiarity is well seen in a Peruvian skull (No. 1407). A similar disposition was noticed in the skull of the Hyrtl collection (No. 92).

The small ossicles named above as occurring at the malo-zygomatic suture tend to break up the uniform smooth surface of the inner aspect of the malar bone—a disposition which may exist even in the absence of a separate ossicle. The squamosal element may be long and irregular and extend forward, along the line occasionally taken by the suture, nearly to the maxilla.¹ This was seen in a Peruvian (No. 1506), which showed an incomplete suture externally, and in the skulls of two Creek Indians (Nos. 652 and 75).

The following measurements were made to indicate the proportionate size of the upper and lower parts of the malar bone. The numbers have been arranged in the order of the size of the upper part of the bone, this being the smallest in the first example named and the largest in the last:

Upper	. . .	2 c. 8 m.	}	Hindoo.
Lower	. . .	0 " 9 "	}	
		3 " 0 "	}	Tabitian.
		0 " 8 "		
		3 " 2 "	}	Esquimaux, 1561.
		0 " 8 "		
		3 " 2 "	}	Marquesas, 1531.
		1 " 5 "		
		3 " 3 "	}	Esquimaux, 1559.
		0 " 6 "		

¹Wenzel Gruber (Archiv. f. Anat. u. Physiol., 1873) has given elaborate attention to this subject as studied in modern European crania.

Upper	.	.	3 "	3 "	} Hindoo, 1047.
Lower	.	.	0 "	7 "	
			3 "	3 "	} Chinese, 426.
			1 "	1 "	
			3 "	3 "	} Malay, 47.
			1 "	3 "	
			3 "	5 "	} Burmese.
			0 "	8 "	
Upper	.	.	3 c.	8 m.	} left side.
Lower	.	.	0 "	10 "	
Upper	.	.	3 "	9 "	} right side.
Lower	.	.	0 "	8 "	

} Cretin of Hyrtl collection.

The measurements were taken from the middle of the fronto-malar suture to a line indicating the boundary between the two parts of the bone as defined by the change in texture of the surface. No sutures existed in the specimens selected.

In the Hyrtl collection of crania, in the College of Physicians of Philadelphia, a Chinese skull (No. 13) showed a complete external suture on both right and left sides of body. A Cretin (No. 7) showed a complete suture in the bone of the left side and an incomplete one on the right side.

A Siamese skull (No. 39) retained an incomplete partial external suture on both bones, with entire posterior grooves.

In No. 67 the malar and zygomatic processes nearly met on the posterior surfaces of both bones. A similar groove was seen in a Japanese skull (No. 50).

In a skull (No. 77) a distinct posterior fissure was seen in both bones.

In a skull of a Hollander (No. 10) a foramen was noted in the maxillo-malar suture.

The malar bone is thus found to exhibit a disposition for the lower part to become distinct from the upper. The disposition is more frequently seen on the inner than the outer surface, and in all

instances is more pronounced posteriorly than anteriorly. The line of the suture when complete answers with an approach to accuracy to the attachment of the masseter muscle; and the existence of the suture might in some instances be found associated with the traction of this muscle.

In skulls which had been in a measure disintegrated by the action of the air, and sunlight and heat—in a word, which had been “weathered”—a distinct texturing was seen at the two parts of the bone. A beautiful instance of “weathering,” demonstrating the texture of the bone, was seen in a skull of a California Indian (No. 1683), as well as in a Peruvian (No. 939, A. N. S.) In like manner fractures of the bone as shown in a skull of a Tahitian (No. 1016, A. N. S.), indicate the same difference in texture of the two parts.

This difference, in brief, is as follows: The superficial lines of the upper part are concentric, or nearly so, with the orbital margin, and the interior is composed of rounded cancelli, while the superficial lines of the lower part are parallel with the inferior free margin of the bone and the cancelli are coarsely laminated.

21. The obliquity of the malar bone depends more upon the lower border than the upper part, and is associated with a change in the zygomatic process of the squamosa. The arch being viewed from above, the entire inner contour of the process last named can be seen in skulls in which the malar (especially at the lower part) is much deflected, as in Peruvians, while the posterior part only of the inner contour can be seen in skulls of low degree of malar deflection, as in negroes.

The degree of obliquity is independent of size. It is marked in in a Tschutki skull, A. N. S., where the malar bone is small.

In skulls of high degree of malar deflection, as in Malays and Chinese, the under surface of the zygomatic process of the squamosa is inclined inward from without and outward from below, while those in which the degree of deflection is small, as in negroes, it is nearly straight.

Such data indicate that with the deflection outward of the lower part of the malar there are associated distinctive changes in the squamosal part of the zygoma.

The malar bone of the fœtus at term shows all the essential peculiarities of the adult bone, (the swelling mentioned on p. 7 alone being absent,) even the minute spine at the posterior margin of the orbital process, (occasionally retained in the adult,) being present.

THE POSITION OF THE MALAR BONE AT THE SPHENO-MAXILLARY FISSURE.

The frequency with which the malar bone may enter into the spheno-maxillary fissure (by the *processus marginalis*) is subject to much variation. Froment (quoted by Henle) found it to enter into the fissure in nearly one-fourth of all skulls observed by him. In the following skulls of immature subjects—*i. e.*, below the age of sixteen years—forty-one in number, the association was present in thirty-one instances; hence I conclude that the exclusion of the malar bone from the fissure is more frequent in adult life than in youth.

The skulls in which the process was excluded were distributed as follows: One each in a Utah, Sioux, Seminole Indian, Chinese, Caucassian, Egyptian, and a Sandwich Islander skull. The remaining three skulls were unnamed.

THE LOWER JAW.

By careful inspection almost the entire outline of the lower jaw can be made out in the living subject. Even without preparation, the degree of projection of the chin can be seen in profile, as also the extent to which the angles are developed; but careful examination with the hand, especially when accompanied with oral inspection, greatly aids the observer in determining the form of the bone.

The most marked variation in the form of the jaw is seen in the depression which lies in advance of the insertion of the masseter

muscle. I have ventured to call this the *antegonium*. This depression can be easily detected by the finger. When the antegonium is well defined the mentum is always high. In a word, the vertical measurement at the anterior end of the horizontal ramus being large, the measurement at the posterior end is small. In one example examined the anterior measurement was $3^{\circ} 9^{\text{mm}}$ and the posterior $2^{\circ} 3^{\text{mm}}$. In another example the anterior measurement was 3° and the posterior $2^{\circ} 2^{\text{mm}}$.

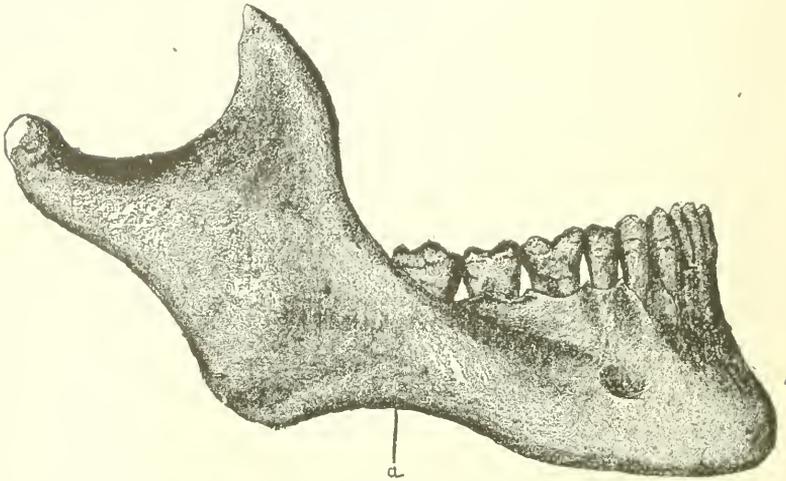


FIG. 1.—The lower jaw, showing the antegonium, and high mentum; a, the antegonium. (No. 200, A. N. S.)

This variation is often met with in patients and is generally seen in Cretins. It appears to be a result of rapid growth of the bone. To what extent the facial artery and vein may exert pressure on the bone to form the depression is not known. The molar teeth are often tilted forward in specimens of the bone which exhibit the antegonium, and in some instances the teeth wear transversely instead of obliquely.

The finger being placed in the interval between the tongue and the lower jaw-bone, one can detect with ease the mylo-hyoid ridge. The

base of the coronoid process can be outlined in emaciated subjects.

The condyles of the lower jaw are the most variable of any part of the bone. Of necessity the general shape of the articular surfaces cannot be made out in the living subject, but the tubercle to which is attached the external lateral ligament can easily be felt. When the lower jaw is depressed the finger can define the outer half (nearly) of the condylar surface.

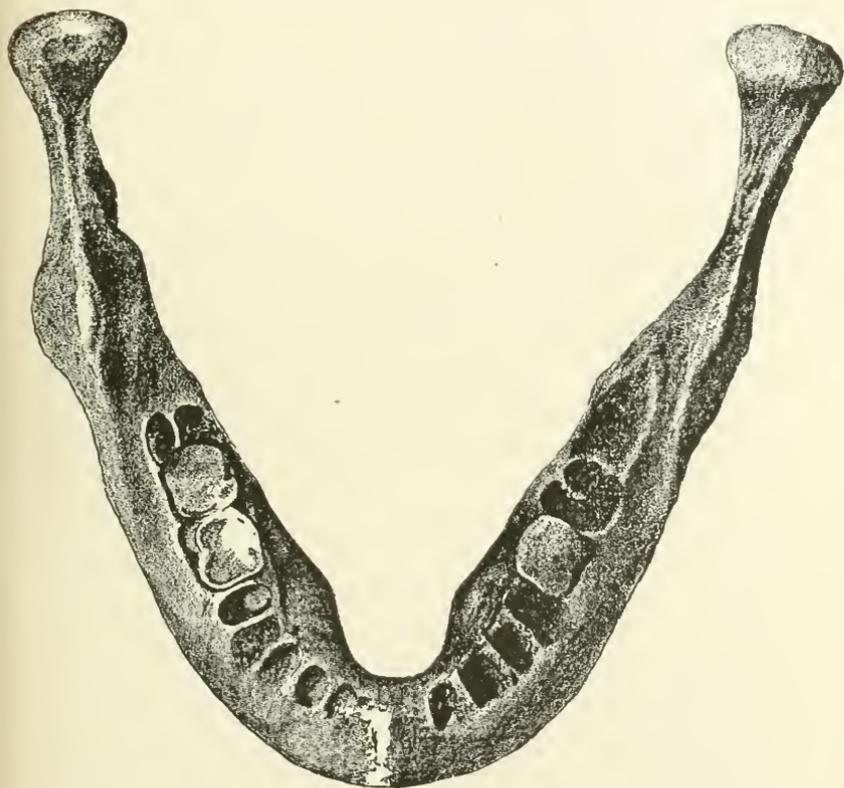


FIG. 2.—Lower jaw of an Esquimaux, showing hyperostosis on the lingual aspect of the horizontal ramus. (No. 173, A. N. S.)

In the specimens of the lower jaw of the cranium of an Esquimaux in the A. N. S. an elongated swelling was noted lying on the

lingual aspect of the ramus from the first molar to the canine tooth. In the skull of a young adult the swelling was mammalated, each nodule answering to the socket of a tooth. In the remaining bones, three in number, the swelling was uniformly convex, and extended to a line which was nearly equal to that of the bottoms of the sockets. The bone constituting the swelling was firm in consistence, but did not appear to be the result of inflammation. Out of thirty-four Esquimaux crania in the Army Medical Museum the hyperostosis was absent in one only.

In the living subject the distance from the angle of the bone to the firm muscle-mass about the cervical vertebræ often differs on the two sides. It is commonly greater on the left side. When separated from the attachments and relations, the bone does not exhibit the degree of asymmetry, which corresponds to the peculiarity named. It is true the left ramus may be deflected slightly outward to correspond with the increase of left-sided deviation of the superior dental arch, but no amount of dental variation could correlate with the apparently gross change at the angle as is seen during life. The explanation lies not in the maxillæ, but in the cervical vertebræ, especially the atlas, the left transverse process of which is the smaller.

The disposition for the left angle of the lower jaw to project to a degree much greater than the angle of the right side has been found by me to correspond also to the relation between the right and left sides of the hyoid bone. In a word, the entire left greater cornu deviates to a greater degree from the median line of the bone than does the right. The same remark is applicable to the two sides of the thyroid cartilage. These parts can be felt in the neck of the living subject. I have notes of several cases in which an irritation of the lower part of the pharynx appeared to be associated with the pressure of the posterior free end of the right great cornu against the mucous membrane. I have never detected similar points of irritation on the left side. The tentative conclusion I have drawn

from the facts is that the right greater cornu of the hyoid bone has a tendency to be pressed in against the wall of the pharynx, while the left appears to have no such disposition.

THE NORMA BASILARIS.

The norma basilaris embraces the skull when viewed from beneath. It is the least natural of any of the normæ, for the parts back of the foramen magnum are included in the region of the neck and are separated from the occiput by inconstant lines, while the facial parts are included in the mouth. The parts intermediate to the occiput and the face (the lower jaw will be considered as absent) constitute the true "base of the skull" as limited by physicians in studying the skull in the living individual. It includes studies of the important region of the pharyngeal vault. Variations in the norma basilaris, as might be expected, are seen in the occipital, facial, and intermediate regions, which do not of necessity correlate with one another, but express oftentimes entirely distinct, if not opposing, tendencies.

In order properly to consider the relations of the somewhat incongruous elements of the norma basilaris it is important to recall the significance of the parts.

Taking the union of the squamosal, tympanic, petrosal, and styloid elements to form the temporal bone as an illustration of the fact that early union between bones is an evidence of their affinity, then the following statements become tenable :

The skull of the child at the sixth year exhibits the bones of the face united completely to one another and to the sphenoid and frontal bones. Thus, since they unite with the facial elements sooner than with the occipital, squamosal, or frontal, they may be said to have closer relations with them. The bones of the face (excepting, of course, the lower jaw) unite with the sphenoid and the frontal bones to form a single segment or piece, while the remaining bones—the parietals, temporals, and the occipital—are

separate. The association of bones above named will receive in this connection the name of the *anterior cranial segment*.

The squamosal portion of the temporal bone unites with the malar bone, while the element first named is in articular union with the lower jaw, thus a natural series on the side and the base of the skull is constituted. The most intimate relations of this series are with the bones of the anterior segment rather than with the parietal, and it may receive the name of the *squamoso-malar series*.

The petrosal elements early unite with the squamosal, but never exhibit inclinations to unite with the occipital or sphenoid bones.

The occipital and parietal elements are also distinct, and nothing can be claimed to show their disposition to unite in any definite manner to one another or to any of the groups above named of cranial bones.

In reviewing the above facts it is seen that the sphenoid and frontal bones have facial affinities; that the squamosal and malar bones form a natural series, which tend to embrace the lower jaw, but that nothing in the attempt to demonstrate affinities by their predilections in articulation can be shown for the parietal or occipital bones.

Conceding that variations in bones are to be studied in connection with the changes in the groups to which they belong, it follows that the variations of the face should include those of the sphenoid and frontal bones; that the squamosal, malar, and inferior maxilla should be studied together, and that the remaining bones cannot be studied as a whole.

The anterior segment can be easily separated from the parts lying back of it by the line of the occipito-sphenoid junction. When the junction is obliterated a hypothetical *transverse line*¹ joining

¹The transverse line answers necessarily to the place of the former suture which unites the sphenoid and occipital bones. Some writers assert that the transverse depression seen in the adult skull is not sutural, but muscular. This is not the case. The two lines are distinct. They are clearly seen as such in No. 87 Carniola (College of Physicians) and obscurely so in many specimens.

the tips of the sphenoidal tongues can be substituted for it. The production of this line across the norma will traverse on either side the alisphenoid, at the region of the oval foramen, the articular eminence, and the root of the zygoma.

The transverse line can be intersected at its centre by a hypothetical *longitudinal line*, which, passing through the mid-point of the *basion*, can be produced so as to divide the norma into a right and a left part.

The points of the greatest interest in the region are the asymmetry of the sides of the superior dental arch, the relative positions of the oval foramina of the sphenoid bones, the position of the anterior border of the articular eminence in connection with the transverse line, the depth of the zygomatic fossa, the thickness of the malar bone, the size of the bulbo petrosus—*i. e.*, the rounded swelling of the free part of the petrosa—and the angles formed by the axes of the tympanic bones and the petrosa with the longitudinal line.

The left side of the dental arch has been found more frequently expanded (it embracing a larger curve at the position of the first and second molars) than is the right. With this expansion is associated a diminished depth of the zygomatic fossa, a weaker articular eminence, and a thinning of the zygomatic arch, as compared with the same parts on the right side. The temporal ridge is also the weaker on the expanded side. The significance of the above facts appears to be as follows: The side of least expansion of the dental arch is the stronger side; hence a dental armature which is straight, or nearly so, is stronger than one which is curved.

The base of the alisphenoid on the stronger side inclines to be carried back farther than is the case on the weaker; but this is variable.

The angles formed by the axis of the tympanic and the petrosal elements vary on the two sides, but appear to be independent of the changes in the anterior segment and the squamoso-malar series. The asymmetry in the sides of the foramen magnum, and in the

distance from the basion to the mastoid process, and to the transverse process, are also variable without reference to other basic structures.

In some specimens the differences between the measurements of the anterior cranial segment and those of the occipital bone suggest that the rates of growth in the two parts of the skull have been determined by independent causes.

Thus, when the base of the skull (*norma basilaris*) is carefully inspected, it is evident that the parts on the sides of a median line are not always of equal value in size; also that the parts of the anterior segment may vary in a manner different from those of the parts posterior to it. In a word, while the contrast of right and left measurements are often discernible, the preponderance is not always the same in the two parts. In some examples the left side of the *norma* is wider throughout, though this is infrequent. In others the left side of the structures posterior to the anterior cranial segment is the wider, while the right side of the anterior segment is best developed. This is a common disposition. In the group last named the increase of the base of the alisphenoid (especially in a backward direction) is associated with a narrowing of the petrosal space—*i. e.*, the space between the alisphenoid and the occipital bones. When this is seen the left side of the dental arch is often more deflected than the right, the right malar bone is the larger and encroaches to a greater degree on the inferior orbital margin, and the surfaces of origin of the right masseter and temporal muscles are the better marked.

The production of the transverse line intersects the foramen ovale at a point near its posterior margin or at one entirely back of the opening. The left side of the incisive foramen is often the larger, and the suture between the palatal plates of the maxillæ is not in line with the basion, but lies to the left. It appears to be probable that the muscles of mastication of the right side are more powerful than are those of the left. Hence the muscular impressions are here most marked and the malar bone is the more robust. The base of the right alisphenoid appears to be forced back, and by

harmonious distribution of the blood-vessels is increased in its diameters, while the angular process becomes wider.

That the left dental arch is more deflected may be the result of a diminished tonicity in the masticatory and buccal muscles on this side. This hypothesis agrees with the fact that the left frontal eminence is commonly the smaller.

The following measurements have been taken in illustration of the data as above stated. No one specimen illustrates all the points, nor is this to be expected in so variable a form as the human skull. When in a given example a measurement is omitted it may be understood that the result is negative, and not that the measurement conflicts with the views as already given.

No. 916, negro, A. N. S., aged 16 years :

Longitudinal line overlies median suture of hard palate.

Transverse line lies back of oval foramen, left ; in front of the foramen, right. The line is 4^{mm} back of anterior border articular eminence, right, 8^{mm} left.

Distance from longitudinal line to outer border first molar tooth, 30^{mm} right, 28^{mm} left.

The left petrosal element has an angle of 60°, the vaginal process 50°, and the tympanic bone 20°. The right petrosal element has an angle of 60°, the vaginal process 45°, and the tympanic bone 25°.

Other peculiarities of this cranium included the lachrymal crest joining the maxilla ; the perpendicular plate of the ethmoid bone rudimental, with deep triangular notch reaching back to the second molar tooth ; the longitudinal palatal suture straight—the atlas ankylosed to occiput.

No. 917, negro, A. N. S., aged 21 years :

Longitudinal line overlies hard palate 2^{mm} to left of longitudinal suture. Transverse line 2^{mm} behind anterior border articular eminence, right ; at level of border, left.

Distance from longitudinal line to outer margin first molar, left, 30^{mm}; right, 28^{mm}; to outer margin 2d molar, left, 32^{mm}; right, 30^{mm}; to outer margin 3d molar, 30 left, 30 right.

Angle of left petrosal element, 50°; left vaginal process, 50°; left tympanic bone, 90°. Angle of right petrosal element, 50°; right vaginal process, 40°; right tympanic bone, 90°.

Left zygomatic fossa, 26^{mm} deep; right, 28^{mm} deep.

Left zygomatic arch at suture, 4^{mm} wide; right, 6^{mm} wide.

Other peculiarities: Large, thick perpendicular plate of ethmoid bone; septum straight; longitudinal palatal suture not straight; jugular and carotid foramen smaller on left than right; also the canal for tensor tympani muscle; bregmal and post-bregmal portions of sagittal suture deflected, the latter about 60°; lachrymal crest inferiorly produced, but not touching maxilla; lingual process of sphenoid bone absent on right.

Distance from middle point of tympanic bone to base of malar process of maxilla, 8°; from alveolar process, left, 6°, and alveolar process right.

The following notes were taken to indicate an occasional character which varied in size on the two sides of the norma:

No. 127, Turk (Col. of Physicians):

Left angular process, 8^{mm}; right, 10^{mm}.

Stephanion more interrupted on the right than the left side.

No. 132 (Col. of Physicians):

Left side palate deflected.

Right, depth of zygomatic fossa, 16^{mm}; left, 17^{mm}.

No. 92, Uskoke (Col. of Physicians):

Left, width from basion to outer border transverse process of occipital bone, 44^{mm}; right, 41^{mm}.

Left, depth of zygomatic fossa, 20^{mm}; right, 23^{mm}.

Left, width of malo-zygomatic suture, 6^{mm}; right, 8^{mm}.

Left, width of bulbo-petrosa narrower than on right.

All parts of the right side of the vertex smaller than left.

No. 94 (Col. of Physicians):

Left basio-transverse (*i. e.*, measurement from basion to outer end of the transverse process of occipital bone), 40^{mm}; right, 43^{mm}.

Left carotid foramen, 5^{mm}; right, 6^{mm}.

Left supra orbital margin more inclined than on right.

Left portion of incisive foramen the larger.

Left side dental arch but slightly larger than on right.

No 114, Elba (Col. of Physicians):

Left dental arch most expanded.

Left basio-transverse, 41^{mm}; right, 43^{mm}.

Left zygomatic fossa, 21^{mm} deep; right, 24^{mm} deep.

No. 73 (Col. of Physicians):

Left dental arch most expanded.

Left basio-transverse measurement, 41^{mm}; right, 40^{mm}.

Left spinous process of sphenoid, 4^{mm}; right, 5^{mm}.

Left angular process from base of lingualis to sphenoido-squamosal suture, 22^{mm}; right, 22^{mm}.

No. 77 (Col. of Physicians):

Left dental arch most expanded.

Left basio-transverse, 36^{mm}; right, 40^{mm}.

Left zygomatic fossa, 23^{mm} deep; right, 25^{mm} deep.

No. 117:

Left dental arch most expanded.

Left zygomatic fossa, 17^{mm} deep; right, 21^{mm} deep.

Temporal ridge greatly interrupted on right; not interrupted on left.

No. 34, Krim. (Col. of Physicians):

Right side dental arch expanded. Distance from base of lingual process to sphenoido-squamosal suture, left, 26^{mm}; right, 25^{mm}.

Transverse line barely reaches back of the rounded form of foramen ovale, or right, while lying well behind the foramen, or left. Left

jugular and carotid foramina smaller on left than on right. Zygomatic fossa, right, 24^{mm} deep; left, 25^{mm} deep.

No. 6 (Col. of Physicians):

Depth of zygomatic fossa, 15^{mm} right, 17^{mm} left.

Width of anterior lacerated foramen, 10^{mm} left, 6^{mm} right.

In cranium of giant in College of Physicians the zygomatic fossa is 30^{mm} deep on right, 22^{mm} on left. The malar bone lacks 2^{mm} of reaching infra-orbital foramen, right, and 5^{mm} on left.

No. 50, Japanese (Col. of Physicians):

Base of alisphenoid, 21½^{mm} right, 20^{mm} left; no asymmetry of dental arches. Transverse line 2^{mm} back of foramen ovale, left; crosses foramen at anterior third right.

No. 545, Malay (A. N. S.):

The foramen ovale is crossed by the transverse line at the posterior margin on the right side, and at the middle, on the left, the line crosses the articular eminence 4^{mm} back of anterior margin.

The antero-posterior line answers to the middle of the socket of the left central incisor.

Right spinous process, 5^{mm}.

Left " " 5^{mm}.

Right base of alisphenoid, back of foramen ovale, 5^{mm}.

Left " " " " " 2^{mm}.

Right from spinous foramen outward, 9^{mm}.

Left " " " " 7^{mm}.

Right width of zygoma at suture, 5^{mm}.

THE POSTERULA.

Since the introduction of the rhinal mirror as an aid to the examination of the pharynx, the region known as the naso-pharynx can be inspected with almost the same ease as any other portion of the body. Many of the features of interest which relate to this portion of the pharynx are of a character which can be analyzed only by reference to the cranium. In the naso-pharynx are de-

tected the outlines of the delicate vertical plate of the vomer, the sphenoidal surfaces of the internal pterygoid processes, the posterior ends of the middle and inferior turbinated bones, and the vault of the pharynx as defined for the most part by the alæ of the vomer and the occipital process of the occipital bone.

In a communication to the American Laryngological Association which I made in 1888 I called attention to a portion of this region which extends from the plane of the posterior nares to the posterior limit of the vomerine alæ, and defined on the side by the internal pterygoid plates, and proposed for it the term *posterula*. Subsequent study has confirmed me in the value of this portion of the naso-pharynx being restricted as a distinct clinical region, and I here venture to show the close relation which exists between it and the morbid condition of the interior of the nasal chamber. I will, in addition, discuss the subject of the basio-cranial angle—that is to say, the clinical interest arising from the angle formed between the posterula on the one part and the inclination of the basilar process of the occipital bone on the other. The separate heads in the description of the posterula include the following:

The under surfaces of the body of the sphenoid bone.

The vomer as seen in articulation with the sphenoid and palatal bones.

The posterior nares or choanæ. (For note on Choanæ see Nasal Chamber.)

The region of the sphenoturbinals.

In no other portion of the skull do so many elements combine as in the naso-pharynx.

The basi-sphenoid and pre-sphenoid here unite. The sphenoturbinals lie in front of the under surface of the sphenoid elements and pass backward a variable distance above the palatals and vaginal processes, and forward along the sides of the meso-ethmoid. The vomer articulates with the body of the sphenoid bone. The borders of the alæ unite in a variable manner with the sphenoidal

of the region lies the basi-sphenoid junction, which is the last of all the sutures in this region to close.

The under surface of the basi-sphenoid, up to the sixth year, is convex in the centre and grooved or fluted on the sides. The convexity serves to receive the concave surface of the vomer, and the flutings accommodate vessels and nerves. The vaginal processes, the body of the sphenoid bone, and the sphenoidal processes of the palatals, later in development, convert these grooves into canals.

In some examples of crania¹ the under surface of the sphenoid bone continues to be convex in adult life.

In others (972, Negro; 1043, Pawnee; 726, Seminole; 1009,

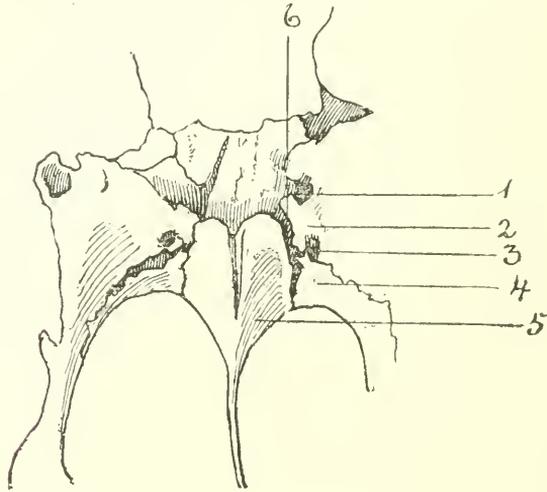


FIG. 3.—The posterula of a German (No. 1188, A. N. S.), showing failure of the vaginal process of the sphenoid bone and the palatal bone to reach the vomer. On the right side a fissure exists between the parts named.

1. Lateral superior foramen.
2. Vaginal process.
3. Lateral inferior foramen.
4. Palatal bone.
5. Vomer.
6. Interval between vomer and vaginal and palatal elements.

¹ Nos. 438, 912, 27, 69, Seminole; 732, Seminole; 954, 953, Narrag.; 43, Menom.; 118, Lenape; 741, Mandan.

Ottawa; 1188, 1063, German; 746, Minitari; 947, Araucanian) the vaginals, and sphenoidal processes of the palatal bones do not reach the vomer, or may be entirely absent.

From this condition of retained juvenile feature the most characteristic departure is to have the under surface of the body of the sphenoid bone slightly rugose (757, Otoe; 1233, Miami; 19, Bengalee; 693, Narragansett).

A few examples may be named in which the surface is moderately convex. On the other hand, it may be flat. The variety last named includes a large number of examples which are of especial interest, since no civilized race is represented (53; 651, Araucanian; 1227, Blackfoot; 1451, Australian; 1029, Fiji; 1342, bastard Malay; 435, Malay; 990, Maya; 1315, N. A. Indian; 730, Seminole; 935, Narragansett; 204, Chinook; 605 Sioux; 142, 905, 913, 973, 654, Negro).

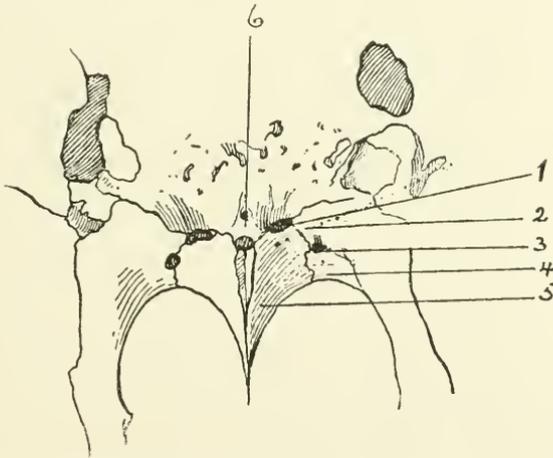


FIG. 4.--The posterula of an adult North American Indian (No. 1322, A. N. S.), showing a median vomero-basilar foramen, in addition to the two lateral foramina.

1. Lateral superior vomero-basilar foramen.
2. Vaginal process.
3. Lateral inferior vomero-basilar foramen.
4. Palatal bone.
5. Vomer.
6. Median vomero-basilar foramen.

In one instance the surface is hyperostosed (No. 78, Menominee).

In three examples the under surface is concave in the centre, and two large canals retained at the sides (1322, Potawatomie; 1229, Upsala; 1228, Upsarooka).

The *vomer* is more or less concave at the upper surface, and is adapted to the convex surface of the sphenoid bone; but the method of union of the two bones is not as simple as the above statement would imply. The posterior part of the vomer, including the wings, may be without union to the sphenoid bone. The two bones are thus separated by an interval, which is variable with the shape of the body of sphenoid itself. The arrangement suggests that during life either blood-vessels or indifferent tissue occupied the intervals, or that hyperostosis at the anterior part of the sphenoid—probably at the line of the pre-sphenoid—had forced the vomer down and thrown it off from attachment to the posterior part. In immature crania the vomer is very generally removed from the sphenoid posteriorly. The disposition seen in the adult skull may be a retention of a juvenile character. If it is not so it is remarkable that the region so commonly exhibits this retardation in nutrition, for it is comparatively rare to see any other arrangement of the parts.

From among all the crania examined but 75 exhibit a departure from the above plan—*i. e.*, in this number of specimens only did the vomer articulate directly with the sphenoid throughout. Is it not strange that the description of the union generally accepted should be that of the entire union? Is it not suggestive that the retardation of the processes of development of the region should be greater in the crania of civilized races than among primitive people? The greater number of examples of entire union were found in the ethnological collection of the Academy of Natural Sciences.

While it is true that the lower animals uniformly exhibit the simple form of union, and on that account the plan may be considered as an instance of reversion, it must be stated that in 65 immature skulls (none, however, of the negro or his congeners) exam-

ined in the collection of the Academy not a single one was seen of such union, while all the examples showed by the extent of the groovings on the side of the body of the sphenoid bone, and by the degree of convexity of the central part of the surface, that the type was that of the variety described in my notes as "convex, hyperostosed," or "open posteriorly."

If we accept the theory that the arrangement seen in primitive races is the same as in many lower animals, and therefore that the earlier races of men more readily resemble the skull of mammals generally, we are forced to conclude that development is more rapid in the primitive races than in civilized, and that a phase of development which is transient in savage races becomes permanent and fixed in the civilized.

It is not unlikely that the retention of the juvenile characteristics in a large proportion of skulls of civilized man may be associated in some individuals with enlargement of the adenoid tissue at the roof of the pharynx, and that these characters of the sphenoid bone and the vomer may be due to the veins which pass from the mass, effecting anastomosis with the nasal venous sinuses and the sphenopalatine veins, and thus tending to keep up the large vascular tracks which lie between the body of the sphenoid bone, its internal pterygoid plate and the palatal bone. The size of the gaps left by failure of the pterygoid and palatal plates to unite with the vomer, as compared to the width of the posterula, is not insignificant. (See Figs. 3, 4, 6, 7.)

The primitive vomer is chiefly found, as above mentioned, in the crania of savages, while the hyperostosed vomer with incomplete sphenoidal union in those of civilized people. In addition it may be said that the last-named group includes a larger number of associated anatomical variations than is the case with the first named—a conclusion in harmony with the statement already quoted, which is attributed to Retzius, that individual differences become greater in proportion to the higher intellectual development.

In illustration of the lack of uniformity of description of the region of the posterula the following citations are made:

Quain's Anatomy (ed. 1876, p. 51): "The alæ are lifted posteriorly, and articulate edge to edge with the lamella projecting inwards at the base of the internal pterygoid plate."

L. Holden (Human Osteology, 1869, p. 101): "The diverging edges of the fissure, called the "wings," fit into the little furrows beneath the vaginal processes of the sphenoid bone."

Ph. C. Sappey (Traite d'Anatomie Descriptive, p. 214) describes the alæ as the borders of the groove by which the vomer articulates with the sphenoid bone, and further states that they are received in the groove on the internal surface of the base of the pterygoid process.

F. O. Ward (Human Osteology, p. 89) describes two projecting laminae of the sphenoid bone overlapping and retaining the vomerine alæ.



FIG. 5.—The posterula of a North American Indian (No. 951, Narragansett), showing entire union between the vomer with the sphenoid bone.

1. Lateral superior foramen.
2. Vaginal process.
3. Lateral inferior foramina.
4. Palatal bone.
5. Vomer.

At the risk of repeating a few phrases the following detailed statements are here made: The crania named below are examples of

entire union of the vomer with the sphenoid bone: Of North American Indians—541, 542, 1054, 1233, 1056, 1052, Miami; 44, 563, 454, 747, Menominee; 118, 876, 40, Lenapé; 739, 741, 742, 644, Mandan; 462, 457, Chinook; 950, 951, Narragansett; 1227, Blackfoot; 897, Mohawk; 1730, Seminole; 91, Columbia R. Ind.; 1214, Ohio Ind.; 461, Chickasaw; 1006, Ottawa; 747, Minitari; 1210, Shawnee; 1,315 unnamed. Of South American Indians—601, 652, Araucanian. Of Negroes—1315, Golgon; 549, 974, 913, 967, 968, 648; "Oceanic Negro," 435. Of other races—573, Kowalitsk; 94, Chinese; 1300, 572, Sandwich Islanders; 1342, Malay; 1244, Hottentot; 1029, Fiji Islanders, and 969, 1263, 563, 142, 247, 400, 421, 1338, unnamed.

The following embrace examples in which the sphenoid bone and the vomer are united, with the exception of a small portion of the vomerine wings and the space between this lifted part, and the flat, small sphenoid body. In essential features the group is the same as the foregoing: Of negroes—905, 900, 904, 961, 968, 1102, 923, 993, 909, 973, 971, 972, 927, 916, 909; two of the negro group marked 1093, Golah, and 580, Macua. Of North American Indians—708, Seminole; 954, Narragansett; 1009, Ottawa. Of other races—1311, Bengalee; 550, Chinese.

From among 164 skulls examined complete apposition of the vomer to the sphenoid bone was found in 94 instances. In connection with the lack of union between the vomer and the sphenoid bone may be named the frequent instances in which the parts of the region become hyperostosed. The vomer is often of great thickness at the *alæ* and upper part of the posterior border.¹

The vaginals, as they extend medianly from the vertical plate, are often massive and present a marked contrast to the thin brittle plate commonly found in this situation.²

¹ 944, 746, Minitari; 744, Blackfoot; 740, Mandan; 977, Araucanian; 204, Chinook; 605, Sioux; 407, Miami; 115, Lenapé; 692, Carib; 693, Narragansett; 895, Mohawk.

² 97, 960, Negro; 112, Naples, nine years (College of Physicians); 113, Genoa, *ibid.*

They may overlap vomer as follows: 692, Carib; 963, 903, Negro; 240, Australian; 87, Peruvian; 737, Otoo; 1281, Peruvian, 12 years old; 986, Irish, 16 years old.

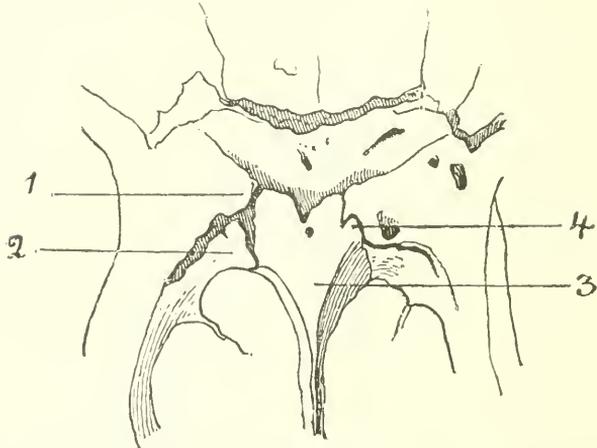


FIG. 6.—The posterula of an Irish girl, aged 16 years (No. 986, A. N. S.), showing an extensive fissure between the vaginal process of the sphenoid bone and the palatal bone on the right side. Both these parts fail to join the vomer. On the left side the same processes not only join the vomer, but in one place tend to overlap.

1. Vaginal process.
2. Palatal bone, a conspicuous interval is seen lying between this element and the vomer.
3. Vomer.
4. Process from vomer joining the vaginal process to form an irregular union.

Open spaces indicate the failure of union between the vaginal and palatal elements and the vomer.

The shaded space back of the vomer indicates the inequality of level between the vomer and the body of the sphenoid bone.

The vaginal and sphenoidal plates may be firmly united throughout, or permit a foramen of varying size to appear between them. The plates may be depressed below the plane of the vomerine alæ.¹

As a rule, the plates agree with the alæ in general character—*i. e.*, when the plates are hyperostosed the vomer is also; but the process may be reversed, and the plates be thin when the alæ are

¹ 572, Sandwich Islander.

thick.¹ The plates as a rule conceal the backward extension of the speno-turbinals, and lie over and protect the veins and nerve of the canal. Thus they are apt to be pushed downward with the vomerine ale in instances of unusual imperfection of the spenoido-vomerine union.

When both the sphenoidal processes of the palatines and the vaginal processes are defective, the speno-turbinals are seen distinctly exposed, thus showing the value of the plates named in covering and in strengthening the body of the sphenoid.²

The vaginal processes rarely extend backward beyond the vomer, and evince a disposition to approach toward the median line.³

It is well to remember that it is possible to have the image of the choana as seen in the rhinal mirror narrowed by thickening of the internal pterygoid plate.

The lower end of the vomer may exhibit the tendency, so commonly seen in the lower animals, of joining the palatal bones in advance of the posterior nasal spine. The vomer may be fully two millimetres within the nasal chambers.⁴ I have seen it recede still farther within the chambers in the living subject. The exact position of the vomer becomes a matter of importance in determining the degree to which the inferior turbinated bone projects from the nasal chamber into the naso-pharynx.

The wings of the vomer may be united as the bone lies against the sphenoid, or a well-defined notch may be defined between them.⁵

A faint ridge is often seen extending vertically on the vomer. It answers to the line of union of the sphenoidal process of the pal-

¹ 1205, Seminole.

² Examples are seen in No. 113, Genoa, 12 years old; 19, Ruthene, 7 years old; American, No. 58, 6 years old (Col. of Phys.), and a Hindoo, aged 8 years, No. 32, A. N. S. No. 89 (Col. of Phys.), an adult skull of an Adrian, shows the same peculiarity.

³ No. 60, Austrian, 16 years old (Col. of Phys.).

⁴ 1315, Golconda; 605, Sioux; 1227, Blackfoot.

⁵ 44, 1220, Menominee; 106, 407, 522, 542, Miami; 952, 953, 733, Narragansett; 207, Puget Sound Indian; 604, Seminole; 436, Chetimache; —, California Indian; 670, Chinese; and in 1205.

atal bone and the vaginal process. The surface in front of this ridge divides the region of the sphenoid base into two portions; that in front of the crest is nasal and that back of the crest is pharyngeal. The relative size of the nasal and pharyngeal spaces is variable. In 47 examples the nasal part equalled the posterior in extent. In 15 examples¹ the nasal part equalled two-thirds of the entire region. In one specimen (No. 956) the nasal portion was little less than one-half. In 971, 973, 974 (Negroes without locality), the nasal portion was one-third. It equalled one-fourth to one-fifth of the whole. In a fourth Negro (No. 983) the nasal portion was one-third on the left side and one-fourth on the right.

THE REGION OF THE SPHENO-TURBINALS.

In instances of absence of union of the sphenoidal process of the palatal bone with the vomerine ala in adult crania, the posterior end of the conch is seen lying upon the base of the sphenoid bone. In the skull of a male Australian in the American Museum of Natural History I have seen this process extend back to the suture between the defective sphenoidal process of the palatal bone and the vomer. I have in several instances seen the same disposition in the skull of the adult gorilla.

An adult Esquimaux cranium, Army Medical Museum, exhibits the conchs entirely free from the sphenoid bone posteriorly, and the suture, which united them to the palatals, open.

Is it not a tenable hypothesis that many of the unusual dispositions of the canales basis vomeres may be correlated with delayed union of the sphenoidal conchs? Is it not probably true that the defects of union between the vaginal and sphenoidal process and the vomer are associated with exceptionally large or numerous veins between the body of the sphenoid bone and the processes named? If this be conceded, but one step more is required to be taken to explain the frequency of congestions and hyperplasiæ in the nasal

¹ 975, 926, 1093, 913, 972, 928, 648, 433, 978, 916, negroes without locality; 648, negro of Liberia; 423, negro of Mozambique; 707, Seminole; 1063, 1064, German.

chamber when there is a history of adenoid disease at the pharyngeal vault. (See p. 27.)

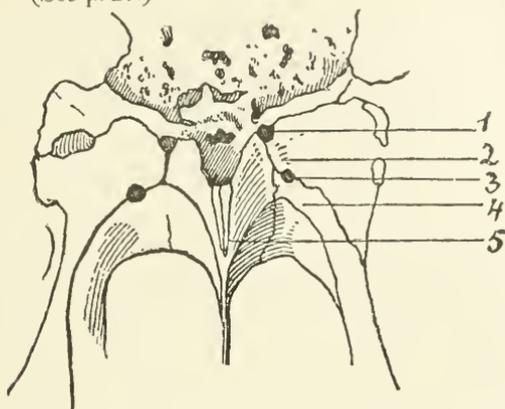


FIG. 7.—The posterula of a North American Indian (Upsarooka, No. 1228), showing large foramina for the transmission of veins. (See also Fig. 4.)

1. Lateral superior foramen.
2. Vaginal process.
3. Lateral inferior foramen.
4. Palatal bone.
5. Vomer.

In a well-defined group of cases characterized by excess of tenacious mucus in the pharynx, a disposition to vascular obstruction in the nasal chambers, a sensation of weariness, if not of pain, in the sides of the neck (which is especially liable to ensue upon a moderate use of the voice, as in reading aloud and in singing), it is found that the roof of the pharynx is occupied by small growths which do not appear to differ, either in locality or consistency, from the adenoid growths found in the same locality in young persons. I have seen many instances in which the symptoms narrated had existed for many years entirely disappear twenty-four hours after the pharyngeal vault had been rasped by the finger nail, the vegetations removed, and the surface subsequently entirely restored by the removal, with the forceps, of bits of remaining tissue. It is reasonable to suppose that the increase of nasal congestion in such cases is dependent upon unusual freedom of communication which

exists between the veins of the nasal chamber and those of the pharynx by means of defects of the canales basis vomeres. Certainly it is a fact that no thickening of the walls of the choanæ occurs in such cases, and that the communication between the nose and the pharynx, if it takes place at all, does so at planes below the mucous and sub-mucous tissues.

THE BASI-CRANIAL ANGLE.

In the living subject the angle at which the basilar process of the occipital bone joins the body of the sphenoid bone can be frequently detected by the finger being inserted in the naso-pharynx. An interruption of the contour-line between the two structures can be often detected. In individuals in whom the angle is high the entire region of the naso-pharynx is narrowed posteriorly, owing to the fact that the inclination of the basilar process renders it easy for the velum to ascend toward it. This is especially marked in subjects which exhibit prominences on the bodies of the second and third cervical vertebræ.

The basi-vomerine angle, when high, places the parts to a great disadvantage should the naso-pharynx be the seat of diseased action. Tenacious secretion forming, either in the nasal chambers or in the naso-pharynx, the material is apt to lodge at the apex of the narrowed space, to resist any effort on the part of the patient to dislodge it, and to make it difficult so to do on the part of the physician.

A high angulation of the process in the living subject would predispose, *à priori*, the naso-pharynx to those distressing conditions which result from the contact of the velum to the posterior wall of the pharynx.

It may be surmised that irregular union of the occipital and sphenoid bones or their separation by a wide interval will be found associated with adenoid growths on the pharyngeal vault. Clinical experience confirms this; but, as far as I know, a careful dissection of a subject in which adenoid masses exist is yet lacking to complete our knowledge of their localization.

The high inclination of the basilar process would be at first sight a condition which would correlate with other cranial structures, but I have not found this to be the case in the living subject or in the crania which I have examined. It is true that in some crania the high angulation is associated with an inclined vomer, as seen at its posterior free border, and a high palatal crest. At one time I was prepared to assert that the high angle of union of the basilar process with the sphenoid bone and the vomer was associated with certain changes in the nasal chambers and in the proportions of the face, but examinations of more extensive series of specimens than those at my command will be required before any definite conclusions on this subject can be secured. To be enabled to harmonize the shape of the naso-pharynx with a series of fixed landmarks of the nose and face would be a most valuable desideratum and one to which I respectfully invite the attention of observers.¹ (See remarks at the end of the lecture on clinical measurements.)

The existence of a high angle with a large conceptaculum cerebelli is sometimes noted, as well as a low angle with a small degree of convexity or descent of the conceptaculum;² yet exceptions to the association can be found in sufficient numbers to forbid a correlation being established between the two.

In the skull of Sandwich Islanders and some Esquimaux the basio-cranial angle is low. Since the human foetus at term exhibits uniformly a low angle or none, the adult crania which retain it may be said to be retarded in this particular.

Lissauer³ has delineated and described the angle created by the union of the basilar process and the vomer. In a Tartar this angle

¹ Dr. Jno. M. Mackenzie (*Arch. of Laryngology*, iv, 164) describes examples of obliquity of the plane of the posterior nares. No mention is made of its correlation with peculiarities of occipito-sphenoidal union.

² The funnel-shaped chamber which lies within the embrace of the conceptaculum and is defined anteriorly by a basilar process has been made the subject of special study by Lissauer. (*Archiv. für Anthropologie*, 1885, 16, Figs. 4 and 5.)

³ *Loc. cit.* xv, Fig. 9, p. 18.

is 74 degrees, in a Cassube 98 degrees, and in a Negro 136 degrees. The difficulty in making a rhinological examination with a mirror placed in the naso-pharynx where the angle is 74 degrees, or approximately so, would evidently be much greater than when the angle is 136 degrees. Very commonly (as already remarked) a high degree of angulation is associated with a large tubercle upon the body of the second cervical vertebra, which tends to diminish the diameter of the pharynx at the place at which the mirror is used.

THE NASAL CHAMBERS.

The study of the nasal chambers in the living subject presents facilities of determining by anterior and posterior inspection the following points:

By *anterior inspection*, the floor of the chamber—the degree it is depressed below the plane of the lower margin of the nostril.

The premaxilla—the degree it enters into the composition of the septum, and the size of the prominence it may make at the floor directly back of the plane of the lower margin of the nostril.

The septum—how it may be deflected either to the right or to the left, and whether the entire septum, or a part only, be deflected.

The inferior turbinal—the degree it may approach the floor and the septum; the relation its superior border holds to the middle turbinal.

The middle turbinal—the contrast between the vertical edge at the anterior and the part back of this border—whether the anterior part is inflated or laminar; whether the lower border is inflected or straight. The posterior part of the median surface, whether it is concealed by the inequality of the septum, or whether it is outlined as far as can be seen. The lateral (external) part, whether it is concealed in the recess which lies back of the plane of the ascending process of the superior maxilla or is distinctly outlined. The uncinate process, whether it is placed parallel to the lateral wall of the chamber or transverse to it. The bulbous anterior border of the lateral mass of the ethmoid bone, whether it is or is not visible.

By *posterior inspection* (by the rhinal mirror)—whether the choanæ are of unequal size; whether the left middle turbinal is more vertically disposed than is the right; whether the vomer is distinctly contoured, or the contour is indistinct by reason of lateral swellings; whether the inferior turbinals are protruding into the nasopharynx; whether the superior turbinals are or are not visible; whether the choanæ and the septum at the choanæ retain the embryonic form.

From this long list it may easily be inferred that the interior of the nasal chamber yields many points for elucidation.

In the study of the nasal chambers of the cranium the parts, while assisting at every stage the demonstration as made in the living subject, soon awaken in the mind of the observer separate lines of inquiry. It is not, therefore, desirable to confine observation to the clinical field, and I have arranged the results of my research under heads which appear to be more convenient.

The bones of which the chambers are composed will be treated under different heads. Many of the examples selected showed more than one peculiarity. In a Peruvian skull,¹ for example, the middle turbinals, anteriorly, were small and primitive, the left bone being the smaller. The septum was deflected to the left along the entire length of the ethmo-vomerine suture. The left uncinatè process was ankylosed to the ethmoid cells.

Each of the points named in the foregoing description will appear under a distinct heading. The parts which have been made the subject of special inquiry are the following:

1. The Middle Turbinated Bone.
2. The Parts which enter into the Composition of the Septum.
3. The Choanæ.
4. The Floor of the Nasal Chamber.
5. The Deviations of the Septum.
6. The Region at which the Frontal Bone forms Part of the Nasal Chamber.
7. The Anterior Part of the Lateral Mass of the Ethmoid Bone.

¹ No. 1705.

1. *The Middle Turbinated Bone.*

The middle turbinated bone is divided into two parts—an anterior one-third and a posterior two-thirds, nearly. The anterior part is best seen when the nasal chamber is examined from in front, and the posterior part is best seen from behind.

The anterior third. This portion is a plate of bone which ranges parallel to the perpendicular plate of the ethmoid bone or is deflected outward at an angle. The free lower border may be abruptly bent in or out. The entire anterior part may become inflated. It is often of greater density than the posterior part (is often covered with spines or is greatly roughened), and may be separated therefrom by a decided change in the inferior contour-line. At times a groove cuts off the anterior from the posterior part. This was well seen in the skull of an Ottawa Indian.¹

In the infant the anterior part is always thin and compressed. It is parallel to the perpendicular plate, as above described. The same disposition exists in many of the skulls of later childhood and in those of adult life. Out of 188 skulls in which the anterior part was examined the plates were as given in 70.

The inferior or free border may be flat and wide, so that the appearance of the part might be compared to a wedge whose apex is directed upward. Of this variety 60 examples were observed.

Instead of being flat and wide the inferior free border may be bent abruptly upon itself or may present an acute projection which is directed either inward or outward. Eleven examples of such conformation can be cited. They were distributed among the races as follows: Seven of Peruvian², one each of German³, ancient Roman⁴, Iroquois⁵, and Mexican⁶ origin.

It is an interesting fact that no example of median inflection of the lower border was noticed in the examination made of 78 negro skulls.

¹ No. 1009. ² Nos. 957, 30, 228, 1432, 100, 1475, 631. ³ No. 1190.

⁴ No. 248. ⁵ No. 119. ⁶ No. 1015.

The border may be inclined on both right and left sides, as was noticed in a Columbia River Indian¹ and in a Peruvian.²

In a second Columbia River Indian³ the deflection is seen to a marked degree on the left side, and in a Peruvian⁴ on the right.

Among other forms of inflated middle turbinals may be named one which resembles the terminal stroke of the German letter *N*. In others the shape is the same, but the direction reversed.⁵ In yet another the bone is parallelogrammatic, and may be a centimetre in width.⁶ A symmetrical disposition of such a form of inflation is seen in the skull of a negro.⁷

Infrequently the anterior portion is slightly though uniformly inflated, and is distorted in the shape of a crescent, or is even S-shaped.⁸ As a rule the inflation begins at the free anterior border and involves the entire portion; but it is in some examples confined to the part immediately back of the anterior border, which remains narrowed and compressed, as in the infant.⁹

As already remarked, changes in the superficies are found confined to the anterior portion, for the posterior part is uniformly smooth or marked by vessel-grooves only. Numerous bristle-like processes are found occupying the surface in some instances.¹⁰

The inflected part may be seen at any section of the surface of the anterior portion. In a Madagascar¹¹ and a Peruvian¹² skull a large spine with a broad base projects from the outer side. I have often met with a similar spine in the living subject.

The flat interior border may even be inflated in common with the

¹ No. 573. ² No. 1366. ³ No. 377.

⁴ No. 1447. ⁵ No. 976.

⁶ The "bulbo-ethmoidalis," by which term I embrace the inflation of the anterior limit to the ethmoidal mass, is distinct from a bulbous inflation of the pedicle of the middle turbinal, which is occasionally met with, but is not included in the description as given above.

⁷ No. 976.

⁸ For examples see Peruvians, 1490, 1462, 1458; Narragansett, 693; Naumkeag, 567; San Miguel, 1636; Nantucket, 104; Ancient Mexican, 1003.

⁹ Peruvian, No. 84. ¹⁰ Peruvian, No. 1460.

¹¹ No. 1306. ¹² No. 1465.

rest of the portion, and as a result the part be club-shaped, or, being flat on the inner, become markedly convex on the outer surface. In the skull of a Mexican¹ a spur on a deflected septum on the right side is firmly indented in a club-shaped right middle turbinal. In most examples, however, of inflated anterior portions with deflected septa the parts are conformed one to the other.

With respect to the right and left disposition of the varieties named nothing can be said. A compressed primitive form of the anterior portion may be associated with a fellow of the same kind or of any of the forms already given.

In thirty examples of the anterior portion studied in skulls of children under eleven years of age the following disposition is noticed:

In six the anterior portion is compressed and primitive; in eleven the plane is the same as above, but the lower border was abruptly inflected; in ten the lower border is flat and the portion more or less wedge-shaped; in two a moderate amount of diffused inflation, and in one a marked degree of the same is present.

The extent to which the anterior portion may advance into the external nose varies greatly. In a Cimbrian and a Peruvian the bone is placed well within the region of the ascending process of the maxilla. I have observed the same peculiarity in the living subject.

Notwithstanding that the interior of the nose is protected by stout bony barriers, the parts may be distorted or destroyed by a variety of circumstances. In the practice of preparing the body for burial adopted by the ancient Peruvians masses of woolen or vegetable fibre were used to plug the nasal chambers. Lateral distortions of the turbinals are occasionally seen to be due to this cause.²

When bodies are left exposed to the air immediately after death dipterous insects deposit ova in and about the nostrils. The ravages made by the larvæ of the insects often destroy the turbinals. In a specimen of a skull of a Mandan Indian the anterior half of

¹ No. 1430, aged six years. ² No. 690.

the lateral mass of the ethmoid bone is eaten away, and the entire remaining portion of the bone is closely packed with the pupa cases.

The Posterior Two-thirds.—While the anterior part of the middle turbinal is apt to be vertical and compressed, so the posterior part is often horizontal at its upper part.¹ The scroll, indeed, may be said to be an inferior volute from a horizontal line, as in the scroll of the Ionic capital. Hence, the term turbinal is characteristic of a portion only of the bone.

The outer border of the posterior end of the horizontal part is usually notched. It is probable that the notch is for the accommodation of a vessel which is in connection with the structures occupying the sphenopalatine foramen. Occasionally, as is seen in a Bengalese skull,² a delicate bridge of bone converts the notch into a foramen.

The ledge-like upper border of the middle turbinal may be inclined or nearly vertical. These different shapes can be indicated (even when the turbinal is absent) by the direction taken by the upper crest on the palatal bone.³

In the posterior nares the ends of the middle turbinated bones, in the great majority of instances, are symmetrical and more or less curved. In 150 out of 234 skulls of adults examined the parts are of the kind described.

In 44 specimens the scroll presented a semicircular outline thus:)(. The curved lines represent the middle turbinals and the vertical line the vomer. Of this number, 3 exhibit the upper part of the middle turbinal horizontal, instead of curved.

The varieties in which the middle turbinals were long and placed high up in the choanæ are included in the list of the symmetrical

¹ The horizontal part is most likely homologous with the ledge of the nasal chambers of quadrupeds where it separates the olfactory from the respiratory tracts.

² No. 25.

³ The middle turbinal may lie well within the nasal chamber, some distance from the plane of the posterior end of the inferior turbinal. Example, No. 679, Esquimaux.

forms above given. In 90 examples of all races the middle turbinals are thus placed. Of this number 78 were Negroes and 2 Hottentots.

In 47 the left middle turbinals are smaller and more vertically placed than the right, and exhibited a small horizontal upper border. In 11 of these the left bone is compressed laterally and is straight. The left contour line of the septum is angulated in three of these examples. A similar peculiarity is met with in 4 immature skulls. The remaining 36 crania show various degrees of increased obliquity and curvature of the left bone over the right, and in a number of ways a diminished surface.

2. *The Parts which Enter Into the Composition of the Septum.*

The septum has been studied in the present paper for the most part in connection with its disposition to deviate from a vertical plane.

Several minor points were observed during the examination, which will be first recorded.

The Perpendicular Plate.—The perpendicular plate advances forward to a variable degree. Even in the adult—it was seen in a Bengalese skull¹—the anterior end of the plate may be placed as in the young subject. Yet in some specimens, as witnessed in a North American Indian,² the plate was in advance of the plane of the anterior nasal aperture. The nasal plate of the frontal bone may be concealed by the advancement of the perpendicular plate of the ethmoid bone beneath. This was noted in a Circassian skull.³ In a second skull of the same race the plate is also well advanced and of enormous thickness.

The plate may reach the nasal bones by a small surface, or may touch the bones along their entire lengths. The latter disposition is well seen in a Negro⁴ and a Peruvian skull.⁵

¹ No. 25.

² Upsarooka, No. 1228.

³ No. 762.

⁴ No. 914.

⁵ No. 413.

In the skull of an Araucanian¹ a large opening is detected in the perpendicular plate at a point directly back of the nasal plate of the frontal bone. Openings elsewhere in the perpendicular plate are so common that no special mention of them need be made.

The Vomer.—When the vomer at the posterior nares is not at the level of the openings, but lies at its lower part a little way within the chambers, the bone may be said to be *recedent*. It is a reversion effect, since it is commonly seen in the skulls of carnivora and in important groups of ungulata. (See p. 31.)

In a Peruvian² skull of five years and a Bengalese³ skull of six years this recedence may be said to be present. The same peculiarity is seen in the adult skull of a Narragansett Indian,⁴ an Assiniboin,⁵ a Golconda,⁶ a Sioux,⁷ and a Blackfoot.⁸

Recedence is so marked in a Maltese⁹ skull that the bone unites with the maxillary crest at the maxillo-palatal suture. There is no upward extension of the spine of the palatal bone. The exact position of the vomer at the choanæ in determining the posterior projection of the inferior turbinated bone is of clinical importance.

The vomer may have two grooves—one for the triangular cartilage (it may be so obliquely placed as to appear to belong to the parieties) anteriorly, and one for a vein placed far back on the side. Examples of the obliquely placed groove for the triangular cartilage are seen in an Araucanian¹⁰ skull and in several skulls of North American Indians.

3. *The Choanæ.*

The choanæ vary remarkably in form and dimensions. They may be as large as 23^{mm} long by 13^{mm} wide, or as small as 13^{mm} long by 6^{mm} wide. Usually wide and of a rectangular form inferiorly, as the borders join the transverse palatal process, they may be oval. The larger varieties include the shape first named, and the smaller one the shape last named.

¹ No. 63. ² No. 1492; ³ 48; ⁴ 951; ⁵ 1554; ⁶ 1315; ⁷ 605;

⁸ 1227.

⁹ No. 117 (Col. of Phys.).

¹⁰ No. 651.

The smaller varieties exhibit relatively long palatal crests when, indeed, they occupy one-third or one-half of the septum at the choanæ plane. Since this arrangement is seen in the fœtus at term, and the openings are oval or sub-rounded, it is fair to assume that the small oval variety is a form of arrested development. In a case of atresia nasi seen in an adult I detected this variety of choanal shape. The small oval form is so often met with in clinical studies that the conclusion may be tentatively drawn that it aids in retaining mucus in the nasal chambers, and in this way an anatomical factor may materially aid in establishing a morbid state. For examples in adult crania see a skull of a Miami Indian¹ and a Menominee.² In immature skulls, an Armenian,³ an Austrian,⁴ a Czech,⁵ a Genoese,⁶ a Sandwich Islander,⁷ a Ruthene,⁸ and a Neapolitan.⁹

It is well to remember, as already stated, p. 29, that it is possible to have the image of the choanæ, as seen by the rhinal mirror, narrowed by thickening of the internal pterygoid process of the sphenoid bone.

4. *The Floor of the Nasal Chamber.*

In many subjects the plane of the lower border of the nostril is higher than that of the floor of the chamber. The inferior turbinal lies a variable distance within this depression. The finger when inserted into the nostril will not, in such cases, enter the inferior meatus, but will pass into a space which is defined by the septum on the one hand and the upper part of the inferior turbinals on the other. An example of the skull showing the depressed floor is seen in a Menominee¹⁰ Indian.

5. *Deviations of the Septum.*

When it is recalled that the bony septum is composed not only of the vomer and the perpendicular plate of the ethmoid bone, but

¹ No. 1052. ² No. 1222. ³ No. 58, Col. of Phys., 6 years.

⁴ No. 60, Col. of Phys., 16 years. ⁵ " 80, " " 17 "

⁶ " 113, " " 12 " ⁷ " 143, " " 16 "

⁸ " 19, " " 7 " ⁹ " 112, " " 9 "

¹⁰ No. 44.

of the frontal bone at the region of the vestibular roof, and small portions of the maxilla and of the palatal bones, it follows that if it is possible for defects to arise from faults of union, more than a single place for such defects must be sought for; or, if by mere distortion any one of the parts may be found out of the straight line, the localities at which such deviation may occur are many.

In point of fact the consideration of some of the lines of suture and plates of bone need not be regarded. Deviations at the region of the frontal spine and at the region of the palatal bone almost never occur, but in the remaining component parts they are of frequent occurrence and are apt to occur are as follows:

The perpendicular plate of the ethmoid bone.

The perpendicular plate of the ethmoid bone and the vomer acting as one factor.

The vomer.

The ethmoido-vomerine suture.

The maxillary crest.

As a rule, it may be said that deviations result from two structures differ in nature uniting one with another under unfavorable conditions. The perpendicular plate of the ethmoid bone may be bent on a broad curve, while all the remaining parts are normal. This is well seen in a Chilian skull,¹ in a Hindoo,² and in an Arab.³ In the skull last named the plate is bulged to the left.

The perpendicular plate may be in the position described and the vomer be bent with it. No hyperostosis need exist at the suture. This is well seen in a Peruvian skull.⁴

The perpendicular plate and the vomer may be straight, but not lie in the same vertical plane. In this way a "fault" is defined between the two. This peculiarity also is shown in a Peruvian skull.⁵

The vomer may exhibit an angulation on the side, posteriorly—*i. e.*, at a point near the choanæ—and is, therefore, best seen from

¹ No. 1699.

² No. 432.

³ No. 499.

⁴ No. 1465.

⁵ No. 403.

behind. The septum may be in other respects straight. The apex of the angulated part often presents a groove which closely resembles the sulcus found in localities marked by the course of vessels. In the skull of an Ottawa Indian¹ the ethmoido-vomerine spur bears a groove which is continuous with a distinct canal posteriorly. The following specimens of skulls may be referred to, in each of which the groove is present on the left side: A Columbia River Indian,² two Peruvians,³ and an Anglo-American.⁴

In one additional skull—that of a Peruvian⁵—the angulation and groove are on the right side.

That the chamber to which the septum inclines should be the smaller is shown by many examples.⁶

Deviations to the right side are seen in two Peruvians,⁷ an Afghan,⁸ a Circassian,⁹ an Armenian,¹⁰ a Finn,¹¹ and a Utah Indian.¹²

The disposition for the ethmoido-vomerine suture, as well as the maxillary crest at the triangular notch, to be hyperostosed and to present spur-like projections to the left side are such striking features in the majority of crania that no more than a recognition of their presence is here demanded.¹³

In a skull of a Ruthene (No. 19, Col. of Phys.) from a child seven years old the perpendicular plate and the vomer slip by one another, are not united, but are simply in apposition. The apposed surfaces are 3^{mm} long. If the degree of variation had been expressed in resistance at the line of normal union, it is difficult to see how deflection could have been avoided. Adult skulls not infrequently show the nasal surface of the frontal bone with the nasal process retaining the long plate of bone in place of the short, compressed spine, as is usually described. Examples of this conformation are seen in three Egyptians,¹⁴ two Peruvians,¹⁵ and one each of Circassians,¹⁶

¹ No. 573. ² No. 1363 and 1407. ³ No. 62. ⁴ No. 67.

⁵ Egyptian, No. 819; Circassian, 765, 498; and a Malay, 459.

⁶ Nos. 412, 1407; ⁷ 1333; ⁸ 762; ⁹ 790; ¹⁰ 1543; ¹¹ 140.

¹² See a paper by the writer, Amer. Journ. Med. Sci., April, 1880, 70.

¹³ Nos. 799, 819, 804, aged 16 years. ¹⁴ No. 432.

¹⁵ “ 642, 1137.

¹⁶ “ 25, aged 12 years.

Hindoo,¹ Bengalese,² a North American Indian (Lenapé), an³ Anglo-American lunatic, and one unnamed.

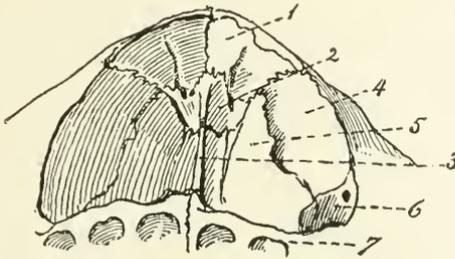


FIG. 8.—View within the anterior nasal aperture of an adult negro (No. 927, A. N. S.)

1. Nasal bone.
2. Frontal bone, forming at this place a keel instead of a spine.
3. Perpendicular plate of the ethmoid bone.
4. Ascending process of the maxilla.
5. Lateral mass of the ethmoid bone.
6. Inferior turbinate bone.
7. Alveolar process.

Thus ten well-defined examples of the nasal plate of the frontal bone were met with. With reference to this conclusion it is stated I have met it in 56 out of 76 negro skulls, and it would appear that we have in the nasal plate a valuable guide to the identity of this race. These facts lead me to consider

6. *The Region at which the Frontal Bone Forms Part of the Nasal Chamber.*

The frontal bone as it enters into the composition of the nasal chamber is usually described in forming a nasal spine.⁴

I have found that in the child the nasal portion of the frontal bone is of a different form from that described, and that in the adult

¹ No. 763.

² No. 40.

³Hoffman's "Lehrbuch der Anatomie des Menschen;" describes the "pars nasalis" as yielding a sharp process of variable length—the spina nasalis superior—which extends between the nasal bones and the perpendicular plate of the ethmoid bone. This description may be accepted as representative of those found in the text-books.

numbers of examples may be cited which do not answer to the accounts given by writers.

In the child, from the fourth to the eighth year the nasal portion is never furnished with a spine, but, in its place, with a plate which extends the entire length of the interval between the nasal and ethmoid bones.¹ The plate joins the perpendicular plate of the ethmoid bone inferiorly. A shallow groove on either side of the plate defines the roof of the nasal chamber at this place.

The nasal plate of the frontal bone is very rarely united to the perpendicular plate of the ethmoid bone. That there exists in the nasal chamber, in the races other than the Negro, an occasional, and in the Negro a frequent, absence of bony union between the two component parts of the septum, is an interesting fact.

Good examples of such apposition without union are seen in Nos. 951, 957 (Narragansett Indians), No. 651 (Araucanian), and No. 13 (Chinese). In the Army Medical Museum at Washington out of twenty Negro crania the parts above named are open in fifteen.

Care should be taken not to confound a fissure of absorption in the perpendicular plate with the form of retention as above described. A defect of this kind is noted in a Peruvian skull.²

Among the examples in which the conversion of the nasal plate into the nasal spine takes place it is interesting to observe the great size which may be attained. In a Negro³ the spine was found to be nearly as large as the nasal bone. In two Araucanian⁴ skulls the processes are also very large.

The nasal spine is found in an Afghan⁵ skull to form part of the periphery of the external nose where it was lodged between the nasal bones.

Good examples are also seen in an Egyptian⁶ and in a Nubian⁷ skull.

¹ Good examples are presented in Nos. 426, 670, Chinese (A. N. S.).

² No. 1705.

³ No. 914.

⁴ Nos. 790, 792.

⁵ No. 735.

⁶ No. 1317.

⁷ No. 829.

That deviations from the vertical plane, which so commonly occur in the nasal septum, might be connected in some way with the changes that take place in the region of the nasal plate is not improbable. It is known that the parts at the root of the nose are exceedingly firm, and that the nasal bones vary greatly in diameter from the outer to the inner surface. It is also known that the perpendicular plate of the ethmoid bone is of inconstant proportion, but on the whole tends to advance. Hence, the nasal plate of the frontal bone may be compressed between these opposed directions of growth; but if the naso-frontal parts are preternaturally fixed the perpendicular plate of the ethmoid bone may be deflected, or the entire septum be forced to expand in a region whose boundaries have been already fixed.

The external nose during the period of transition from childhood to adult life changes greatly in shape. It is probable that at this time the substitution from the nasal plate to the nasal spine takes place, and that the deviation in some way correlates with the shape of the nasal bones in the adult. In the negroes, in whom the nasal bones are small and flattened, both at the root and the bridge (the juvenile shape), the process in question retains the plate-like form, while in other races the prominence of the root and bridge is associated with increased frequency of change of the nasal plate to the nasal spine; but in the alteration last named the increase of septal deviation is also to be noticed, and an obliteration of the harmonic apposition of the spine with the perpendicular plate of the ethmoid is likely to occur.

Enough has been observed to warrant the tentative conclusion that a cause for deviation of the septum (especially in that portion of the septum into which the perpendicular plate of the ethmoid enters) exists at the junction of the nasal spine of the frontal bone and the ethmoid, together with the rate and character of the change in the forms of the nasal bones.

While this is a conclusion which the premises in many instances validate, it is true that no one explanation suffices for the explanation of all deviations. (See p. 45.)

7. *The Anterior Part of the Lateral Mass of the Ethmoid Bone.*

This region, as a rule, has a narrow border. The superior border of the middle turbinal and the base of the uncinatè process here unite. Occasionally, as is seen in a Peruvian skull,¹ the three structures are separated by a large globose surface, which forms the boundary of the most advanced of the ethmoid cells.

The Uncinatè Process.—The uncinatè process is flat and usually lies on the plane of the outer wall of the nose. In a low type of skull (this is well exemplified in a Hottentot,² in which it is firmly united to the inferior turbinal) the process may be found lying transverse to the long diameter of the nasal chamber, and of such dimensions as almost entirely to conceal the large middle turbinal. This disposition is seen in the left side of a skull of a Negro,³ and in a second from Santa Barbara, Cal. In two Peruvian⁴ skulls the uncinatè process on the left side is united to the ethmoid cells.

The degree to which the uncinatè process extends in an antero-posterior direction is subject to considerable variation. It may be in contact anteriorly with the inferior turbinal, so that an opening on the lateral wall of the chamber alone exists between the pedicle of the uncinatè and the ascending process of the superior maxilla. It may be entirely free from the inferior turbinal at this section of the chamber, so in place of a foramen a long interval is found between its antero-inferior limit and the maxilla and the inferior turbinal. The extent to which the opening into the maxillary sinus is narrowed is also subject to variation. The opening appears to be the smallest in the prognathic and the largest in the orthognathic form of crania.

THE VERTEX.

The sponce or crown constitutes in the language of craniology the vertex. The main parts comprising it are so easily determined by

¹ No. 1432.

² No. 1107.

³ No. 964.

⁴ No. 1705, 1432.

palpation that, so far as they are concerned, the clinical and anatomical study can be pursued on identical lines. Respecting the details, especially such as are seen in the sutures, it is only necessary to say that the topography of the general surface has been based, by common consent, on the arrangement of the parts at or near the sutures, and I have concluded to give the details of such localization the first place.

The names proposed for the suture-divisions, eminences, and depressions are easily adapted to the nomenclature of Broca. While it is acknowledged that multiplicity of terms is undesirable, I see no way out of the difficulty in presenting new names, since accuracy of description is impossible without them.

It is hoped that by their aid not only the vertex, but the scalp as well, can be mapped out for clinical purposes.

The sagittal, coronal, and lambdoidal sutures show peculiarities of the several parts entering into their composition which are worthy of special description.

To speak first of the *sagittal suture*, it is found that the portion which answers to the parietal end of the anterior fontanel and to the suture a short distance back from this opening is simpler in composition than the adjacent part of the suture.¹ It measures 1 to 2 centimetres in length. It is convenient to call this the *bregmal* portion.

The second portion of the sagittal suture is the longest and contains, as a rule, the largest serrations. These are either denticulate or lobate. The line answers to the region of the parietal tubera, and measures from 4 to 6 centimetres in length. In the normal cranium it represents the highest portion of the glabello-inial curve, and may receive the name of the *intertuberal portion of the sagittal suture*.

The part of the intertuberal portion which lies back of the bregmal for a distance of 1° to $1^{\circ} 5^{\text{mm}}$ is often of a distinct type of ser-

¹ Out of the 66 negroes' crania with open sutures examined 21 retained sinuate and 45 serrate bregmal portions.

ration and may be deflected from the line of the intertuberal portion. It corresponds nearly to the position of a depression which is commonly symmetrical on either side of the suture as seen on the endocranial surface. When well marked it may receive the name of the *post-bregmal portion*. In Negroes it is commonly merged in the intertuberal.

The third portion of the sagittal suture is the *obelion* of Broca.¹ The parietal foramina lie on the sides and serve as guides to this the *obelial portion*.

Broca describes the obelion as having a length of 2°, measuring, as it does, 1° either way from the foramina. The suture is very commonly harmonic, while it may be sinuate, serrate,² or lobate, but rarely the last named. The vertex, as a rule, is rounded or ridged at the sides of the obelion, which thus appears to be depressed.

The fourth and last portion of the sagittal suture also appears to be depressed. It extends from the obelial to the lambdoidal suture. The serrations are coarse, and are often composed of denticles which exceed in length any seen in the foregoing divisions of the sagittal suture. In the growing subject it is often the thickest part of the suture. It measures from 1 to 2 centimetres in length and may be called the *post-obelial portion*.

The *coronal suture* is constantly divided into three parts—the internal or ental, which answers to the anterior fontanel; the middle or mesal, and the external or ectal. The internal is simple or wavy; the middle is denticulate and extends from the internal third to the stephanion, while the external or ectal is again simple, and lies between the stephanion and the pterion. It is covered by the temporal muscle. The external or ectal may remain open while the remaining portion of the suture is obliterated (No. 38, Col. of Phys.). In some subjects, notably the Negro, the middle portion

¹ Instructions Craniologiques et Craniometriques, Paris, 1875, p. 24.

² Out of the 55 crania of negroes in the collection of the Academy of Natural Sciences 35 exhibited sinuate obelial portions and 20 serrate.

becomes simple when it runs forward parallel to the temporal ridge for a short distance before crossing it at the stephanion.

In an Esquimaux skull (No. 200, A. N. S.) the line of the temporal fascia crosses an almost simple coronal suture 28^{mm} from the bregma. The stephanion is practically unseen.

Kuppfer und Bessel Hagen, in 281 skulls from East Prussia, found the coronal suture running along the temporal ridge a short distance before crossing it in 5 per cent. males and 6 per cent. females. In the skulls of the insane these observers noted the disposition in 40 per cent. W. Sommer (Virchow's Archiv., vol. 90) in a similar examination found this disposition in 17 per cent. of males and 7 per cent. of females.

The *lambdoidal suture*,¹ like the coronal, is divided also into three parts, which may be named, in a similar manner, the endal, mesal, and ectal. Of these the ectal is the simplest in composition, and the mesal the most denticulated. Wormian bones, when present, are commonly situate in one or the other of these divisions, and not at their lines of juncture. The divisions appear to be subject to greater variation than in the cases of the sagittal and coronal sutures.²

W. Sommers (loc. cit.) found the lambdoidal suture concave forward in 90 per cent. of skulls of the insane, and 10 per cent. convex. No mention is made of the eminence which I have named meso-lambdoidal. It is fair to assume that it was present in those

¹ Broca practically makes similar subdivisions of the coronal and lambdoidal sutures in his method of studying the relations which exist between the cranium and the cerebrum. (See Revue de Anthropologie, v. 1, p. 36.)

² In No. 461, Clickitat (Columbia river) and 730 (Seminole) the lambdoidal suture is completely occupied by a number of Wormian bones. The divisions of the sutures, as above named, are lost, and the entire region presents an elliptical figure. In No. 208, Nisqually, A. N. S., the suture is nearly straight and with few serrations. Out of 60 negro crania examined the lambdoidal suture was straight, or nearly so, in 21, and arranged as described above in 39. In Esquimaux crania the outer part of the lambdoidal is much smaller than is usually found in skulls of other races, and the meso-lambdoidal is less convex forward.

in which the suture was convex, inasmuch as this convexity is most marked in, if not confined to, the mesal part of the suture. (See *infra*.)

THE EMINENCES AND DEPRESSIONS OF THE VERTEX.

The eminences of the vertex which have been separately named are the frontal, the parietal or the tuberal, and the occipital. In addition, I venture to name five others, as follows :

The meso-coronal.

The metopic.

The para-tuberal.

The meso-lambdoidal.

The *meso-coronal eminence*, lies on the frontal bone just in advance of the meso-coronal portion of the suture, about two centimetres above the stephanion. It may involve the suture itself, when the corresponding part of the parietal bone is also elevated. It is marked in many Peruvian crania, but is often absent in the skulls of Negroes and Esquimaux.

The *metopic eminence* is a median elevation of the frontal bone over the interfrontal suture. It is inconstant, but may amount to a conspicuous carination which can be seen often in the living individual.

The *para-tuberal eminence* is a rounded elevation which lies between the parietal tuber at its posterior limit and the obelion. It is commonly present. It is least developed in the Esquimaux.

The *meso-lambdoidal eminence* lies on the parietal bone in advance of the lambdoidal suture at its middle portion, or it may cross the suture and involve the occiput. It is marked in synostotic crania of the criminal type. It is very well seen in a skull of a Krim.¹ In some crania it appears to be continuous with the tubera.

In No. 1561, Esquimaux (A. N. S.), the vertex is marked by a large adventitious but distinct swelling (measuring 2 centimetres

¹ Coll. Phys.

long by 1 wide), which lies between the tuber and the lambdoidal suture. In No. 1562, of the same race, an elevation extends from the tuber to the sagittal suture. It limits the inclination of the parietal bone towards the occiput.

The temporo-frontal eminence.—Under this head may be mentioned a swelling which is felt occasionally in the living subject directly to the outside of the temporal ridge as it is defined on the frontal bone. It forms a low obtuse prominence, measuring about 3 centimetres in diameter. It is best discerned in young individuals, since in adults it is obscured by the massive temporal muscle. I have found the temporo-frontal eminence, so frequently in Peruvian crania that it may be included among the characters distinguishing them. In a Marquesas skull, in the A. N. S., a similar prominence is marked.

The *depressions* which can be detected on the vertex are arranged as follows: In advance of the bregma; this constitutes the *pre-bregmal*. At the centre of the fontanel, or embracing in a general way the region of the fontanel; this is the *bregmal*. At the line of the coronal suture and the part directly back of it; this is the *coronal*. At the broad interspace between the frontal bone and the tubera; this is the *post-coronal*, and appears to be an extension of the foregoing. An apparent depression is defined at the obelion.

The coronal depression has been described by Prof. J. Cleland (*Philosoph. Trans.*, vol. clx, 1870). It can be easily defined in the living subject. Abundant means are at hand for confirmation of this statement. Children exhibit the peculiarity as well as adults. It is generally seen in short high heads, which also retain a short sagittal suture and an abrupt curve to the mid-vertex. Rolleston (*British Barrows*, 1877) names skulls which show this peculiarity "cut off;" it appears to be the same variety as is described by Lissauer (*Archiv. f. Anthropologie*, 1885, p. 9) under the name of "sagittal Krümmung."

When the two coronal depressions are associated with large tu-

bera and para-tubera, and the interval between them (viz., the obelion and the post-obelion) is on a lower plane than the occipital angle, the variety of skull named by Prof. Cleland, "trilobate," is defined. Trilobate skulls have been found by Prof. Rolleston¹ in the barrows of England. In the College of Physicians, No. 87, Carniolian, and No. 10, Hollander, exhibit the peculiarity. I have detected one in a Peruvian, another in N. A. Indian (No. 747, A. N. S.), and a third in a Tschutchi Indian (No. 3, A. N. S.). An imperfectly developed form is seen in a Nantucket Indian child aged 12 years. W. H. Flower gives an example in Catalogue Osteol. Collection, Col. of Phys. and Surgeons, Lond., 1879, 172. The natiform skull of congenital syphilis appears to be of the same nature as the trilobate.

The *post-coronal depression* is often associated with the general roundness and fullness of contour of the frontal bone just in front of the coronal suture. This is well seen in No. 1492, Peruvian (A. N. S.), aged five years, and in 890, *Ibid.*

Instead of the coronal depression being marked the bregma may be greatly depressed, the sagitta shortened, and the occiput knobbed. Such crania are frequently seen, and in the living subject make it exceedingly difficult to determine accurate measurements from the line into which the bregma enters. The subjects are apt to exhibit hyperostosis of the sutures of the hard palate, and to have small choanæ. Examples are seen in two Italian skulls in the College of Physicians (Nos. 110 and 113).

Occasionally a depression is seen above the temporal ridge and corresponds to the curve of this elevation. It is well seen in an Esquimaux cranium (No. 677, A. N. S.).

The Ridges of the Vertex.—The ridges of the vertex are those at the sagittal suture, above the temporal ridge, and at the sides of the obelion and the post-obelion.

The ridges of the sagittal suture constitute the carinations de-

¹ "The precipitous dip downward of the posterior half of the parietals which is so characteristic of brachycephaly generally.—*Ibid.*, p. 682.

scribed by anthropologists. They may be restricted to the subdivisions of the sagittal as above proposed. Thus the post-obelial and the intertuberal parts are often separately and distinctly carinated. The bregmal and post-bregmal parts may be carinated, while the rest of the sagitta is normal. The post-obelial, obelial, and the posterior half of the intertuberal parts have been found to be carinated, together with the bregmal and post-bregmal, the anterior part of the intertuberal alone remaining normal. The carinated portion of the sagitta may extend the entire length of the suture, excepting only the post-obelial. This arrangement is admirably seen in the figures of a woman's skull in Welcker's monograph (*infra*, xiii, Figs. 1, 2, 3, 4).

The ridge which conforms to the temporal ridge is relatively infrequent. It is found in heavy male skulls as far as my observations go. It should be easily felt in the head of the living subject. The enormous lateral ridges of *Uintatherium* are probably developments of the temporal ridges, thus showing the extraordinary influence muscle-traction can exert over bony surfaces. If the exact degree of influence of all the muscles having bony attachments could be measured, osteology would be placed upon a philosophical basis.

Instead of the sagittal suture at the obelion and the post-obelion being depressed it may remain unchanged. The margins of the parietal bone remain also unchanged, while a ridge-like elevation of bone passes obliquely from the sagitta, at the end of the intertuberal portion, backward and outward to the meso-lambdoid eminence. Such conformation is well marked in the skull of a Chinese in the College of Physicians. In a living individual retaining such a peculiarity it is highly probable that a large triangular depression could be felt at the posterior part of the vertex.

THE STUDY OF THE INTERIOR OF THE VERTEX.

The interior or endo-cranial view of the vertex confirms the proposed division of the sagittal suture. The several parts are as dis-

tinctly separated as on the exterior, and, as the interior plane of the sagittal suture tends to remain open when the exterior is closed, the evidence of the disposition is here often alone available.

The side of least expansion of the parietal bones correlates with increase of thickness of the inner plate. The elevation of the inner plate of the unexpanded side is easily detected by the finger.

In No. 24 of the College of Physicians the vertex-sutures are open, the bregmal, post-bregmal, obelial, and post-obelial parts are serrated, both exteriorly and interiorly, while the intertuberal (the post-bregmal portion being here counted a separate quantity) is harmonic.

In No. 50, of the same collection, the interior view of skull is harmonic throughout, the bregmal being alone distinguished by its obliquity to the rest of the sagittal suture.

The relations of the depressions (presumably for the Pacchionian bodies) are, if of simple form, very commonly on either side of the intertuberal portion of the suture at the post-bregmal division. In thirty examinations of normal crania I have found but five where the depression was either absent or merged with a depression placed still farther back.

When the vitreous plate is thickened at the region of the former anterior fontanel and extends along the lines of the sutures so as to form a lozenge-shape figure, depressions for the Pacchionian bodies are often seen at its sides. It is rare to see depressions at the obelial or the post-obelial parts, though they may be oftener found on the frontal bones below the frontal eminences. Between the parietal tubera and the sagittal suture at the obelion an eminence is frequently found which almost equals the tuber in size. It is very commonly found in the skulls of Peruvians.

As in all other anatomical quantities, the subdivisions of the sutures of the vertex are subject to variation.

The simple statement upon which such subdivisions may be rendered tenable is one universally conceded, namely, that structures in their range of variation show traces of their origin and rates of

growth. That the bregmal and post-obelial portions of the sagittal suture are distinct from the remaining portion is probable when it is recalled that both portions are completed after birth in the process of obliteration of the fontanels. That the post-bregmal portion may be a good subdivision is also probable, since it answers pretty nearly to the position of the Pacchionian bodies and from the fact that in the parietal bone of the young subject this portion is seen to be pectinated, while the intertuberal is nearly smooth. The intertuberal portion represents the shortest distance from the tuber to the suture. The obelial portion has an admirable *raison d'être* in being the region of the parietal foramina.

The following notes in illustration of the manner in which the foregoing statements may be employed in description of crania may be found useful: The specimens are all in the College of Physicians.

No. 114, native of Elba :

Sutures open.

Bregmal, $1^{\circ} 5^{\text{mm}}$; post-bregmal, $1^{\circ} 5^{\text{mm}}$; intertuberal, $4^{\circ} 5^{\text{mm}}$; obelial, 2° ; post-obelial, 1° .

No. 30 :

Acrocephalic, synostotic.

Bregmal and post-bregmal, 4° .

Entire region elevated; not carinate; intertuberal, 4° , slightly carinate; obelial, $2^{\circ} 5^{\text{mm}}$, flat; post-obelial, 2° , carinate.

No. 92, Uskoke :

Left coronal suture closed; obelial portion lobate; post-bregmal with markedly oblique axes to the serrations, in contrast to the transversely disposed serrations of the intertuberal portions.

No. 38, Kabardine :

Both coronals obliterated; no wisdom teeth, yet the basi-cranial suture is closed; bregmal, $1^{\circ} 2^{\text{mm}}$; post-bregmal, $1^{\circ} 2^{\text{mm}}$; intertu-

beral, 5° 5^{mm}; obelial, 2°; post-obelial, 2°. The obelial is serrate; post-bregmal depression is markedly developed.

No. 34, Krim :

Synostotic, forehead prominent; resembles skull of Pomeranian weaver described by B. Davis; metopic eminence conspicuous. Entire region of bregmal, post-bregmal portions, and the anterior half of the intertuberal is elevated, but broadly carinate. The posterior half of the intertuberal is smooth; the obelial and post-obelial portions carinate.

No. 98, Gypsy :

Vertex remarkably "cut off" posteriorly. Entire suture-line is carinate except the post-obelial portion.

Australian skull (Col. of Phys.):

Sagittal suture open; bregmal, 1°; post-bregmal, 1°; intertuberal, 6°; obelial, 2°; post-obelial, 2°.

In the skulls of Esquimaux, A. N. S., the vertex is "cut off;" the intertuberal, excepting the post-bregmal part, is carinate in No. 678. The entire intertuberal is carinate in No. 279; the para-obelial eminence continuous, with a smaller ridge which extends one-half the length of the intertuberal portion of the sagittal suture in No. 677.

The right and left sides of the vertex are almost always asymmetrical. The left side at the forehead is commonly more projecting than the posterior part of the parietal bone of the same side. The reverse of these proportions is seen on the right. At the level of the occiput the left part may be projecting. Thus a circumferential measurement of the left side at the level of the frontal eminence may show the curve exaggerated anteriorly while diminished posteriorly, and a similar measurement taken from frontal eminence, so as to include the occiput above the inion, will show both anterior and posterior parts exaggerated on the left side as compared with those on the right.

Linear measurements taken in the median line from the glabella to the inion will represent more nearly the curve of the left side of the calvarium than do those taken on the right. The measurements last named may differ so widely from those of the left side as to throw the point given by Thrane for the fissure of Rolando on the right side as much as one-half inch out from that of the left.

The vertex in the space included at the sides by the temporal ridges—at the front by the corona and at the back by the lambda—is subject to local atrophic changes. Rounded depressions measuring one or two centimetres across and one to three millimetres in depth are scattered irregularly over the surface. There is no diseased action elsewhere in the skulls showing this peculiarity, and no evidence can be presented that the depressions themselves are of morbid origin. They have been seen always in crania showing early signs of advanced age, and some of them are found in distinctly senile skulls. Examples are seen in several of the skulls of Arabs (A. N. S.). A Narragansett¹ and a Chinese skull² also exhibit the depression.

In a cranium in the possession of the Academy of Natural Sciences the vertex has been mapped out and the localities named after the phrenological method of Gall and Spurzheim. It is interesting to note that a number of the enclosures which constitute what is known in the language of phrenology as the "organs" answer accurately to the eminences which I have named as above. Thus the para-tuberal eminence becomes the organ of "ambition," the meso-lambdoidal eminence that of "friendship," etc. The "organ" of "philoprogenitiveness" appears to be always well developed in females, and frequently so in males. I find no reference to this association of parts in the writings of phrenology, and I am, therefore, led to infer that it is a co-incidence only that the eminences which I have named happened also to have attracted the attention of the phrenologist.

¹ No. 951.

² No. 94.

NOTE.—H. Welcker (*Wachsthum und Bau des menschlichen Schädels*, 1862, Fig. 7, p. 17) divides the sagittal suture into five parts. These divisions are the same as I suggest in the text. My attention was called to Welcker's work by Dr. Frank Baker after I had delivered the lecture. Instead of naming the parts separately, Welcker includes them in the numbers 1, 2, 3, 4, and 5. It will be noticed that this writer retains the post-bregmal division, which I have included with some doubt. The reference of Welcker to the entire subject is very brief and is embraced in the following language: "For more accurate examination of the shape of these sutures I have illustrated (Plate iii, Fig. 7) five regions, of which No. 1 is on the coronal; No. 5 borders on the lambdoida, while No. 4, which lies between the straight parts of the parietal foramina, is a trifle smaller than the other divisions."

Rolleston (*British Barrows*, 1877, 623), probably influenced by the same authority, speaks of the sagittal suture as divided into fifths. The post-obelical is the "posterior fifth" of this writer, and the obelical the "penultimate fifth."

REMARKS ON THE SUTURES OTHER THAN THOSE OF THE VERTEX.

Sutures often indicate the manner in which the bones have grown. As already stated, the comparatively deep serrations in the middle of the sagittal and coronal sutures correspond to the most precocious extensions of growth-force in those directions. Premature union of two opposed portions of bone, namely, at the surfaces of greatest acceleration, may lead to a suture at such portions, being raised above the plane of the adjacent surface. The carinated portion of the sagittal suture is an illustration of this peculiarity. A group of instructive examples is seen in the sutures between the maxilla and the bones adjacent; thus the malo-maxillary at its lower part, where two obtuse processes project, the process pertaining to the maxilla being the larger; the inequality and even rugosity of the same suture, as it aids in defining the lower border of the orbit; the union of the horizontal plates of the maxillæ by means of which an upward extension results, aiding in the composition of the nasal septum; a downward extension of the same in the form of a thickening and even of an exostosis, which lies upon the roof of the mouth; and also in the nasal spine, which is formed at the intermaxillary

suture and projects from the lower anterior margin of the nasal chamber. These changes on the line of union of the maxilla with the malar bone, and with its fellow of the opposite side of the body, indicate that the direction of pressure during the growth of the bone has been greater at the sides toward the malar bone and at the median line of the face than elsewhere. It has been least between the maxillæ and the nasal bones and between the maxillæ and the palatals, which would indicate that the maxilla has grown forward and from side to side earlier and more aggressively than it has grown upward and backward. In this statement it is assumed that each nasal bone lies above the ascending process of the maxilla rather than in front of it. The backward extension of the maxilla against the palatal bone in the line of the dental arch demands special consideration, since it belongs to the means of accommodation of the molar teeth. Such as it is, however, the pressure of the extending bone in this direction leads to increased thickening of the palatal bone in all directions, and forms the pyramidal process. This process may be looked upon as an exemplification of an active suture-formation, which leads to hyperostosis of a part, although only one of the bones interested becomes entirely involved.

The maxilla in two places shows the effects of nerves and vessels in modifying suture lines. The roof of the infra-orbital canal is closed in a variable manner by the approximation of two portions of the maxilla at the inferior border of the orbit. Very commonly the border is thickened and an additional element of roughness and unevenness presented to that already noticed in the malo-maxillary suture. In like manner the maxilla as it joins the malar bone at the orbito-temporal septum exhibits one to three fissures in the immature bone (for the accommodation of minute vessels and nerves), which by the closure determine the positions of new grooves. Now, the growth in the direction of the orbito-temporal septum is variable. The maxillary process may reach the sphenoid bone or it may terminate at the malar. If it attains the bone first named, the malar bone is excluded from the spheno-maxillary fissure. If it

does not so attain, the malar enters into the composition of the fissure. (See p. 11.)

The connection which exists between nutritive processes and grooves caused by the positions of blood vessels is considered on page 70. It becomes difficult at times to decide which is the most effective in inducing the position of sutures. For example: While the masseteric ridge answers in position to the intermalar suture, it also corresponds to the position of a vessel groove. The groove is commonly seen in the immature skull. It is, however, conspicuous in the skull of an adult idiot.¹

In illustration of the fact that nutrition of bone is apt to be influenced by the position of sutures the following may be mentioned: Nodules of a size of a millimetre, sessile in form and of hard consistence, are occasionally seen on the frontal bone near the median line. They are to be attributed to localized hyperostoses in the neighborhood of the interfrontal suture.²

The frontal bone directly in advance of the coronal suture is often the seat of a convexity only secondary in height to the frontal eminence. It is especially well developed in Peruvian crania. A second eminence, more generally distributed, is seen on the same bone in the temporal fossa, directly below the temporal ridge.³

The coronal suture is deflected forward slightly as it is crossed by the temporal ridge. In 31 out of the 64 skulls of negroes examined the suture extended parallel to the ridge for about two centimetres before it crossed it. In no other skull, save in a Seminole Indian⁴ and a Carib,⁵ was a similar peculiarity noticed. It thus becomes a character which should be sought for in describing the cranium of the negro. (See Vertex, p. 53.)

The borders of muscular impressions, such as the temporal ridge is to the impression for the temporal muscle, may be said to modify

¹ No. 1190, German, A. N. S.

² No. 1035, Apache; 742, Mandan; 647, and three Peruvians.

³ This is well seen in 316, a young Malay; 1029, Fiji; and 44, Menominee.

⁴ No. 708, Academy of Natural Sciences. ⁵ 692, *ibid.*

the bone itself, and may even lead to the separation of the bone in two parts. This is apparently the case in the instance of a double parietal bone as figured by Professor Turner in the skull of an Admiralty Islander.¹ The line of origin on the inner surface of the malar bone answers to the position of the suture in two instances of double malar bone which I have studied.² In four crania³ traces of a suture were seen on the maxillary portion of the hard palate extending obliquely forward and outward at or near the maxillo-palatal junction. They may unite with the junction last named at the median line or lie a little to the ectal side.

The squamosal suture (parieto-temporal) ends posteriorly at the mastoid process somewhat abruptly. A process of the suture is apt to be directed upward and backward from the hinder part of this suture on the level of the temporal vein-groove. Although small, the process practically limits the squamosal region in this direction, since the curves which are continuous with the tuber of the parietal bone here begin. The slope from the side of the skull to the occiput is also announced.⁴

THE SUTURE BETWEEN THE INFRA-ORBITAL FORAMEN AND THE INTERIOR MARGIN OF THE ORBIT, INCLUDING VARIATIONS OF THE LATTER.

An interesting region for variation is seen in the inferior border of the orbit. The border may be said to lie below a curved line which is continued across the orbit along the upper limit of the zygoma. The bones which enter into the composition of the border are the malar and the superior maxilla.

The malar comprises the outer half, nearly, of the border. As a rule, the anterior limit reaches a point about 4^{mm} from the infra-orbital canal, but in place of this it may end over the canal, or may reach the ascending process of the maxilla.

¹ The Challenger Rep. X. 57. ² 1255, Ostrogoth; and 130, Chinese.

³ Nos. 20, 60, 80, 136, 139, College of Physicians.

⁴ See 1482 (A. N. S.), Peruvian, right side

The maxillary portion is divided into the part over the infra-orbital foramen and the part answering to the base of the ascending process of the maxilla.

The first of these divisions is exceedingly variable. The remains of the suture at the roof of the infra-orbital foramen, usually ending at the border, may extend to the malar.¹ The entire sutural arc of the orbital border may be depressed below the rest of the curve, and a minute spicule on the median side appears to indicate that fibrous tissue had bridged or occupied the interval caused by the depression.

Negroes frequently exhibit the above-named variety. The line of the suture over the foramen is often hyperostosed, so as to assume a rounded form which may be irregularly roughened. Such a variation is often found in large, heavy crania.² The ascending process of the maxilla entering into the composition of the border may be sharply ridged and abruptly raised above the planes of the floor of the orbit.³

In No. 1516, Malay, the infra-orbital suture does not extend to the inferior border of the orbit, but reaches the malar bone. A well-defined groove is seen on the inferior orbital border in 1450, Australian; 44, Menominee; and 739, Mandan.

In the same group, with the rugose suture over the infra-orbital foramen, may be placed the rather decided ledge-like hyperostosis which marks the maxilla directly above and in front of the palatal as it lies over the speno-palatine foramen.

¹ 1316, Malay (A. N. S.), aged eight years.

² Well illustrated in a skull of Lenapé (North American Indian), No. 40, A. N. S.

³ The suture over the infra-orbital foramen is raised or rugose in many examples of crania. In this connection see 1451, 1262, Australian; 747, Minitari; 740, Mandan. The suture is often open. Examples are seen in Nos. 1300, 1342, Sandwich Islanders; Nos. 69, 703, 707, 733, and 726, Seminole; Nos. 951 and 955, Narragansett; Nos. 1227, 745, 1233, Blackfoot; 1322, Pottawatomie; and 739, Mandan.

NOTES ON SOME OF THE FORAMINA OF THE SKULL.

The foramina of the skull are chiefly of interest in exhibiting retentions of embryonic states. The most striking of these states are seen at the base of the skull, at the region of the union of the vomer with the sphenoid bone and the sphenoidal processes of the palatal bone and pterygoid process, as already seen¹ (page 23).

The foramina may be asymmetrical; the foramen ovale less so than the others. A second group of retention—variations is seen at the surface of the sphenoid bone, where it lies against the petrosal to form the petroso-sphenoidal suture. Along the lines of this suture are found the oval foramen, the spinous foramen, and the canalis innominata. The suture widens not infrequently at the outer end to form an opening, which may receive the name of the petroso-sphenoidal foramen. The oval, spinous, and petroso-sphenoidal foramina may be confluent, or the spinous and petroso-sphenoidal may alone unite, or the oval and the spinous. The canalis innominata² may be large or absent. In the skull up to the fourth year the spinous and petroso-sphenoidal openings are always united. I have often remarked that the spinous foramen may be entirely absent on one side.³ In some lower animals, as is seen in the Virginian opossum, the foramina retain throughout life the type seen in this disposition to coalescence.

The development of the tympanic bone is peculiar, for instead of uniformly extending in all its proportions a large foramen is always seen on the bone at its inferior surface. The significance of the opening is unknown.

The foramen is very variable in form and position. As a rule, it recedes with age from the aperture of the meatus, so that in adult examples the retained foramen is almost always a centimetre or more from the outer free margin. Examples of the retention of the

¹ For a good example see No. 924, negro.

² The foramina ovale are at times asymmetrical.

³ No. 142, Marquesas (A. N. S.), furnishes an example.

foramen in adult life are by no means infrequent. In fourteen skulls of Esquimaux examined eight showed the tympanic foramen of defect. I have never seen the foramen in a Sandwich Island or Tahite cranium. Extended examinations might show variable percentage of occurrences in the different races. That the foramina are factors in the distribution of pus in peri-meatal abscesses there can be no doubt.

The oval foramina of the sphenoid bone are often unequal in size and of different shapes. The form may be so slightly changed from the circular that the term oval is scarcely applicable to it. This is often seen in Esquimaux crania. The rounded shape is frequently found associated with the short skull and the oval form with the long skull. When an asymmetry of the openings exists it is rational to entertain the opinion that the side of the skull which shows the greater elongation is also the side which will retain the most elliptical foramen.

If the base of the skull were perfectly symmetrical the line of the basio-cranial suture, produced outward to the right and left, should intersect the oval foramina at a fixed point; but, in fact, the intersection is variable. This is in part owing to the differences in the shapes of the openings, as already noted, and in part to the torsion of the anterior segment of the skull. (See page 18.)

The carotid canals may be asymmetrical. The left canal, when asymmetry is present, is ordinarily the smaller.¹

The foramen lacerum medium may be entirely absent, as is the rule with the lower animals. The union of the apex of the petrosal element against the body of the sphenoid bone is more frequently seen in long, narrow skulls than in others, but may be seen independently of skull form.

The foramina on the side of the skull are the familiar mastoid and the alisphenoid foramina. The latter are infrequently present. They are the orifices of small diploic veins which come to the sur-

¹ For good examples see 1548, Swede; 914, negro (A. N. S.).

face, probably to unite with the deep temporal veins. The sphenopalatine foramina are relatively of large size in the skull of the young subject. In an adult Tchutchi skull¹ these foramina were 6^{mm} in diameter.

The foramina of the vertex are few in number. The parietal foramina may be larger than usual, or they may disappear and abrupt openings may occur through the outer plate so as to expose the diploe along the line of the temporal ridge. They are more common on the frontal portion of the crest than elsewhere.

The variations of the front of the skull pertain to the anterior lacerated foramina, the infra-orbital foramina, and the opening along the line of the frontal suture. The differences in the anterior lacerated foramina are chiefly those of symmetry. The infra-orbital foramina vary chiefly in the manner by which the fissures of the maxilla close and the extent of the forward growth of the malar bone. Foramina occasionally appear at the median line of the forehead, and are doubtless due to the partial failure of the two halves of the frontal bone entirely to unite.

The foramina which transmit important structure are commonly modified from fissures, and in reversion easily assume again the stage of the fissure. Since they so originate, it is easy to account for their presence near the margins of fissures (as is seen in the foramen ovale and foramen spinosum, near the fissure between the sphenoidal and petrosal elements). In like manner the parietal foramina appear at the side of the sagittal suture. Exceptions to this rule are seen in a small canal (occasionally present) which transmits a vein between the squamosal and parietal bones, and in a foramen in a Peruvian skull.²

¹ No. 1030, A. N. S.

² No. 17, from San Mateo, which exhibits an opening between the frontal and parietal bones.

THE GROOVES, OR THE INFLUENCES EXERTED BY BLOOD-VESSELS IN DETERMINING THE FORM OF THE SKULL.

Inspection of the bones of the human subject shows that the surfaces are not infrequently marked by superficial grooves which appear to be the tracks of blood-vessels. Such markings are best seen in the long bones, which exhibit the usual appearances of chronic inflammation. Assuming that the impression made upon the bones are proportionate to the amount of increase of volume of the bone, and that the vessels remain fixed, a simple problem is presented by means of which the observer can determine the significance of blood-vessel tracks in other than in inflammatory conditions.

The vessel-grooves on the periphery.—The cranium yields a number of examples of these grooves. In the forehead, especially of specimens in which the forehead is rounded, numbers of deep, narrow grooves an inch or more in length are seen extending upward and backward from near the supra-orbital foramen or from the outer side of the frontal eminence and in line with the supra-orbital foramen or supra-orbital notch. In rare instances a simple small-groove lies near the frontal portion of the temporal ridge.¹ I have seen both the above-named grooves present in a child of nine months of age. They appear earlier than the grooves described in the succeeding paragraphs.

Good examples of the frontal vessel-grooves have been found in skulls of all nationalities. They are not uncommon in the negro, when the narrow, convex forehead appears to favor their appearance.²

¹ See No. 760, Copt, for a good example and many negro crania.

² For example see: Nos. 905, 912, negro; No. 438, Ohio Indian; No. 1035, Apache; No. 87, Peruvian; No. 1024, Fiji; No. 1214, Hamilton, Ohio, Indian; No. 1043, Pawnee; Nos. 78, 44, 35, 1222, Menominee; Nos. 749, 650, Minitari; Nos. 744, 745, Blackfoot; No. 1057, Miami; Nos. 644, 742, Mandan; Nos. 39, 1333, 1233, unnamed.

It has been found in one side of the skull only, as seen in the skull of a Sandwich Islander.¹

In a second skull of a Sandwich Islander (No. 695) the frontal grooves are absent, but a number of foramina perforating the outer plate of the bone are directed upward. It would appear that diploic veins had passed into the frontal veins, which had in their turn failed to make any impression upon the bone itself.

Many crania show a vertically placed groove, which is more or less arborescent, and rather shallow as compared to the frontal, lying upon the squamosal, a short distance above the external auditory meatus and reaching as far as the upper limit of the bone, or even crossing the parieto-squamosal suture and describing a curve upward and forward over the parietal bone, a short distance below the temporal crest. In a few examples the track originates in the parieto-squamosal when the squamosa itself is free.

The grooves are absent on surfaces from which muscles arise, as is seen on the occiput.² The squamosal groove is an apparent exception to this conclusion. May it be said that the temporal muscle makes but little traction at the region of the groove?

The region of the asterion is quite commonly the seat of numerous closely disposed grooves which are deep and sharply defined. It will be observed that in the above examples the grooves are deepest where the skull is thick, as on the convex frontal bone and in the massive region of the asterion, and most shallow when the bone is the thinnest, as over the squamosal; also that they may communicate with the diploic veins, as in the forehead, or even anastomose with an intra-cranial vein, as in the parieto-squamosal suture.³

¹ No. 572.

² I have observed a branched depression of unknown significance above the nucha-mark in the skull of a Hindoo child four years of age.

³ For good examples of squamosal vessel-grooves see the following: 542, Miami; 670, Chinese; 741, Mandan; 1043, Pawnee; 1283, 1051, Hottentot; 59, 987, 1283, 28, unnamed.

Linear grooves of doubtful origin on the periphery.—A number of grooves are seen on the superior maxilla as it enters into the composition of the outer wall of the orbit and of the boundaries of the sphenomaxillary sinus which closely resemble those caused by vessels. They are seen as fissures in the skull of the child and as linear depression in the skull of older subjects. Should they be accepted as vessel-grooves, the interesting question is raised: May not such irregular fissures as are here seen on the maxilla as it extends upward toward the orbital wall be caused by the presence of vessels, and may not the irregular sinuate edges on the margin of a growing bone of the flat class be generally associated with such modifying causes?

The malar bone occasionally exhibits a transverse linear groove upon the middle of the inner (temporal) surface. (See page 8.) It corresponds to the division between the masseteric and the temporal surfaces as seen in the child at three years, and to the line of the suture which so rarely divides the malar into two parts.

Vessel-grooves on the encranial surface.—Among the grooves on the endocranial surface of the parietal bone which are of undoubted influence, the form of the surrounding parts, is the conspicuously broad and deep depression which lies directly back of the coronal suture. The constriction so commonly seen in the periphery in this portion of the skull cannot be disassociated with the position of these vessels. The nutritive processes appear to be at first stimulated by the presence of this line of vessels, but after union with the frontal bone it remains stationary and permits the adjacent portion of the skull to rise above it. At the antero-inferior angle of the parietal bone the groove is converted into a canal and the inner layer of the bone notably thickened. In crania which exhibit a tendency to thickening of the vitreous plate the vessel-grooves are deep, sharply defined, and resemble the tracks made by insect-larvæ in old wood and in neglected books. The diploe is often exposed at the bottom of these grooves. Doubtless the diploic vessels freely unite with the vessels.

Vessel-grooves within the nasal chamber.—The nasal bone is often marked with a groove which extends the entire length of the surface within the nasal chamber and lies near the maxilla-nasal suture. A similar groove is often found on the ascending process of the maxilla near and parallel to the same suture.

The temporal ridge, as it is crossed by the coronal suture, is occasionally depressed, or the line of the ridge may be said to exhibit a fault at the point of section of the coronal. This arrangement is seen oftener in the skulls of negroes than those of other races.¹

The temporal ridges divide the dome of the cranium (*i. e.*, the parts included in the sides and vertex of the brain case) into the natural divisions within which the characters of the minor details are distinctive. The vertex between the ridges is almost uniformly marked by more numerous diploic openings (*aperturæ emissariæ*). The vessel-grooves are absent. In some examples the striæ which radiate from the tubera medianward and backward are retained and distinguish the adult cranium.²

In narrow "ill-filled" skulls the temporal ridge may overlie the parietal tuber, as I have observed in a cranium of a convict, or greatly underlie it, as is seen in No. 77 of the College of Physicians collection.

Among the *processes of bone* which were noticed in the course of the examination may be mentioned the following:

A number of small but stout spines, each measuring a millimetre or two millimetres in length, which were appended to the frontal portion of the temporal ridge and directed downward; the spines

¹ The following are the numbers of negro crania in A. N. S. showing this peculiarity: No. 912, to a marked degree; also 975, 1102, 920, 994, 1094, 918, 907, 902, 913.

The ridge is well seen in No. 1300, Sandwich Islander; 1064, German; 207, Puget Sound; 133, Cossack; 89, Adrian; 99, Armenian (the four last named are in the College of Physicians).

² The temporal ridges often limit the distribution of morbid processes and the changes due to old age. The diameter of the vertex measured between the two temporal ridges varies greatly in individuals. In tapeinocephalic and in all long, narrow crania the distance is smaller than in other types.

were slightly curved. They were undoubtedly developed in the direction of the vertical fibres of the temporal muscle.¹

The pneumatic process of the occipital bone was met with in six² instances. In six of these the process was on the left side.

The paroccipital process may be bent inward and flattened,³ and in one instance was found to articulate on the left side with the atlas.⁴

Regions of great density of bone structure.—The disposition for some parts of the cranium to show dense ivory-like thickenings is very noticeable. The causes which induce the vascular cancellous tissue to assume greater density with diminution of blood-vessel supply would be interesting to trace. Four localities are named for the occurrence of this change—1st, the petrous portion of the temporal bone; 2d, the inner or vitreous plate of the bones entering into the composition of the vertex;⁵ 3d, the margins of the jugular foramen, notably the anterior; 4th, occasionally in the interior of sinuses, as seen in the maxillary and ethmoid sinuses.

The disposition to ivory-like density is often morbid (this probably includes the third and fourth groups as given above), and may even be present in the vitreous plate of the vertex. Scarcely a cranium can be found in our dissecting-rooms in which solid nodules are not found in some part of the interior of the calvarium, especially at the frontal portion on either side of the metopic line. Many individuals exhibit dense, white, low eminences of the general internal surface at the region of the bregma. They are lozenge-shaped and measure four to six centimetres in diameter.

¹ See No. 1271, North American Indian; No. 742, Mandan; No. 963, negro.

² No. 1229, Upsarooka; 20, Bengalee; 78, 35, Menominee; 204, Che-nook; 707, Seminole.

³ See skull of Alaskan in museum of Princeton College, N. J.

⁴ No. 706, German.

⁵ This is seen to be the case to a remarkable degree in the skull of an Esquimaux (No. 1554) in the Army Medical Museum.

The formations as they exist in the sinuses are nodular and apparently lead up by easy grades to the ivory-exostoses recognized by the physician as distinctly pathological.¹

ON THE MANNER OF TAKING A CLINICAL NOTE OF THE CRANIUM.

It will be remembered that one of the objects in view in undertaking the study which is now completed was to ascertain the degree of correlation, if any existed, which could be traced between structural peculiarities in the region of the mouth, of the nasal chamber, of the naso-pharynx, and other portions of the cranium. A laryngologist has an opportunity of taking measurements in the mouth, throat, and adjacent parts which is withheld from the general observer. It goes without saying that for general craniological purposes it will be impossible for measurements within the nose and throat to be made. The contrast between any of these regions in patients is so great it was suggested that a series of observations might be of some importance. The following is an example of the kind of measurements which can be secured in the living subject:

In a woman aged twenty-six, suffering from chronic nasal catarrh, it was found that the distance from the axis tubercle (which is very plainly seen when the velum is lifted) to the cutting edge of the right superior incisor at the median line was $8^{\circ} 1^{\text{mm}}$; the distance from the vault of the naso-pharynx to the lower border of the anterior nasal aperture, $7^{\circ} 7^{\text{mm}}$; the distance from the glabella to the post-remal prominence, 18° ; the circumference of the head taken on the line of the parietal tubera was 54° .

It will be noted in the above that the axo-incisorial measurement ends at the edge of the incisor. It is acknowledged that this is undesirable, since the inclination of the teeth is a variable quantity. Indeed, any point about the dental arches is subject to the same criticism, but does not apply with any greater force in this

¹For a general essay on hyperostosis in man and animals see Gervais *Journal de Zoologie*, 1875, p. 421.

measurement than to other craniological lines into which the teeth may enter. It is also difficult to determine the anterior limit of the line extending from the vault of the naso-pharynx to the anterior nasal aperture (pharyngo-narial line), for the reason that the depth of the soft parts covering the nasal aperture is variable; but such an ending is not more inconstant than that of the anterior nasal spine, which is relied upon generally as a point from which measurements may be taken. The individual who furnished these measurements had a high basi-cranial angle. Indeed, it was impossible to inspect the vault of the pharynx of this subject with satisfaction, since the anterior position of the body of the axis conjoining with the acute angle of the vault made it difficult to depress the mirror so as to obtain a satisfactory image of the space.

In addition to the above the following observations were made: The lower jaw with marked outward deflection of the left angle; the antegonial depression marked; the mentum high; the bregmal depression marked; the post-coronal depression absent; the deep depression in the region of the obelion present; the para-tuberal and meso-lambdoidal eminences well developed.

It is submitted that a series of measurements made on this simple scheme might yield interesting results. The material I have collected is insufficient for study at this time.

The study of the skull in children often throws light upon the nature of morbid processes. In this connection I have special reference to minor changes, some of them, indeed, so slight as to escape notice if the standards of comparison be those which the observer is usually expected to entertain—such, for example, if the gross changes recognized as cretinic, hydrocephalic, etc., be selected as basis for study. I allude more particularly to such appearances as would follow a delayed disappearance of the anterior fontanel, the result of which is a saucer-shaped concavity at the anterior portion of the vertex. Another peculiarity is an unduly marked convexity on either side of the sagittal depression. This need not be sufficient to constitute the natiform skull (see page 56), but to suggest

with this variety a common interest, namely, a disposition to premature disappearance of the sagittal suture associated with retarded ossification of the parietals, as a result of which they become unduly convex.

The third variety is confined to the anterior cranial segment—*i. e.*, a phase of deformation in which all the peculiarities are in the frontal bone or in the bones of the face. The frontal eminences may be too near one another; the metopic suture may be here and there carinated; the muscular ridge at the anterior border of the temporal fossa may be unduly prominent; the inferior border of the orbit at the region of the union of the malar bone and the line over the infra-orbital canal may be roughened, etc. Many of these peculiarities are associated with errors in the shape of the mouth and the nasal chambers, and easily come within the range of anatomical studies which are suggested by clinical observations on catarrhal diseases of the respiratory mucous surfaces.

ADDENDUM.—The number of skulls stated on 8th line from bottom page 29 refers to others than those in the collection of the Academy of National Sciences.



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