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SKELETAL REMAINS FROM SANTA BARBARA, CALIFORNIA

I
CRANIOLOGY

By

BRUNO OETTEKING

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ERRATA

Page 34, fourth line, for *mastoid*, read *parietal*.

" 34, twentieth and twenty-second lines, for *mastoidea*, read *parietalis*.

" 35, fig. 3, second line of legend, for *mastoideæ*, read *parietales*.

" 129, eighth line, for *postcoronoideum*, read *postcoronoidea*.

" 161, sixth line from bottom, omit *34*.

" 161, between fifth and sixth lines from bottom, insert *parietalis*, *34*, *35*.

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FOREWORD

LIKE many other finds of supposed antiquity in America, the much noted skeletal remains from Santa Barbara, California, have passed through the usual stages of fantastic misrepresentation in the daily press to sober evaluation by scientific judgment. The bones were found in October, 1923, by Mr. J. P. Harrington of the Bureau of American Ethnology, Washington, D. C., in the course of work conducted jointly with the Museum of the American Indian, Heye Foundation, in connection with the exploration of the Burton Mound at Santa Barbara, which was made possible by the generosity of Mrs. Thea Heye. The exploration was conducted under the immediate auspices of the Museum, by an agreement whereby the remains came to its Department of Physical Anthropology, where their methodical study was undertaken. Its procedures, so far as the craniology is concerned, are set forth in the following pages, while the results, remarks on the geological conditions and otherwise, and the discussion of the morphological significance of the find, are treated in the final chapter.

A preliminary note by the author on the Santa Barbara skeletal remains appeared in *Indian Notes*, 1924, v. I, pp. 76–83, Museum of the American Indian, Heye Foundation. He also reported on the find at the Ninety-second Meeting of the British Association for the Advancement of Science, held at Toronto in August, 1924.

BRUNO OETTEKING

SKELETAL REMAINS FROM SANTA BARBARA, CALIFORNIA

I. CRANIOLOGY

By Bruno Oetteking

STATE OF PRESERVATION AND CLASSIFICATION

THE skeletal remains from Santa Barbara as they were received during the month of February, 1924, at the Department of Physical Anthropology of the Museum, consist of three lots, named A, B, and C. The bones were heavy from the adhering soil, and incrusted with earth and ashes. After cleaning they regained their original color, which is dirty brownish for all the B items, and a lighter but uneven brownish for C. The fragments of A had absorbed ashes and remained smoke-blackened even after cleaning. The viscous consistency of the incrustation seemed to be due to a hardened and perhaps a fatty substance; however, no attempt was made to analyze it.

During the summer of 1924 two additional specimens from the same site were acquired by Mr. F. W. Hodge, then traveling in California, and sent by him to the Museum. They bore similar traces of adhering earthy material and were listed with the others as D and E, and the results of their examination are incorporated with those of the primary finds.

It deserves special mention that none of the skulls had been submitted to intentional deformation, in which respect they conform to the general status of crania from southern California. Only skull E is slightly deformed, as a result of unintentional pressure, concerning which mention is made later (pages 14, 22, 32).

In general the state of preservation is very good, except that of A, which, as already mentioned, consists of a number of fragments, and D which represents a skull cap or calotte only. The external compacta of all the parts belonging to B is so little impaired that it retains its glossy appearance. The same is true of D and partly of E. In the latter and in C the compacta is less smooth and is slightly injured in places by the chemical action of the soil and perhaps by root erosion, without, however, being scaly or calcined. Minor defects in the skulls are mentioned in connection with the parts affected in the detailed list below.

Specimens B, D, and E were quite probably males of adult age between 40 and 45 years. All the teeth, except the third lower molars of E, are erupted and worn in the way usual with North American Indians. All the sutures are open. The same applies to specimen C, quite probably a female. The fragments of A are doubtless those of a male. Frequent mention will be made of them in comparison. The five specimens are referred to in the text as either A, B, C, D, and E, or the Santa Barbara specimens, or the males (B, D, E) and the female (C), and in the tables as: A (♂), B (♂); (D ♂), E (♂), and C (♀).

The Santa Barbara cranial remains, then, comprise the following items:

A, cranial fragments of an adult male:

a. frontal bone, with adhering portions of right parietal and nasal bones, and portion of right ala magna.

b. right temporal bone, with incomplete squama.

c. right zygomatic and maxillary bones, with adhering portions of right palatine bone, and of the palatine and alveolar processes of the left maxillary, and the horizontal process of the left palatine bone.

d. right condyle of lower jaw.

Teeth:

8 7 6 5 4 3 2 1	1 x 3 x x x x x[1]
—	—

B, cranium of an adult male:

right lacrimal bone missing, left one fragmentary.

Teeth:

x 7 6 5 4 x 2 x	1 2 3 4 5 6 7 x
8 7 6 5 4 3 2 x	1 2 3 x x 6 7 8

C, cranium of an adult female:

coronal and left spheno-parietal sutures, slightly rifted after cleaning, were rejoined; as also were cracked portions of the occipital bone posteriorly of the foramen magnum; roofs of both orbits and nasal bones slightly defective;

[1] A cross (x) indicates loss of teeth, a dash (—) teeth not erupted, while numbers in parentheses refer to defectiveness. The latter is indicated in the same way in other bones.

anterior walls of alveoli for both upper lateral incisors and both left lower incisors open, in the latter apparently by some pathological process.

Teeth:

$$\frac{8\ 7\ 6\ 5\ 4\ 3\ 2\ 1\ |\ x\ 2\ 3\ 4\ 5\ 6\ 7\ 8}{8\ 7\ 6\ 5\ 4\ 3\ 2\ 1\ |\ 1\ 2\ 3\ 4\ 5\ 6\ 7\ 8}$$

D, skull cap of an adult male:

with adhering nasal bones, the upper extreme end of the left ala magna, and the interparietal portion of the occipital bone; the squamosal margin of the right parietal bone is slightly defective.

E, cranium of an adult male:

brain case slightly depressed on right side, caused perhaps by cradle-board pressure[1] or by carrying the infant on its mother's back; posterior border of foramen magnum slightly defective, also right orbital roof and both laminæ papyraceæ.

Teeth:

$$\frac{8\ 7\ 6\ x\ 4\ 3\ 2\ 1\ |\ 1\ 2\ 3\ 4\ 5\ 6\ 7\ 8}{-\ 7\ 6\ 5\ 4\ 3\ 2\ x\ |\ 1\ x\ 3\ 4\ 5\ 6\ 7\ -}$$

[1] On this particular form of plagiocephaly, *Boas* (1889, 365) remarks: "It is a noteworthy fact that in the majority of cases the left side of the head is more prominent than the right side. Presumably this is due to the fact that the child mostly lies on his right side when in his cradle."

THE PROBLEM AND THE PLAN OF ITS INVESTIGATION

Notwithstanding the fact that on first examination the skeletal material from Santa Barbara did not appear to present any extraordinary features from the morphological angle of observation, its methodical investigation seemed to be commensurate with the importance attached to the find. This was done in such a way that in the five cranial aspects or normæ the descriptive and metrical features were subjected to a careful individual and comparative study. It is by such procedure that the significance of a given specimen might be ascertained. Furthermore, it is only by exhaustive investigation that the gradually multiplying American finds will receive the full scientific treatment due them.

The investigations were carried on with the aid of a modern instrumentarium, particularly with regard to the drawing of outlines, superimposing these, and the ascertaining of angular relations. In most of the cases the technique is that prescribed by *Rud. Martin* (1914).

CRANIAL SIZE (CAPACITY; HORIZONTAL CIRCUMFERENCE; MODULE)

In order to afford a conception of the cranial size in general, the three quantities mentioned in the heading were studied and their metrical expressions are listed in the subjoined table. On the basis of the classification of the cubic capacity of the skull as established by *Fr. and P. Sarasin*, our three skulls are euencephalic. The only pronounced difference is to be noted between the female and the males. Its capacity of 1158 ccm. places

HUMAN VARIETY	CRANIAL SIZE		
	Capacity ccm.	Horizontal circumference mm.	Module: $\frac{L+Br+H}{3}$
Santa Barbara			
B (♂)	1379	495	149.7
C (♀)	1158	478	141.0
E (♂)	1338	482	145.3
North Pacific Coast (Undeformed)			
Averages ♂	1349.5	516.4	150.2
Averages ♀	1243.8	484.5	145.6
Eskimo, Southampton Island*			
Averages ♂	1563	524	156.5
Averages ♀	1458	510	152.0
Chinese†			
Averages ♂	1456	507.4	152.7
Averages ♀	1380	492.6	147.5

* *Hrdlička* 1910.
† *Haberer* 1902.

the female skull near the lower limit of euencephaly and toward the oligencephalic class. The Santa Barbara skulls are seen to be fairly in line with the male and female averages of the North Pacific Coast. They are exceeded only slightly by the Chinese, who have just aristencephalic averages, while the Eskimo of the same column are well advanced in aristencephaly, with a male average of 1563 ccm. and a female one of 1458 ccm.

Similarly expressive are the cranial modules according to the formula $\frac{\textit{length} + \textit{height} + \textit{breadth}}{3}$. The

Santa Barbara modules fall short of all the averages contained in the third column of our table, which differ among themselves proportionally in the same way as the cubic capacities. Consulting *Hrdlička's* (1916, 118) table of cranial modules of Eastern Indians, which contains male averages of 152.2–160.4 mm., and female averages of 146.4–150.0 mm.,[1] it is seen that of our own averages the male of the North Pacific Coast does not reach even the lowest male average of that table; that in the Chinese it is level with it, and only in the Eskimo does it occupy about the middle of *Hrdlička's* range. Similar conditions obtain among the female averages, where, however, the Eskimo average of 152.0 mm. exceeds the highest Eastern Indian average of 150.0 mm. The rather low position of our own crania is furthermore confirmed by the average values of our collection from San Miguel island, where the males yielded 148.0 mm. and the females 142.3 mm. On the whole it will be realized that the cranial size of the Eastern Indians, as expressed by the cranial module, noticeably exceeds that of the Western, at least those listed in our table, while the Chinese enter the range at its lowest station and the Eskimo maintain a medial one.

The horizontal circumference also listed in our table brings out in a similar way the differences of cranial size as expressed by the other two indications. In the physiological range of that measurement, extending from 454–578 mm. (*Martin* 1914, 654), they fall quite low.

[1] *Hrdlička* designates centimeters; e.g., 15.22 cm.

They range likewise considerably below the averages which the same author quotes for Europeans, namely, 550 mm. for males and 520 mm. for females. The smaller size of the latter results naturally in the smaller values for all the quantitative expressions listed here.

INTRACRANIAL AND CRANIO-FACIAL CORRELATIONS

More recent craniological research has pointed to certain cranio-facial and intracranial correlations which may also briefly be referred to in our specimens. It was *Falkenburger* (1913) who, following up *Klaatsch's* (1909) discovery of the "central angle," discovered on his part the "cranio-facial" angle and the parallelism between

HUMAN VARIETY	INTRACRANIAL AND CRANIO-FACIAL CORRELATIONS		
	Angle		Angular relations between basion-nasion and bregma-lambda lines
	Central	Cranio-facial	
Santa Barbara			
B (♂)	92°	87°	−3°
C (♀)	87°	92°	+2°
E (♂)	95°	85°	−15°
Haida			
Averages ♂	91.7°	89.0°	+2.9°
	(88–97)	(86–92)	(−4 to +11)
Averages ♀	90.4°	88.1°	+0.8°
	(90–93)	(86–91)	(−5 to +7)
Australian "K72"*	90°	90°	−8°
European†	90°	92°	−4°

**Klaatsch* 1909, 18.

† Swabian; Am. Mus. Nat. Hist., 4555.

the cranial base (basion-nasion) line and the bregma-lambda chord. There are a number of other correlations, like the parallelism of the alveolar plane lines with the glabella-lambda plane as pointed out by *Klaatsch*, but only the aforementioned correlations will be discussed here. These are listed in the table on page 18.

The "central angle" is the angle which *Klaatsch* (1909) described as a rectangular correlation between the basion-bregma and glabella-lambda lines, and after the reinstitution of the latter which was *Hamy's* line of cranial orientation. This angle, ∠ glabella-intersection-bregma of pls. X–XII, oscillates around 90°. Our Santa Barbara skulls have angles of 92° in B, 87° in C, and 95° in E. This deficiency in C is probably due to the greater declination of the cranial base line, as well as to the more anterior position of the bregma. The three angles are illustrative of the variation under which they come about and which in the Haida series of our table extends from 88° to 97°, yielding averages of 91.7° in the males and 90.4° in the females. Both *Klaatsch's* Australian and the European of our table represent at 90° the ideal size of the "central angle." On the other hand, *Falkenburger's* assertion and demonstration of the recurrence, in deformed Peruvian skulls, of the correlative conditions as encountered in the normal ones, does not hold true, for instance, for the strongly deformed Chinook, whose "central angles" average 99.8° in the males and 99.2° in the females.

The cranio-facial angle is formed by the intersection of the nasion-basion and prosthion-bregma lines, i.e., ∠ nasion-intersection-bregma of pls. X–XII. This angle also oscillates around 90°, and occurs generally at that figure in varying frequencies in the different series. The deviations do not frustrate the correlation at all, but are rather in accordance with the variability of organic forms in general (*Falkenburger*, p. 94). The cranio-facial angle of the Santa Barbara skulls is like 87° in B, 92° in C, and 85° in D; in other words, it falls short of the ideal angle of 90° in B and D, and exceeds it in C. *Falkenburger* points out repeatedly his interesting observation that with increasing prognathism the cranio-facial angle also increases, an observation corroborated in the Santa Barbara skulls, and it is particularly the alveolar prognathism of C that must be held responsible for such deviation. In larger series the variation results correspondingly. The author (p. 84) gives, for instance, a range of variation for Australians of 86–96°, with an average of 90.6°. The Haida series of our table yielded averages of 89.0° and 88.1° in the sexes at a total variation of 86–92°. The two individual values of our table represent in the Australian the ideal angle of 90°, while the Swabian slightly exceeds it at 92°.

The parallelism between the nasion-basion and bregma-lambda lines also shows deviations resulting in either their anterior or posterior convergence. *Falkenburger* does not point out these possibilities, but they may be distinguished by a plus or a minus sign in the two cases. The two lines deviate in skull B at −3°, in skull C at +2°, and in E at −15°, which finds its explanation in part in the stronger declination of the nasion-basion line as expressed by the cranial base-angle of 33° in the males and 27° in the females. The two bregma-lambda lines, on the other hand, are nearly parallel, with parietal angles of 30° and 29° in specimens B and C, while an angle of 20° in D explains the stronger posterior divergence of the two lines in question. The averages of the Haida group fall on the plus side of the angle; the two individual values of the Australian and the European are found on the minus side.

Another relationship seems to obtain between the correlations described, and which are particularly noticeable in the varying figures of the Santa Barbara specimens. It is seen there that the higher "central angle" associates itself with a proportionately lower craniofacial angle and similarly a minus divergence of the basion-nasion and bregma-lambda lines, and vice versa. It appears as if these conditions represent a sort of compensatory adjustment of the varying dimensions within the cranial complex. They are not borne out, however, by the other figures of our table, but may be worthy of special study.

NORMA VERTICALIS

Following *Giuseppe Sergi's* (1893) tassonomic method of enclosing the skull contour of the vertical aspect within a geometrical or other definite outline, specimens B, C, and E are byrsoides in appearance, while D is somewhat more roundish on account of its greater frontal width. It resembles thus rather an ellipsoides or a sphenoides rotundus. The byrsoides differs from the ovoides, of which it is rather a subform, insofar as its outlines from the parietal bulgings forward are not continuously convex toward the frontal outline, but more or less concave, i.e., constricted in the temporal region. At the same time, the occipital contour is well rounded off, while the postorbital constriction is quite marked. The dotted outlines of skulls B, C, and E (pls. VII–IX), taken in ear-eye orientation at the height of the supraorbital margin, resemble thus those of a purse, as signified by the term byrsoides.[1] The outlines are amplified each by solid outlines at the height of the ear-eye plane proper. These fall entirely within the supra-orbital outlines posteriorly of the ear-frontal plane through the poria-points. In advance of it they transgress them, inclosing the zygomatic arches, bridging spacious temporal fossæ, and returning finally into the supra-orbital curve in skulls C and E, but still further exceeding it in B. This is indicative of a facial projection in the latter, which will be properly dealt with later (see page 51).

The skull C (♀) is slightly plagiocrane in consequence of a mild right parieto-occipital depression, a condition somewhat more pronounced in E (♂), and referred to on pages 12, 14, 32, 121.

The sutures, on the whole, show the typical regional differences. Of the coronal suture, the pars bregmatica is simple in the four skulls, broadly but insignificantly meandering in B, slightly serrate in the others, but somewhat obscured on account of disarticulation in C. They

[1] *Liddell and Scott's* dictionary gives the following translation: *ἡ βύρσα*, the skin stripped off, a wine-skin. In a wider sense this may have referred to the similarly shaped purse which is a direct etymological derivation.

correspond to forms I 1 and II 2 of *Oppenheim's* (1907) scheme. The pars complicata is individually different, showing rather large excursions of lively movement in B, while those of C and D are very complicated frizzy patterns, both comparable with numbers *1* and *3* of the same author's sutures of rarely occurring designs. The pars complicata of E, on the other hand, is somewhat simpler and may be likened to form IV 6. The partes temporales of the coronal sutures, again simplifying, represent an almost exact repetition of the pars bregmatica patterns.

The pars bregmatica of the sagittal sutures resembles quite precisely those of the coronal sutures. The pars verticis of B is composed of long and moderately narrow loops, only slightly simplified in the pars obelica, and continued as pars postica s. lambdica similar to the pars verticis. In C they are much more in keeping with the sutural character of the pars bregmatica of both, its sagittal and coronal sutures, although of stronger, somewhat irregular dentation. Here, likewise, the pars obelica is only slightly modified as against the vertex and lambda parts. The sutural patterns of the three portions of the sagittal sutures in B and C, outside of the partes bregmaticæ, may be likened to *Oppenheim's* II 5 and II 4.

Altogether livelier is the sagittal suture of D, which indeed refers to all four divisions of the latter and which differ between themselves. Thus, while the pars bregmatica of this suture and skull conforms to scheme IV 3, the pars verticis equals I 4, the pars obelica II 4, and the pars postica s. lambdica to III 7. Similarly agitated is the sagittal suture of E, whose first two divisions may be likened to I 3 and 4, while the pars obelica is more like II 3, and the short pars postica s. lambdica like IV 6.

The discussion of the lambdoid suture, although belonging rather to the norma occipitalis, may nevertheless have its place in this connection. In all human varieties this suture is the most complicated in its partes lambdoideæ and mediæ, while the third divisions, the partes astericæ, range with the simplest of all the cranial sutures. The partes lambdoideæ of B and C are comparatively less complicated than those of D and E, the former corresponding to *Oppenheim's* sutural patterns I 4 and II 3, while the latter conforms to the very complex types III 7 and IV 8. Following in character these divisions, the partes mediæ show slight differences in type, although exceeding in complication all the other sutures. Thus, while the pars media of B assumes a form like II 6, those of C and E are like III 8 and IV 8, the latter simply continuing the pattern of its pars lambdoidea. The lambdoid suture of D is not accounted for because of the defectiveness of this skull.

The three principal cranial sutures of our skulls, showing no signs of obliteration, are neither exceedingly complicated nor very simple, and may be classed, therefore, between the Europeans as the exponents of the former, and the Chinese of the latter condition.

The partes bregmaticæ of the coronal suture are only slightly inclined toward each other, as may be seen in fig. 1. With the bregma as a vertex, they form large coronal angles of 149° in B and 152° in C, 160° in D and 150° in E. According to *Martin* (1914, 749) this angle

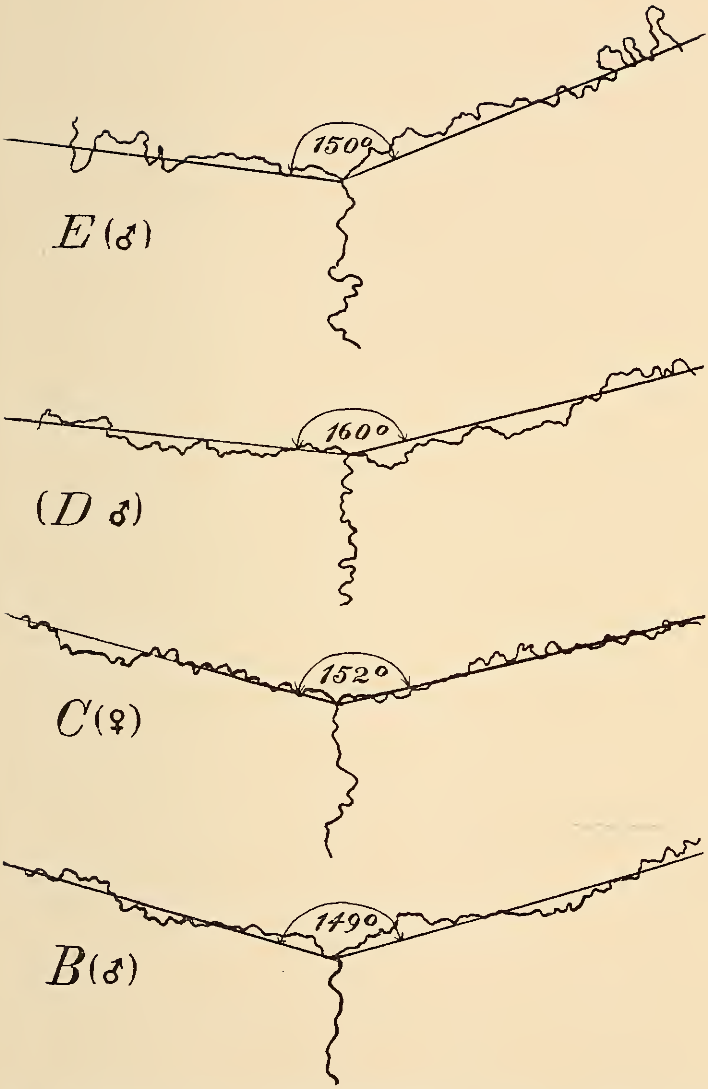

FIG. 1.—Coronal angle of partes bregmaticæ of coronal sutures in the Santa Barbara skulls

varies from 75° (Cebus) to 140° (Orang-utan) in simiidæ. It varies also in the human skull, short-headedness producing larger angles than long-headedness. Brüx, for instance, has a coronal angle of 125° only.

How variable the course of the coronal suture may be in a single series of skulls may be gained from fig. 2, *a-d*. They come from San Miguel island, California, and are contained in the collections of this Museum. In *a*, a fairly straight transverse course is to be noticed, while in *b* and *c* the two halves of the coronal suture slant forward, in *c*, however, swinging backward again and forming semicircular notches before the forward course is resumed. In *d* the great liveliness of the sutures, even of their partes bregmaticæ, is of particular interest. In illustration of what was remarked regarding the coronal angle in short- and long-headedness, it is to be stated that *a* belongs to the brachycranial variety, while *b-d* are mesocranial.

The foramina parietalia are much better developed in C than in B. While their typical number is two in the former, one on each side of the obelion portion of the sagittal suture, and at about 1 mm. in diameter, there is only one tiny foramen parietale on the left side of B. The foramina parietalia are entirely lacking in skulls D and E. It is just these two crania whose pars obelica of the sagittal suture was found to be rather complicated in contrast with the usual behavior there. This may have something to do with the absence of the foramina, suggesting a premature union of the two parietals in the obelion region of the occipital fontanelle and the suppression of the foramina. Variation as to multiple

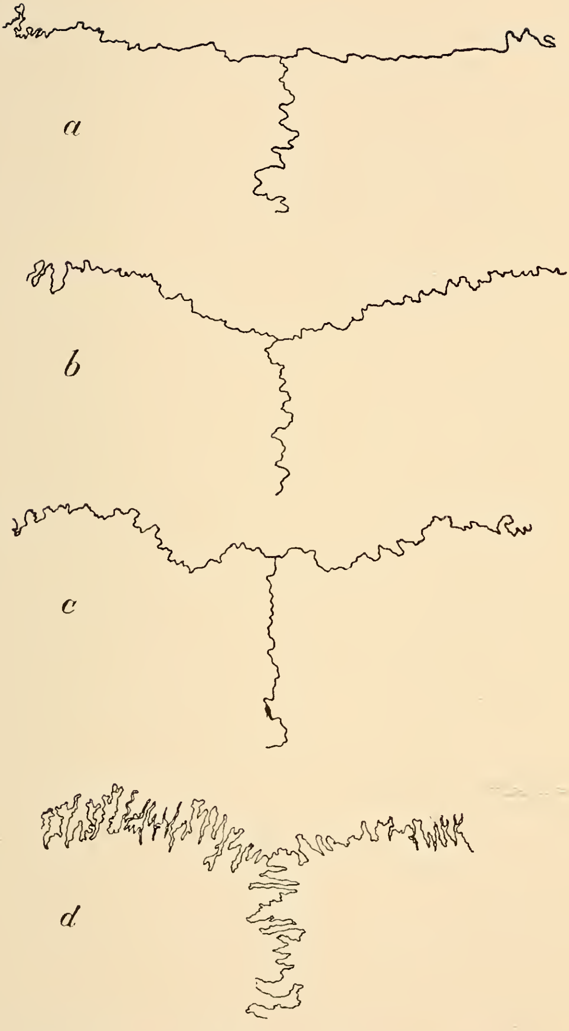

FIG. 2.—Diversity of the coronal suture in skulls from San Miguel Island, California. (M. A. I.)

or uneven occurrence is quite frequent, and total absence was noted in 19.2% in the undeformed skulls from the American North Pacific Coast.[1] *Hrdlička* (1916, 36) states that in almost half of the Lenape Indian skulls there are no parietal foramina at all.

Of the cranial dimensions observable in the norma verticalis, the length and breadth may first be discussed. The maximum length of our skulls amounts to 174 mm. in B, 167 mm. in C, 177 mm. in D, and 169 mm. in E. Within the physiological range of the cranial length measurements from a series of 84 adult skulls from San Miguel island, California, and extending from 168–193 mm. in men, our male skulls B and E occupy low stations, while D conforms exactly with the male average of 177.0 mm. The position of skull C in the female range of that series is similar to the position of B and E in the male range. Somewhat different falls the cranial breadth. Skulls B and D, with individual breadths of 141 mm. and 142 mm., hold about medium positions in the San Miguel male range of 130–151 mm., while E attains only to 134 mm. The cranial breadth of 131 mm. in the female skull C is almost in line with the lowest value of the female range of 130–140 mm. The cranial length and breadth of the Santa Barbara specimens are thus to be considered as rather submedium. The length-breadth indices computed from these figures render the two male skulls B and D brachycranial at 81.0 and 80.2, but E

[1] References to craniological conditions in the Pacific Northwest here and in other parts of this monograph are from the author's studies of the Jesup Expedition skeletal material, not yet published.

and the female skull C mesocranial at 79.3 and 78.4. The sex difference generally observed, of greater short-headedness of the female skull, does not obtain in our specimens; but it must be remembered that individual values only are dealt with here. Group averages of a larger number of skulls like those under discussion would quite probably be in keeping with that general condition. From the same point of view must be considered the slightly higher indices of the Santa Barbara male skulls, and the slightly lower index of the female, when compared with the San Miguel averages. Mesocrany with a tendency toward brachycrany is the character of both.

The minimum frontal breadth as an expression of post-orbital constriction (*Schwalbe* 1899, 62–63) amounts to 96 mm. and 94 mm. in the male skulls B and D, and 90 mm. in the female. Conspicuously low at 85 mm. is this measurement in the male E. It ranges thus below the figures 88–92 mm. which *Nehring* (1905) quotes as characteristically low for skulls from Brazilian Sambaquis. *Hooton* (1920, 93), on the other hand, found in the Madisonville (Ohio) crania averages of 94.97 mm. and 92.71 mm. in the two sexes, but the lowest values of his ranges drop to 87 mm. in the males and to 85 mm. in the females; both ranges, however, rise to 103 mm. Compared with the average value of minimum frontal breadth in brachycranial groups (*Martin* 1914, 759), namely 99 mm., all of our four values fall below that average. But their real significance becomes manifest if brought in proportion to the parietal breadth as expressed by the transverse fronto-parietal index. This index falls with 68.1 in B, 66.2 in D, and 68.7 in C, markedly below 77, which *Martin* (1914, 759) quotes as an average for brachycrany, but coincides with *Sullivan's* (1921) Andamanese at 68.1 and 67.8 for the two sexes, whose average cranial indices are 83.4 and 81.0. Considerably below that average lies the index of skull E, namely 63.4, and that on account of its minimum frontal breadth of only 85 mm. It is thus seen that, although the absolute frontal breadth measurements of our skulls B, C, and D are not excessively low, they appear to be so in the cranial complex. Nevertheless, they fall into the metriometopic class of the transverse fronto-parietal index. Quite different, of course, is the position of skull E, whose low index of 63.4 marks it stenometopic.

There is, however, a morphological detail which, in spite of the non-excessive minimum frontal breadth, adds to the impression of pronounced postorbital constriction: the horizontal trend of the processus zygomaticus of the frontal bone, and, in consequence thereof, the obvious lateral deviation of the crista temporalis of the frontal bone. This condition will more suitably be referred to in the discussion of the norma frontalis (page 83).

As to Indian skulls with narrow foreheads, there is in our collection the full-grown skull of a Carijo Indian of the Guarani stock of southern Brazil, with even a smaller minimum frontal breadth than that listed by *Nehring* for the Sambaqui skulls, namely 85 mm., which thus corresponds with our skull E. This Carijo skull is dolichocranial at 72.6, as against the mesocranial skull E at 79.3, its transverse fronto-parietal index dropping to 66.9 as compared with 63.4 in the same Santa Barbara skull. The lower index of the latter is due to its greater parietal (maximum cranial) breadth 134 mm. to 127 mm., while both min mum frontal breadths amount to 85 mm., as mentioned above. In consequence of the pronounced postorbital constriction in conjunction with bulging zygomatic arches, the latter are phænozygous in the vertical aspect, as shown in the photographic reproductions (pls. XXI–XXIII). The cranial measurements pertaining to the norma verticalis are listed in the following table.

HUMAN VARIETY	CRANIAL MEASUREMENTS				
	length *mm.*	breadth *mm.*	minimum frontal breadth *mm.*	$\frac{\text{breadth} \cdot 100}{\text{length}}$	$\frac{\text{minimum frontal breadth} \cdot 100}{\text{cranial breadth}}$
Santa Barbara					
B (♂)........	174	141	96	81.0	68.1
C (♀)........	167	131	90	78.4	68.7
(D ♂)........	177	142	94	80.2	66.2
E (♂)........	169	134	85.	79.3	63.4
San Miguel island					
Averages ♂	177.0	139.7	—	78.3	—
	(168–193)	(130–151)		(72.0–83.9)	
Averages ♀	170.0	135.3	—	79.2	—
	(164–175)	(130–140)		(77.1–83.3)	
Carijo (Brazil) ♂	175	127	85	72.6	66.9

NORMA LATERALIS

The main impression given by the outlines of the Santa Barbara skulls in side view is in addition to an even vaulting of the brain case, the bulging development of the postauricular portion, and the protrusion of the face. The frontal outline is mildly retreating, showing the typical flexion of the human forehead by the supraglabellar depression above weakly developed superciliary ridges. The frontal outline is continued into that of the parietal, which reaches its highest point behind the bregma, more so in skulls C and E than in B. In each of the skulls the postbregmatic elevation is perfectly absorbed by the evenness of the general outline. The extreme occipital extension is reached in B, D, and E by a slight curving fall from the vertex, which is somewhat more abrupt in C. The entire occipital curve is well rounded, with almost no indication of an inial flexure in B and C, owing to a very weak development of the occipital relief, which however is slightly more marked in D. The mastoid processes pointing forward at about 45° with the plane of ear-eye orientation are well developed, and of elegant form in B and E, but rather small and insignificant in C. The elliptic pori acustici externi are rather large in the three skulls, even somewhat wider in the female, and vertically oriented. The right porus of E is slightly compressed bilaterally, very probably in consequence of the depression on that side of the cranium referred to on pages 12, 14, 22, 121. The tympanic margins are only scantily thickened inferiorly and posteriorly, excessive thickening being very frequently found in Indian skulls of the Pacific area, as is well known, and in those of the Eskimo.

Turning now to the face, it will be noticed that the nasion shows no depression whatsoever. The nasal bones protrude somewhat in their lower portions, i.e., are convex in outline, particularly in skulls B and D, while the upper form deep concavities, but no side-to-side flattening. The facial protrusion, which is quite pronounced in B and C, is augmented by alveolar prognathism in the female skull C. It differs, however, from alveolar prognathism, for intance, of the Veddah, in whom the cousins *Sarasin* pointed out the enhancement of that condition by prodenty, i.e., the strongly inclining incisor teeth. In the Santa Barbara female skull the teeth are vertically set and labidodont with those of the lower jaw. In the teeth of skulls B and C, which are fairly complete in both skulls, the plane of mastication is convexly rounded in the upper jaws, and in the fore-to-aft direction, while that of the lower jaw forms a compensatory concavity for complete occlusion of the two dental rows. Those of E do not exhibit this condition. The chins are only slightly protruding, a feature in keeping with the Mongoloid characteristics.

Muscle marks are rather weakly developed, except the temporal ones in B and E. The temporal crest of the frontal bone in the former is strong and sharp. The lineæ temporales, into which it continues in an even curve, are well marked. The upper temporal line diverges from the frontal crest about 2.5 cm. before it reaches the coronal suture, the zonula circummuscularis becoming wider and comprising the parietal bump. In a sharp turn and continuing along the lambdoid suture they terminate in the mastoid region, the zonula circummuscularis diminishing in width at the same time. The asterion region is somewhat rugged, less so the area of muscular insertion (mm. sternocleidomastoideus and splenius capitis) on the outside of the mastoids. The female skull has all these details in a less marked degree, although the mastoid outer surface is more rugged than that of the male, and in spite of much smaller mastoid processes. The cristæ supramastoideæ are well marked, although not excessively, in our specimens, and correspond more or less with the conditions generally met in Indian skulls of the Pacific Coast. The supramastoid fossæ are for that reason not very deep.

The shape of the temporal squama differs in our skulls, tending to be shorter and higher in B, and longer and lower in C and E. It is a general observation that, in connection with the former, deeper cut mastoid incisures are found, i.e., incisuræ of an angularity of 90° or less. How different, however, the conditions may be found in one and the same skull is demonstrated by fig. 3, *a* and *b*, where the two temporal squamæ of B are shown in contraposition. Of about equal height, the right squama produces a sharp-angled incisura mastoidea, while on the left side it is indicated by a shallow concavity only. The formation of an incisura mastoidea comes about occasionally by the crista supramastoidea forming a triangular ridge-like projection of the temporal squama. This temporal ridge is sometimes found continued as a parietal one upon the parietal bone, where it then terminates thinning or sickle-shape, as is the case in a mild form in skull E. Both formations are shown in fig. 4, *a*, *b*, the thorn-like one being that of a Bellacoola male (no. 4626, American Museum of Natural History), the ridge belonging to a male Haida (no. 3738, same).

The first case in particular is instructive for the reason that the low squama temporal's would very probably

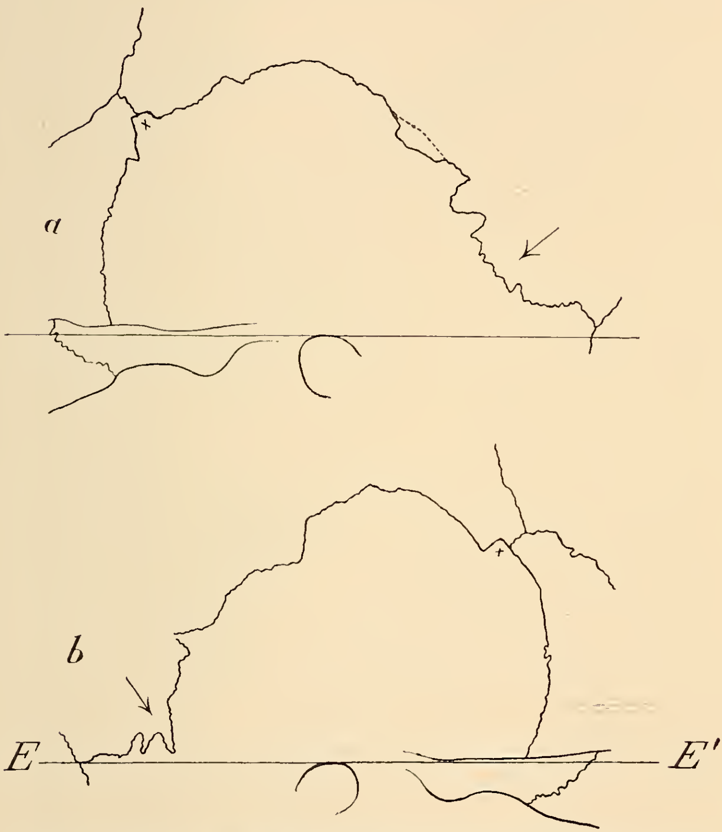

FIG. 3.—Right and left squama temporalis of Santa Barbara B (♂) to show difference of incisuræ mastoideæ (see arrows) and incipient stages of processus frontales (x). *a*, left squama; *b*, right squama; *E—E′*, ear-eye plane. (About $\frac{2}{3}$ natural size.)

have been without a parietal incisura were it not for the triangular projection of the supramastoid crista, the

FIG. 4.—Crista supramastoidea projecting upon parietal bone. *a*, thorn-like ($\frac{2}{3}$ natural size); *b*, sickle-like (natural size)

latter continuing very slightly upon the parietal. Stronger parietal projections are quite frequently encountered in skulls from the Pacific Northwest, as mentioned on page 33.

The squamosal sutures are very simple, on the whole, becoming slightly livelier posteriorly. The zygomatic processes of the temporal squamæ in B and E incline very slightly and reach their maximum depression at a point above the anterior slope of the well-developed articular tubercles. From this point they rise again to continue evenly into the temporal processes of the zygomatic bones. In C the arcus are perfectly straight. Both these forms show too little significance to associate them with racial types; they occur in Europeans, Negroes, and Mongoloids.

The temporal squamæ of B are markedly bulged laterally, signifying a better development of the temporal lobes of the brain as compared with more plane surfaces of the squamæ in C and E. The sulcus sphenoparietalis (*Schwalbe*), indicative on the cranial outside of the dividing furrow of the fronto-parietal and temporal lobes of the brain (*fissura Sylvii*), is therefore somewhat more distinct in the male skull B.

The fossæ temporales are spacious transversely, as well as longitudinally, especially in the female skull. Here and in E this state is recognizable by the greater length of the spheno-parietal suture and the greater width of the ala magna. In skull B, on the other hand, the temporal squama extends farther forward into the fossa temporalis, thus shortening the length of the latter. For a better understanding of the size and depth of the tem-

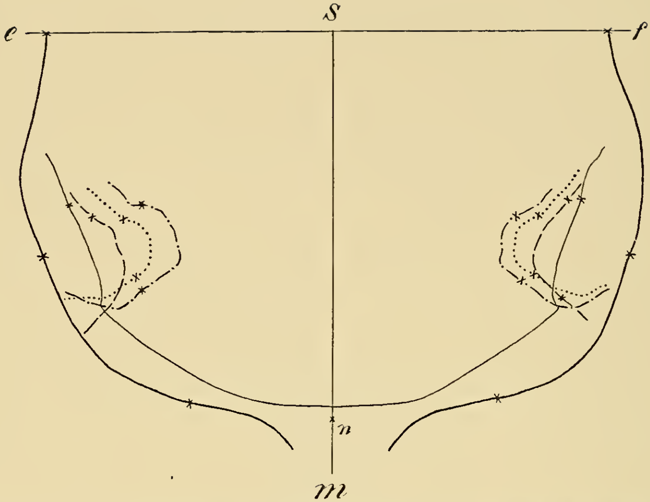

FIG. 5.—Tracings of fossa temporalis of skull B (♂) in ear-eye orientation, on a level with: ——— ear-eye plane; ——— minimum frontal breadth; - - - - - zygomatico-frontal suture; . . . . ektokonchion; —.—.— crista infratemporalis. *e—f*, ear-frontal; *m—s*, median sagittal plane. (½ natural size.)

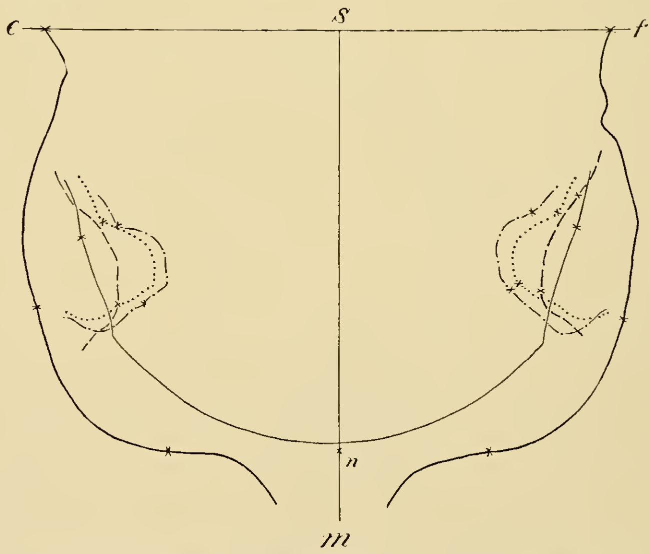

FIG. 6.—Tracings of fossa temporalis of skull C (♀) in ear-eye orientation. Levels and markings as in fig. 5. (½ natural size)

poral fossæ of our three skulls, their outlines have been traced at different levels as shown in figs. 5–7. Enclosed in a facial curve coinciding with the ear-eye plane, the temporal fossæ have been traced at the four different levels of the minimum frontal breadth, the zygomatico-frontal suture, the ektokonchion, and the crista infra-

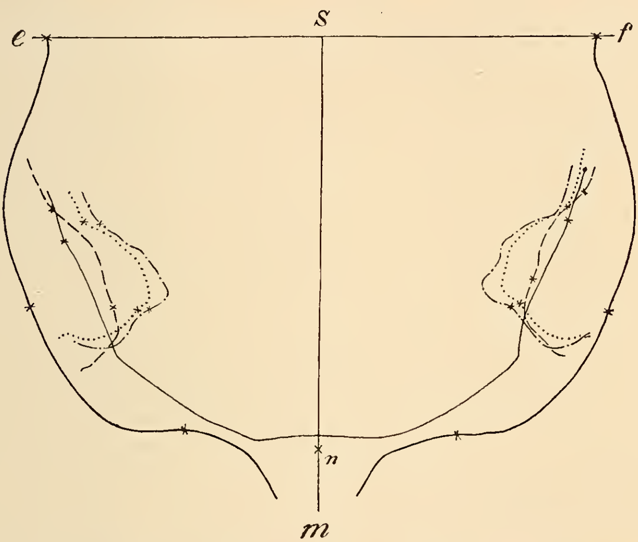

FIG. 7.—Tracings of fossa temporalis of skull E (♂) in ear-eye orientation Levels and markings as in fig. 5. (½ natural size)

temporalis. The latter illustrates in every case the greatest depth of the temporal fossæ, which gradually diminishes upward. The curve systems are supplemented by the next table of measurements. It gives the length of the fossa temporalis as taken between the deepest point of the notch of the zygomatic process of the temporal bone, and the sutura zygomaticomaxillaris on its temporal course, and at half the corpus height of the zygomatic bone; the width of the temporal fossa as measured between the crista infratemporalis[1] and the temporal surface of the zygomatic arch, parallel with the frontal plane; the index derived from these two measurements; the length of the sphenoparietal suture between the krotaphion and sphenion measuring points; the combined lengths of the sphenoparietal and sphenofrontal sutures, directly between the krotaphion and sphenofrontale (mihi; the point of meeting of the sphenofrontal and sphenozygomatic sutures); the projective distance between the krotaphion and frontotemporale, the latter indicating on the crista temporalis of the frontal bone the point of greatest frontal constriction.

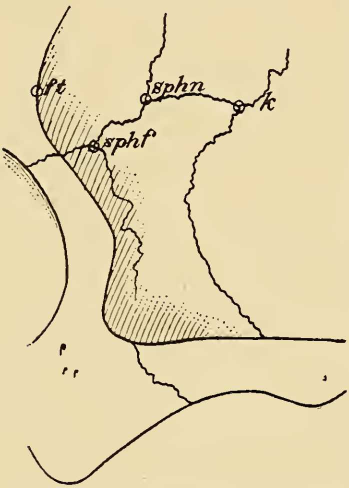

Fig. 8.—Anatomical configuration and landmarks of fossa temporalis. *ft*, frontotemporale; *sphf*, sphenofrontale; *sphn*, sphenion; *k*, krotaphion.

The anatomical configuration in the fossa temporalis and the landmarks are illustrated in fig. 8.

The table, with a few additions, lists only the Santa Barbara data and may be used as a model for future comparative study.

[1] The tuberculum spinosum of the crista infratemporalis may be recommended as a measuring point, if not so bulky as to modify the true width of the temporal fossa.

HUMAN VARIETY	FOSSA TEMPORALIS*											
	length		width		$\frac{\text{width} \cdot 100}{\text{length}}$		Krotaphion-sphenion†		Krotaphion-sphenofrontale		Krotaphion-frontotemporale	
	r	l	r	l	r	l	r	l	r	l	r	l
Santa Barbara	*											
B (♂)	38	38	30	28	78.9	73.7	4	7	28	28	31	31
C (♀)	42	40	30	30	71.4	75.0	14	16	33	34	37	42
E (♂)	41	42	28	29	68.3	69.0	14	16	37	38	41	44
Eskimo‡ ♂	—	—	29		—	--	—	—	—	—	—	—
Eskimo‡ ♀	—	—	27		—	--	—	—	—	—	—	—
Europeans‡	—	—	25.5		—	—	—	—	—	—	—	—

* The measurements are in millimeters.
† For explanations see text immediately preceding.
‡ *Cameron* 1923, p.c. 39.

The difference of dimension between the two sides of the skull is the rule in the listings of this table. The length-width index of the fossa temporalis is more influenced by its variable length than by its width, which is more stable. The male width is quite in keeping with *Cameron's* figure for Eskimo, while his female Eskimo range below the female Santa Barbara skull. The Europeans have a width of only 25.5 mm.; it must be taken in consideration, however, that the zygomatic bridge, which is involved in this measurement, represents a racially differing feature. Coinciding with the low indices of our skull E (♂) are seen the high sutural lengths as compared with those of B (♂) and C (♀), a fact already referred to.

Additional mention should be made regarding the sphenoparietal suture of skull B. Approaching the stenocrotaphic state[1] with a length of only 4 mm., the left suture takes a strong upward turn. The krotaphion is situated on the summit of a trapezoid projection of the temporal squama, denoting an incipient stage of the processus frontalis.

This condition is prompted on the right side of skull B by a sharp rectangular forward turn of the squamosal suture, which latter is evenly continued into the spheno-squamosal suture. Fig. 3, *a*, *b*, depict these slightly irregular appearances.

The shape of the processus frontosphenoidalis is rather slender and high in our three skulls, with marginal processes hardly indicated. In the fragments of skull A, however, the frontosphenoidal process is somewhat more robust, and the marginal one well developed. The height of the processus frontosphenoidalis in our skulls is influenced by the more horizontally directed zygomatic processes of the frontal bone, particularly in skull B. The bearing of this condition on the production and

[1] A stenocrotaphic state is reached with a length of 3–0 mm. of the sutura sphenoparietalis (*R. Virchow* 1875, 52). *Lange* (1924, 373) has found that the greatest absolute length of the suture occurs in Europeans; it is less extended in the Negroes, and shortest in the Australians. Stenocrotaphy was noted in the undeformed North Pacific crania in 0.8% on the right, 1.6% on the left, and 0.8% on both sides. This insignificant frequency does not conform with *Anutschin's* (*Martin* 1914, 780) findings of 3.0 % in Mongols of North Asia, 5.8% in Mongols in general, and even 8.2% in Chinese. It is an interesting fact, however, that the frequency of stenocrotaphy rises in the deformed skulls of the North Pacific Coast.

extent of postorbital constriction is referred to on page 30 and will be further discussed on page 83. In a previous publication (*Oetteking* 1919) racial differences prevailing in this region as concerns the shape and lateral recession of the process under discussion have been pointed out. It was shown there that among European, Eskimo, and Negro, the first named held a medium position as regards the recession of the processus frontosphenoidalis. Measured in lateral projection between the medial and lateral borders of the left orbit (maxillofrontale-ektokonchion), the greatest distance amounted to 9 mm. in the Eskimo, 13 mm. in the European, and 16 mm. in the Negro. Our three skulls, with 14 mm. in B, and 12 mm. each in C and E, thus conform with medium conditions as represented by Europeans. The orbital measurements in general are treated on pages 91, 98.

Among the main measurements observable in norma lateralis are those of the cranial length and height. The former has been discussed in connection with the norma verticalis. The basion-bregma height of B is 134 mm., of C 125 mm., and of E 133 mm. Compared with the height averages of 129.9 mm. and 122.4 mm. of the two sexes of the San Miguel skull series, the cranial heights of the Santa Barbara skulls exceed them. This is demonstrated also by their relative position within the ranges of variation of 120–139 mm. and 115–130 mm. for the San Miguel males and females. The length-height index becomes accordingly 77.0 for skull B, 74.9 for skull C, and 78.7 for skull E, rendering the two males hypsicranial, the female orthocranial, but at the border line of orthocrany and hypsicrany. The relatively high individual values of the length-height index of the Santa Barbara crania are somewhat disproportionate to the San Miguel averages of 72.5 and 71.4 in the two sexes, although covered by the range of variation of the latter. The difference is due, as will be seen from the table of measurements, to both the greater length and the lesser height of the San Miguel skulls. In dolichocranial Mongoloid varieties like the Eastern Eskimo, the length-height index is naturally decisively influenced by the relatively greater cranial length. Thus, while the basion-bregma height in that human variety (*Oetteking* 1909) yielded an average as high as 134.6 mm., at a range of from 128–144 mm., the length-height index yielded only an orthocranial average of 73.7, owing to the greater cranial length averaging 182.3 mm. from a range of 171–200 mm. Chamæcrany, on the other hand, is the prevailing condition in the paleolithic skulls (La Chapelle-aux-Saints = 62.9, and approximately: Piltdown = 68.4; Galley Hill = 67.4), owing here to their excessive cranial length, which amounts to 208 mm. in the first-named skull.

The cranial ear-heights (porion-bregma) nearly coincide with 112 mm. in B and 111 mm. in C, while E has only 109 mm. A pronounced sex difference was noticed in the San Miguel skulls, where the males attained an average of 111.2 mm. against 104.2 mm. for the females. The difference between their basion-bregma and porion-bregma heights is the result of different infraporial extension. The basion-porion portions of the cranial height measure 22 mm. in B, 14 mm. in C, and 26 mm. in E, showing the two male skulls considerably in excess of the female skull. This seems to be the general condition between the two sexes, although *R. Virchow* (quoted by *R. Martin* 1914, 691) found the position of the porion to be higher in Frisian women. In our frequently mentioned San Miguel series there is an average infraporial extension of 20.3 mm. in men and 17.9 mm. in women, varying from 13 mm. to 30 mm. and 12 mm. to 24 mm. respectively. Males and females combined yield an average of 19.9 mm., which ranges among the highest quoted by *Martin* (p. 691), comprising the Maori with 19.4 mm., Papuans with 20.3 mm., and Old Egyptians with 21.6 mm. The infraporial height varies according to the same author from 6 mm. to 26 mm. in the human varieties.

The ear-heights brought into proportion with the length measurements of 174 mm., 167 mm., and 169 mm., in the three Santa Barbara skulls, give rise to indices of 64.4 for B, 66.5 for C, and 63.9 for E. Applying for the ear-height index the same nomenclature as used for the cranial height index, all our skulls turn out hypsicranial, the female even more than the two males. The ear-height index reverses somewhat the calculations of our cranial height index in so far as skull C (♀), which was found to be orthocranial by the latter, is hypsicranial by the former, and even exceeds the two male skulls in ear-height hypsicrany. The reason is to be seen, first, in the smaller infraporial extension of the height diameter in C, and, secondly, its smaller cranial length. The San Miguel averages of the ear-height index at 61+ are orthocranial, although their range of variation comprises also a number of hypsicranial individuals.

From a general point of view it seems that the peoples of Mongol extraction manifest a tendency toward hypsicrany, while the true Mongols (Buriat, Ostiak, Kalmuck) are rather platycranial.

The measurements just discussed are listed in the following table.

HUMAN VARIETY	CRANIAL HEIGHT MEASUREMENTS					
	length *mm.*	height *mm.*	$\frac{\text{height} \cdot 100}{\text{length}}$	Infraporial height (basion-porion) *mm.*	Porion bregma height (ear height) *mm.*	$\frac{\text{Ear height} \cdot 100}{\text{length}}$
Santa Barbara						
B (♂)	174	134	77.0	22	112	64.4
C (♀)	167	125	74.9	14	111	66.5
E (♂)	169	133	78.7	26	109	63.9
San Miguel island						
Averages ♂	177 (168–193)	129.9 (120–139)	72.5 (66.3–79.3)	20.3 (13–30)	111.2 (100–118)	61.5 (56.8–66.7)
Averages ♀	170 (164–175)	122.4 (115–130)	71.4 (66.9–76.0)	17.9 (12–24)	104.2 (100–118)	61.3 (59.4–64.9)

The median-sagittal arc is, with 359 mm., largest in the male B, while that of the other male, E, measures 342 mm., and the female, C, only 340 mm. This is in conformity with about average conditions on the coast of southern California, but conspicuously less than the averages of tribes farther north, like the Haida with male and female averages of 371.2 mm. and 355.2 mm., or the Western Eskimo at 366.4 mm. and 356.6 mm.

Of greater interest is the participation of the individual arcs that constitute the median-sagittal arc. The proportional lengths of the frontal, parietal, and occipital divisions are as 119–120–120 mm. in B, 114–126–100 mm. in C, and 113–105–124 mm. in E. The parietal arc exceeding both the frontal and occipital arcs in true human proportion is the condition met in the female skull C, and is only conditionally true of B. Here the three participants are almost of the same length, which is the exact proportion between the parietal and occipital arcs, while the frontal is only 1 mm. in default. The two arcs of the skull cap D, with 121 mm. for the frontal and 123 mm. for the parietal, retain the proportion as met in B and C. Fully out of the ordinary are the proportions of skull E, with 113–105–124 mm. The parietal arc is exceeded here by both the frontal and the occipital, owing in the latter perhaps to the excessive development of the interparietal part of the occipital squama. Agreeing with *Schwalbe* that in 50% of human skulls the frontal arc exceeds the parietal, while in 42.8% the reverse is true as a progressive proportion, the remainder going to the proportion of equality, skulls B, C, and D are seen to conform with the progressive state, while E marks in every respect the opposite. Equality of frontal and parietal arcs at 121 mm. was noted in La Chapelle-aux-Saints. The larger frontal arc, however, seems to be the prevailing condition in the undeformed skulls from the North Pacific Coast, where the three proportions—frontal arc greater than parietal, equal with parietal, or smaller than parietal—occur in the males in the proportions 82.1%–3.8%–14.1%, and in the females in 82.3%–5.9%–11.8%.

The measurements just discussed are combined in the following table.

HUMAN VARIETY	MEDIAN-SAGITTAL ARC							
	Arc				Fronto-parietal proportions			
	Median-sagittal mm.	Frontal mm.	Parietal mm.	Occipital mm.	Par. arc · 100 / front. arc	F>P %	F=P %	F<P %
Santa Barbara....	..							
B (♂).........	359	119	120	120	100.8	—	—	—
C (♀).........	340	114	126	100	110.5	—	—	—
(D ♂).........	—	121	123	—	101.7	—	—	—
E (♂).........	342	113	105	124	92.9	—	—	—
North Pacific Coast Undeformed								
Averages ♂...	363.6 (317–395)	127.2 (109–145)	119 (88–139)	117.6 (103–140)	93.6	82.1	3.8	14.1
Averages ♀...	350 (325–380)	122.3 (113–135)	115 (102–131)	112 (98–123)	95.6	82.3	5.9	11.8
La Chapelle-aux-Saints............	357	121	121	115	100.0	—	—	—

Important in a racial diagnosis are declination and curvature of the frontal bone, because both determine the relative position of the forehead in the cranial complex. *Hrdlička* (1907, 1908) has repeatedly called attention to the "low forehead" in non-deformed Indian skulls, but without proving his observations methodically. From his comments it is quite clear that low vaulting, as well as different degrees of sloping, was involved. At first glance our three skulls give the impression of the distinctive development of both those conditions. However, this is somewhat deceptive with regard to the declination of the frontal bone, as will be seen. The angles formed by the nasion-bregma chord with a parallel of the ear-eye plane passing through the nasion are 48° in B and E, and 51° in C, thus preserving between themselves the predominance of the female angle over the male—the condition most frequently present. The Santa Barbara skulls fall well within the variation of, for instance, the San Miguel islanders of (39) 43–54°, and whose averages are 47.2° for the males and 46.4° for the females. Lower averages, at least for the males, were found for the Haida, namely, 43.6° and 50.4°, while the Western Eskimo have 46.1° in both sexes. Taking further into consideration the averages of North Pacific undeformed skulls, amounting to 46.0° and 48.1° in the two sexes, the variations running from 40° to 54° and 43° to 54° respectively, it is clear that we cannot attribute to our skulls any exceptional position among the Pacific groups as regards the declination of the frontal bone. It may be of interest to cite in this connection the declination of the frontal bone in the La Chapelle-aux-Saints skull which, on account of its fair state of preservation among the Neandertaloids, admits of an orientation in the ear-eye plane. *Fr. Sarasin* (1916–1922, 210) found in that specimen an angle of frontal declination of 48°, which curiously enough coincides with that of the Santa Barbara males. The same author gives a European average of 49.5°, which as such demonstrates the predominance of the European frontal angle, although the Haida female average reached as high as 50.4°. An obvious difference was noted in seven Chimpanzee skulls with an average of 35°.

The impression of low frontal vaulting, as mentioned above, is borne out by the measurements. The median-sagittal frontal index amounts to 91+ in skulls B, D, and E, and 92.1 in skull C, expressing well-marked flatness of the frontal vault. Drawing the line at 90 between orthometopism and chamæmetopism, our skulls are seen to be chamæmetopic, and the female more so than the males. The indices mark a condition of flatness which exceeds all the racial averages of *Martin's* (1914, 765) table, and which occur there between the figures 87.1 and 89.1. Their indices exceed even the highest individual indices of the Haida at 90.8 and 89.7, and of the Eskimo at 90.5 and 91.1 in the two sexes, while the San Miguel Island skulls comprise individual indices as high as 96.8 in the males and 91.2 in the females, which latter is level with the Santa Barbara males. Astonishing again is the well-curved forehead in the Neandertaloids at 87, conforming with the European average. The Chimpanzee skulls also, at 89.5, have better vaulted frontals. These conditions are likewise expressible by the angle of frontal curvature which is formed by two lines extending from the point of highest elevation of the median-sagittal frontal curve above its chord (frontal acrion [mihi], to distinguish it from the parietal and occipital acria) to the nasion and bregma respectively. Depending somewhat on the length of the chord, the angle nevertheless is expressive of the frontal curvature in such a way that the greater angle indicates the lesser vaulting, and vice versa. Our specimens B and C present angles of 140° each, while E rises to 142°, but D attains to only 135°. Comparing these figures (see table) with those given by *R. Martin* (1914, 766), it is immediately observed that the Santa Barbara skulls range with the Neandertal skull. Compared with the averages given for Alsatians and Australians, Neandertal, as well as our skulls shows a distinctly flatter forehead.

The glabella-projection is only mildly developed. As the highest points of the glabellar curves do not in anterior projection exceed the nasion in the properly oriented skulls (ear-eye plane), *Mollison's* (1908, 575) index of glabella-projection in advance of the nasion-vertical and glabella-height above the nasion-horizontal was not applicable. Thus another method based on absolute measurements had to be resorted to. The most reliable of several methods that offered themselves seemed to be that proposed by *Fr. Sarasin* (p. 211), who computed an index from the glabellar arc and chord, the latter marking the distance between the nasion and supraglabellare, i.e., the deepest point between the fronto-glabellar and fronto-cerebral median-sagittal curves. The indices derived from the absolute measurements for the glabellar arc and chord differing 1–2 mm. in the individual skulls, are in B and C 95.8 and 96.0, and in D and E 92.0 and 92.3. Although these indices are indicative of only slight bulging, *Fr. Sarasin* gives an average for European men of 98, signifying a still less vaulted glabella than that of the Santa Barbara. His New-Caledonian men yielded a markedly lower average of only 91.1 in illustration of strong glabellar vaulting, at a variation of 82.8–97.8, but a female one of 97.2, ranging 92.2–100.0. For further comparison

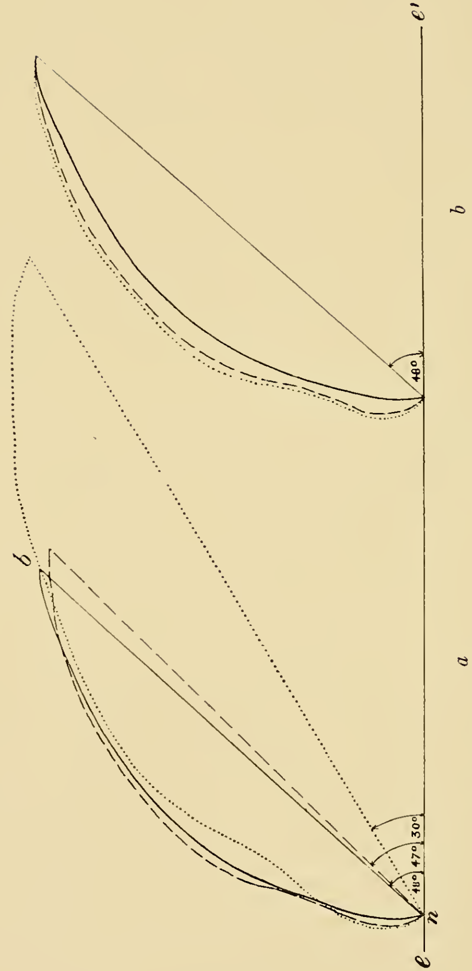

FIG. 9.—Median-sagittal frontal outlines in superposition: *a*, in natural size and individual angularity; *b*, sizes and angles adjusted to those of skull B. ——— Santa Barbara B (♂); – – – – Swabian (No. 4555, A. M. N. H.); . . . . Neandertal. *e*—*e′*, parallel of ear-eye plane passing through *n*, nasion; *b*, bregma; ∠ *b*—*n*—*e′*, angle of frontal declination. (½ natural size.)

Fr. Sarasin's findings upon Neandertaloid crania may be given, namely, 80–83, and it is furthermore seen that his lowest New-Caledonian male of 82.8 fits with those. The glabellar protrusion is naturally greatest in a series of Chimpanzee skulls at an average of 78.1 from a range of 70.1–81.8.

In order to show some of these conditions in a graphic way, the frontal outlines of a European and the Neandertal calotte have been superposed in fig. 9, *a*, upon that of our skull B. They are oriented on the ear-eye plane at their individual angles of frontal declination. The Neandertal outline was approximately oriented on the ear-eye plane in such a way that in adjustment with the orientation of skull B, the angular difference between this skull's ear-eye and nasion-inion lines (which latter is the line of orientation of the Neandertal calotte!) was subtracted from the frontal angle of the Neandertal. The result is an angle of 30°. This procedure is justified only in this particular case in view of the fact that the frontal angle of B represents in a way an average condition of frontal angularity; it is by no means supposed to be final. In *b* of the same figure the same three outlines as in *a* are again superposed, the frontal chords reduced to the length of that of B, and their angles of frontal declination adjusted to the latter's angle of 48°. This shows to better advantage the differing amount of frontal vaulting, disclosing at the same time the more pronounced one of the Neandertal forehead which exceeds even that of the European.

The measurements discussed in connection with the frontal bone are assembled in the next table.

HUMAN VARIETY AND ANTHROPOIDS	OS FRONTALE							
	∠ Nasion-bregma (ear-eye plane)	Median-sagittal			Glabellar			∠ Frontal curvature (nasion-acrion-bregma*)
		arc *mm.*	chord *mm.*	chord·100 / arc	arc *mm.*	chord *mm.*	chord·100 / arc	
Santa Barbara								
B (♂)	48°	119	109	91.6	24	23	95.8	140°
C (♀)	51°	114	105	92.1	25	24	96.0	140°
(D ♂)	—	121	108	91.2	25	23	92.0	135°
E (♂)	48°	130	103	91.2	26	24	92.3	142°
San Miguel island					New Caledonians (*Fr. Sarasin*, 1916–1922) ♂ 26.7 (21.0–34.0) ♀ 22.7 (19.0–26.0)	♂ 24.3 (20.0–29.5) ♀ 22.0 (19.0–24.5)	♂ 91.1 (82.8–97.8) ♀ 97.2 (92.2–100.0)	§ Alsatians 130° ♂, 131° ♀; Australians 131°; Kalmucks 136°; Neandertal 139°; Spy I 151°
Averages ♂	47.2° [(39)43–54]	122.3 (109–140)	109.8 (101–120)	88.7 (83.1–96.8)				
Averages ♀	46.4° (44–50)	118.5 (114–124)	104.3 (98–113)	88.7 (84.7–91.2)				
Haida								
Averages ♂	43.6° (40–54)	129.3 (118–145)	113.8 (105–145)	88.1 (85.0–90.8)				

Eskimo, Averages ♀	50.4° (46–54)	123.7 (117–133)	109.0 (104–115)	88.1 (85.7–89.7)				
Eskimo, Averages ♂	46.1° (41–53)	129.3 (118–145)	113.8 (106–128)	88.1 (84.9–90.5)				
Eskimo, Averages ♀	46.1° (43–52)	124.7 (121–135)	110.2 (107–117)	88.4 (85.9–91.1)				
Europeans† ♂	49.5° (46–54)	—	—	87.4 (85.4–89.3)	—	—	98 (96–100)	—
La Chapelle-aux-Saints†	48°	—	—	87.5–88	—	—	80–83	—
Chimpanzee†	35° (31–41)	—	—	89.5 (87.1–90.8)	—	—	78.1 (70.1–81.8)	—
Neandertal‡	—	133	119	87.2	—	—	80–83	—

* The angle is formed by two lines connecting the nasion and bregma points with the greatest elevation of the medium sagittal frontal curve (*R. Martin* 1914, 536). The present writer proposes for this hitherto unnamed point the term acrion (from ἄκρος, highest, apex), which may be distinguished as a frontal, parietal, or occipital one.

† *Fr. Sarasin* (1916–1922, 205 sq.).

‡ *Schwalbe* 1899.

§ *R Martin* 1914, 766.

Following up the cranial outline posteriorly, a marked post-bregmatic elevation is noticed. This is particularly true of the female skull and coincidental with its higher sagittal frontal index. As the maximum or total cranial height is rarely identical with the basion-bregma height, it is quite natural that the highest point of the cranial vault, the vertex, falls behind the bregma also in European skulls. But pronounced cases may duly

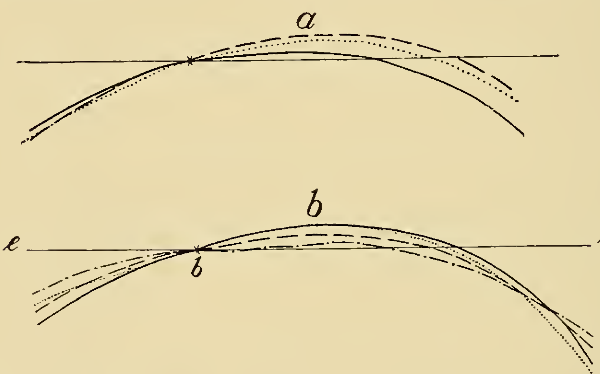

FIG. 10.—Post-bregmatic elevation. Superposition of outlines: *a.* ——— Santa Barbara B (♂); - - - - - - Santa Barbara C (♀); . . . . . . Santa Barbara E (♂). *b.* ——— Santa Barbara C (♀); - - - - - Swabian (No. 4555, A. M. N. H.); . . . . . . Senoi (*Martin* 1905); —.—.— Ainu (No. 1634, A. M. N. H.). *e—e′*, parallel to ear-eye plane through *b*, bregma. (½ natural size.)

be signified as morphologically inferior, especially if accompanied by low vaulting of the forehead as in our skulls, which again is commensurate with the development of the frontal brain. A comparative demonstration of these conditions has been attempted in fig. 10, *a*, *b*, where the horizontal e-e′ is a parallel to the ear-eye plane laid through the bregma. In *a* the differences of post-bregmatic elevation are shown in our three skulls, C exceeding B and E, and amounting to 5 mm. as against 2 mm. and 4 mm., and occurring 3 cm. behind the bregma in C and E, and 2 cm. in B. In *b*, the parietal outlines of a Senoi, a Swabian, and an Aino are seen superposed upon that of C, which represents the highest postbregmatic elevation. This racial order of individual values is, of course, fortuitous. It is of interest, however, that the outline of highest post-bregmatic elevation coincides with low, and that of least elevation with high, frontal vaulting.

The parietal angle between the bregma-lambda line and a parallel to the ear-eye plane passing through the lambda is not affected by the post-bregmatic elevation, since its variation depends on quite different factors, such as the position of the bregma and lambda, and post-bregmatic extension of the skull. The angles are fairly identical at 30° in the male B, and 29° in the female C, but it drops to 20° in E, owing to the comparatively shorter parietal arc which is compensated by an occipital arc of considerable length. The first two values conform exactly with the averages of the Western Eskimo. The Haida, on the other hand, have slightly lower averages of 27° in both sexes, resulting quite probably from their tendency toward longheadedness.

The sagittal parietal vaulting is well developed and illustrates, with indices of 89.2, 86.5, 87.8, and 91.4 for skulls B, C, D, and E, the variable conditions generally met in Indian skulls. The higher male indices indicating a slightly flatter bend seem to be likewise a generally prevailing condition, which is corroborated by the Haida and Eskimo indices in the subjoined table, where the factors underlying the sagittal parietal index also are listed. It will be noted that the averages for the parietal arcs of the Santa Barbara skulls, as well as of the groups mentioned there, present values near 120 mm. This is in conformity with the average value for the median-sagittal parietal arc in brachycrany which *R. Martin* (1914, 747) gives as 122 mm., while that of dolichocrany lies at 130 mm.

HUMAN VARIETY	OS PARIETALE			
	Median-sagittal			∠ bregma-lambda on ear-eye plane
	arc *mm.*	chord *mm.*	$\frac{\text{chord}\cdot 100}{\text{arc}}$	
Santa Barbara				
B (♂).......	120	107	89.2	30°
C (♀).......	126	109	86.5	30°
(D ♂).......	123	108	87.8	—
E (♂).......	105	96	91.4	20°
Haida (♂)				
Averages ♂...	119.6	107.7	89.9	27.4°
	(103–134)	(94–120)	(83.1–92.5)	(20–38)
Averages ♀...	119.8	105.8	88.1	27.8°
	(115–131)	(101–115)	(86.4–90.4)	(23–33)
Eskimo (Western)				
Averages ♂...	121.5	108.4	89.3	30.2°
	(107–139)	(98–117)	(81.3–92.9)	(24–38)
Averages ♀...	117.7	104.7	88.9	29.5°
	(110–131)	(98–115)	(86.5–90.3)	(27–38)

What was said with respect to the median-sagittal parietal vaulting does not hold true for the occipital one. The higher indices here, indicating lesser curvature, are those of the females. Skull C (♀) has a median-sagittal occipital index of 87.0, while the corresponding indices of B (♂) and E (♂) are 83.3 and 84.7. But the remarkable fact about the entire posterior outline (bregma-opisthion) in Santa Barbara specimens B and C, less so in E, is the almost semicircular bulging with hardly any interruption at the lambda or inion. *Martin* (1905, 465–466) describes this condition as characteristic of the Senoi and as depending partly upon the position, i.e., declination of the planum nuchale of the occipital bone, as indicated by an angle between the opisthion-inion line and the ear-eye plane, or rather the parallel of the latter passing through the inion. The angle with the inion for its vertex opens toward the cranial cavity if measured below the inion-parallel of the ear-eye plane. The compensatory angle lies above it and opens outwardly. It is clear that a more erect position of the planum, as expressed by a greater angle, is more conducive of a perfect occipital rounding than the opposite, which, however, is easily disturbed by other morphological features, like the protrusion of the upper occipital squama, and, as *Martin* correctly points out, the development of the protuberantia occipitalis externa. His listings of the nuchal angle are quite instructive and are presented on page 60.

The nuchal angles of 23° in the Santa Barbara B skull, and 34° in the C, and even 38° in E, are comparable with *Martin's* highest figures, and thus justify what has been said about their significance with regard to the occipital curve. The nuchal angle in a way bears on the interoccipital angle opisthion-inion-lambda in such manner that

GROUP	NUCHAL ANGLE
Senoi ♂	36°
Senoi ♀	30°
Usa ♂	28°
Disentis ♂	23°
Timorese ♂	21°
Vedda ♂	18°
Vedda ♀	17°
Hohberg ♂	17°

in our cases the higher and lower figures appear to be correlated, 23° to 124°, 34° to 128°, and 38° to 127°. Also another correlation is to be noticed between the nuchal angles and those of occipital declination as given by the angle between the opisthion-lambda line and the ear-eye plane. The more erect position of both the opisthion-inion and opisthion-lambda lines in C and E finds its expression through a greater nuchal angle of 34° and a smaller occipital angle of 118° in the former, and still more significant in the latter of 38° and 109°, as against 23° and 122° for the same angles in B. Another correlation seems to exist between these angles and the median-sagittal index, as may be seen from the next table. The stronger occipital vaulting appears to be characteristic of the male skull, which seems to be the prevailing condition among the sexes of the Indians. The variability of the averages of this index is very limited, *Martin* (1914, 738) listing them for a number of human groups between 81.2 and 83.6. Among our own observations were male and female averages from undeformed skulls of the North Pacific

Coast at 82.3 and 83.8; the Haida at 81.8 and 84.1, the Eskimo at 83.8 and 84.0. But very considerable is the individual variation which, for instance, amounts to 77.4–91.2 and 80.8–88.7 in the first-named group.

The occipital measurements discussed in the immediately preceding paragraphs are listed in the following table:

HUMAN VARIETY	OS OCCIPITALE					
	Median-sagittal			Angles with ear-eye plane		∠ opisthion-inion-lambda (interoccipital)
	arc mm.	chord mm.	$\frac{\text{chord}\cdot 100}{\text{arc}}$	opisthion-lambda (occipital)	opisthion-inion (nuchal	
Santa Barbara						
B (♂)........	120	100	83.3	122°	23°	124°
C (♀)........	100	87	87.0	118°	34°	128°
E (♂)	124	105	84.7	109°	38°	127°
Haida						
Averages ♂	122 (108–140)	100.2 (92–113)	81.8 (77.4–91.2)	117.6° (105–131)	—	123.1° (115–134)
Averages ♀	111.7 (106–120)	93.9 (90–97)	84.1 (80.8–88.7)	117.9° (113–124)	—	122.8 (96–133)
Eskimo						
Averages ♂	116.2 (111–126)	97.2 (86–110)	83.8 (78.2–88.6)	120.7° (111–131)	—	127.9° (115–136)
Averages ♀	114.4 (106–123)	96.8 (88–103)	84.0 (77.6–88.6)	118.6° (114–126)	—	129.2° (119–140)

The more upright position of the planum nuchale as expressed by a higher nuchal angle may be correlated with the phylogenetic downward progression of the opisthion, and furthermore with the increasing foramen magnum angle. Formed by the basion-opisthion line and a parallel to the ear-eye plane laid through the basion, this angle expresses advanced morphological conditions if situated below that parallel and marked minus, the basion being the vertex. Its situation above the parallel is marked plus, and signifies more primitive stages as found in the anthropoid apes and occasionally in man. The Santa Barbara skulls have angles of −8° each in B and C, and thus represent a higher phylogenetic stage. In skull E, on the other hand, the basion-opisthion line coincides with the ear-eye parallel, indicating a neutral state between the more primitive and advanced stages of the foramen magnum declination. Compared with the San Miguel Island series, the averages of the latter are found to be still more progressive, with −9.4° in the males and −13.2° in the females. In spite of this, the variability is quite pronounced in that series, affording ranges of +3° to −21°, and −5° to −22° in the two sexes.

The writer's observations on a series of eighty Chinook skulls in the American Museum of Natural History may be of interest in this connection (*Oetteking* 1924). It is recalled that the Chinook practised excessive antero-posterior head deformation. The averages of foramen magnum declination were found to be +0.6° in the males and −0.5° in the females. Their ranges, from +14° to −15° in the former and from +7° to −14° in the latter, distinctly show the influence of deformation by their low values and great extensions.

The low value of +7° in La Chapelle-aux-Saints (*Fr. Sarasin* 1916–1922, 195), on the other hand, is directly expressive of the primitive phyletic stage of this specimen. *Fr. Sarasin* (p. 195) also gives a general average for Europeans amounting to −12°, with which the San Miguel averages mentioned in the second preceding paragraph conform.

The ear-eye parallel involved in the angle just discussed helps also to form the angle of the cranial base as represented by the nasion-basion line. This line measures 97 mm. in skulls B and C, and 101 mm. in E, and as the position of the nasion above the ear-eye plane proper is fairly alike in the three skulls (30 mm. in B and E as against 29 mm. on C), the size of the angles depends entirely on the infraporial position of the basion. With a basion-porion extension of 22 mm. in B, 14 mm. in C, and 26 mm. in E, the greater cranio-basal angle of 33° is naturally found in the two male skulls, while the angle in the female skull amounts to 27°. Within the physiological range of the angle under discussion in series from different human provinces and covering values from 20° to 39°, our two angles occupy stations only slightly removed from a medium condition. This is confirmed by an examination of averages which *Lüthy* (1912, 35) lists from 26.7° to 29.0°, the extremes being those of Singhalese and Australians. Our frequently quoted San Miguel islanders yielded averages of 30.2° in both sexes, and thus range with *Martin's* (1914, 484) Chinese at 30.5°. Considering furthermore the Western Eskimo averages for the two sexes of 31.6° and 31.0°, and those of the Haida of 29.9° and 30.0°, it appears that the peoples of Mongoloid extraction are possessed of steeper cranial bases than the other human varieties.

In close relation to the angular conditions of the cranial base line (nasion-basion) stand those of the pars basilaris of the occipital bone.

The declination of the pars basilaris measured on its underside, the angle being formed by the sphenobasion-

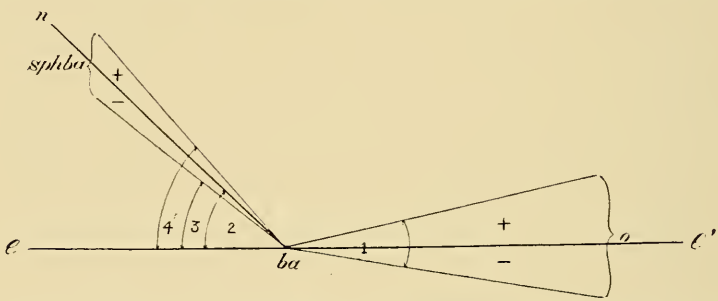

FIG. 11.—Schematic representation of angles at the cranial base: ∠ 1, foramen magnum angle; ∠ 2, angle of cranial base; ∠ 3, 4, angle of pars basilaris; *e—e'*, parallel to ear-eye plane through *b*, basion; *n*, nasion; *o*, opisthion; *sphba*, sphenobasion.

basion line and the parallel to the ear-eye plane through the basion, amounts to 33° in skulls B and E and to only 22° in C. This signifies, according to *Fr. Sarasin's* (1916–22, 251) classification, platyclin and hyperplatyclin states and illustrates not only the sex difference generally met in human groups, but also the specific conditions among the Indians of the Pacific coast (*Oetteking* 1924). Moreover, in our particular case it is the limited infraporial extension of the cranial height diameter which is responsible for the depressed condition of the pars basilaris in C, and consequently its small angle of declination.

A schematic representation of the angles at the cranial base is given in fig. 11.

The following table contains the measurements just discussed:

HUMAN VARIETY	ANGLES OF THE CRANIAL BASE		
	Ear-eye plane and lines		
	opisthion-basion (foramen magnum)	basion-nasion (cranial base)	spheno-basion-basion (pars basilaris)
Santa Barbara			
B (♂)	−8°	33°	33°
C (♀)	−8°	27°	22°
E (♂)	≅	33°	33°
San Miguel island			
Averages ♂	−9.4°	30.2°	32.0°
	(+3 to −21°)	(25–35)	(19–46)
Averages ♀	−13.2°	30.2°	29.8°
	(−5 to −22°)	(25–34)	(20–38)
La Chapelle-aux-Saints*	+7°	—	14–20°

**Fr. Sarasin* 1916–22, 195 and 253.

Turning now to the profilation of the face, its vertical projection relative to the ear-eye plane must be considered first.[1] The three angles known as profile angles are: (1) the facial (nasion-prosthion-E′), (2) the

[1] The discussion of the vertical declination of the orbit and the nasal bones has been joined with the study of the orbit and nasal aperture, and will be found in the section on the norma frontalis (pages 98–99).

nasal (nasion-nasospinale-e′), and (3) the alveolar (nasospinale-prosthion-e′). E′ and e′ indicate the extensions of the ear-eye plane or its parallels to the right. The angles themselves may be identified from the diagrams of pls. X–XII. Those of the Santa Barbara crania, and, for wider comparison, of a Pacific Coast tribe, groups from southern India, and of a European group, are listed in the table on page 67. For some of them *Flower's* index gnathicus, $\frac{\text{prosthion to basion}\cdot 100}{\text{nasion to basion}}$, could be ascertained, and at the bottom the physiological range for each angle and applying to human conditions in general is given.

The figures show the typical proportions obtaining in man: the nasal angle as the greatest exceeds the other two, and that of the alveolar process is the smallest. *Lüthy* (1912, 39) has proposed the following classification of the angles of vertical profilation:

Hyperprognathy................	x – 69.9
Prognathy....................	70.0 – 79.9
Mesognathy....................	80.0 – 84.9
Orthognathy..................	85.0 – 92.9
Hyperorthognathy..............	93.0 – x

According to this classification the facial angles of our skulls B, C, and E, are seen to be prognathous at 77°, just mesognathous at 80°, and pronounced mesognathous at 82°. The same proportions hold true for the nasal angles at 78° in B, and 84° in C and E, which places the latter two skulls close to orthognathy. Quite remark-

HUMAN VARIETY	VERTICAL PROFILATION (EAR-EYE PLANE) Angle facial	nasal	alveolar	INDEX GNATHICUS (FLOWER)
Santa Barbara				
B (♂)	77°	78°	71°	106.3
C (♀)	80°	84°	68°	104.1
E (♂)	82°	84°	76°	96.0
San Miguel island				
Averages ♂	81°	83.2°	74.6°	99.0
	(72–88)	(76–91)	(61–91)	—
Averages ♀	80.2°	84.4°	74.6°	99.7
	(75–89)	(77–89)	(62–89)	—
Senoi*				
♂	85°	90°	55°	—
♀	82°	85°	66°	
Semang†				
♂	80°	82°	65°	100.0
♀	81°	83°	75°	98.0
Averages Vedda‡	84.3°	87.6°	71.6°	94.7
Averages Singhalese‡	82.1°	85.5°	69.9°	99.2
Averages Swiss‡	87.0°	88.7°	82.4°	93.6
General variation‡	70–93°	73–95°	49–92°	—

**Martin* 1905.
† *Schlaginhaufen* 1907.
‡ *Lüthy* 1912.

able is the relapse into the prognathous state of the alveolar angle of 71° in B, and the hyperprognathous of 68° in C, while E at 76°, although likewise prognathous, holds an intermediate position between the first two. Besides the pronounced state of alveolar hyperprognathy in the female skull, the other interesting fact is revealed that it coincides in the same skull with the distinct superiority of the facial and nasal angles over male skull B. This interesting combination in a similar way obtains in the averages of the San Miguel series, and is fully equaled by the Senoi, Semang, Vedda, and Singhalese. The individual figures of the Senoi and Semang show the two conditions even exaggerated, i.e., a decidedly stronger alveolar prognathism, excepting in the Semang woman, and a more pronounced tendency toward orthognathy of the two facial angles, as compared with the Santa Barbara specimens. The differences between the averages of the Vedda and Singhalese in each of the three angles are, according to *P.* and *F. Sarasin* (1893, III), notable from the standpoint of a phylogenetically secondary and stronger prognathism in the phylogenetically younger Singhalese. Regarding the alveolar prognathism, our Santa Barbara specimens show closer affinity to the averages of both the latter groups, while their two facial angles are markedly less orthognathous.

The different findings in all these groups are exceeded by those of the Swiss, who, as a European group, are included in the table for comparison. With distinctly orthognathous facial angles they are seen to combine well-marked alveolar mesognathy of 82.4°. Alveolar orthognathy even of 85° and 86° on an average obtain in two other European groups—the Tyrolese and the Bavarians (*Martin* 1914, 809).

All these findings gain in significance under the consideration of the stations which they occupy in the ranges of variation at the bottom of our table. It will be noted that, with the exception of Santa Barbara skull B, most of the facial angles hold medium or supramedium positions which is equal to mesognathy with a tendency toward orthognathy. The same cannot be said of the alveolar range, which *per se* is considerably wider than the ranges of the two facial angles. Thus, the middle stations in that range are still decidedly prognathous, and only a few of our figures exceed the middle.

In the last column of the preceding table *Flower's* gnathic index reaches its highest values of 106.3 and 104.1 with our skulls B and C, marking both prognathous with reference to the facial angle and according to the classification of that index. The two methods are thus seen not to yield identical results, as the angle of facial profilation indicates a slightly mesognathous state of C. In the San Miguel series, on the other hand, the angle, as well as the index, results in mesognathous averages, signifying the conditions prevailing in general in the Mongoloids. The other indices are in agreement with the angular expressions, the other extreme being represented with an index of orthognathy of 93.6 in the Swiss.

NORMA BASILARIS

The basilar aspect is much alike in the skulls from Santa Barbara, in that the occipital region is fairly of globular shape, which, however, is slightly modified in skull E. Only the radius of occipital extension posterior of the foramen magnum (opisthion) differs according to the individual size of the skulls and measures about 60 mm. in B, 45 mm. in C, and 44 mm. in E. The greatest width extension of the skulls in the basilar aspect is somewhat covered in perspective by the supramastoidal expansion, the mastoids themselves slanting mesially only insignificantly, which condition is still better to be observed in the occipital norma.

The shape of the foramen magnum is almost circular in B, but narrows slightly anteriorly in C and E. The circular shape, or the tendency toward it, seems to be the predominant one in skulls of Mongoloid extraction; it occurs in the San Miguel islanders in 41.0%. This is likewise expressed by the length-width index of the foramen magnum at 93.8 in B, 90.9 in C, but only 77.8 in E. The length measurements amount to 32 mm., 33 mm., and 36 mm. in skulls B, C, and E, those of the width to 30 mm. in B and C, and 28 mm. in E. *Martin* (1914, 743) gives physiological ranges of these two dimensions extending from (25) 30–40 (43) mm. for the length and from (20) 23–38 mm. for the width. The foramina of the Santa Barbara skulls are thus to be characterized as submedium in size. This holds true also for the averages in the San Miguel series at 33.6 mm. and 32.8 mm., and 28.6 mm. and 27.3 mm., for the two dimensions and sexes, while their indices at 84.8 and 83.2 are expressive of foramina of slightly longer shape (37.3% elliptic and 21.7% oval). The range of variation is not very extensive. The averages in *Martin's* table (p. 714) run from 72.6 to 89.1, and the sex difference almost throughout is expressed by lower figures for the females. A very low index in illustration of a foramen magnum of considerable length (46 mm.!) is that of La Chapelle-aux-Saints, namely, 65.2.

Some comparative foramen magnum measurements are listed in the following table.

HUMAN VARIETY	FORAMEN MAGNUM		
	length mm.	width mm.	$\frac{\text{width}\cdot 100}{\text{length}}$
Santa Barbara			
B (♂)	32	30	93.8
C (♀)	33	30	90.9
E (♂)	36	28	77.8
San Miguel island			
♂	33.7 (29–38)	28.6 (24–33)	84.8 [71.4–97.1 (103.5)]
♀	32.8 (29–37)	27.3 (24–31)	83.2 (72.7–93.1)
La Chapelle-aux-Saints	46	30	65.2

The condyles are medium high and wide, their angular position resulting in intervals of 21 mm. in B and E, and 19 mm. in C, between the most anterior points of their articulating surfaces. The articular surface of the left condyle in C is posteriorly drawn out about 1 cm. around the circumference of the foramen magnum, tapering beyond the fossa condyloidea and ending on a roughened ridge which ends about 1 cm. before reaching the opisthion. The right condyle is constricted at its posterior end and about 1 cm. in advance of the fossa condyloidea, the articular surface thus acquiring a slipper-like appearance. The canales condyloidei are above medium width, circular at their entrance and approached through narrow funnel-like fossæ condyloideæ, more so in the males than in the females.

The canales hypoglossi are of medium size in our skulls, but an anomaly, namely, bipartition, is noticed in each. This is not of very rare occurrence in this region, and was proclaimed by *Kollmann* (1905, 1907) as a "manifestation of the occipital vertebra." In the tribes of the North Pacific Coast not addicted to artificial deformation, bipartition was found in 20.5%, distributed among its variable forms in such a way that 4.9% of bipartition occur on the right, 11.5% on the left side, and 3.3% on both sides. The remaining 0.8% accounts for a case of left occurrence, while a canalis hypoglossi is absent on the right side. Our skull B shows a complete bipartition on the right side, skull C an incomplete one on the left. The latter case is complicated in such a way that from the medial superior edge of the canalis an osseous spicule, between 2 mm. and 3 mm. in length, runs free, ending free on a level with the plane of the medial opening of the canalis hypoglossi. The lateral opening is drawn out posteriorly. The extension, 3.5 mm. long and 2 mm. broad, is level with the lateral wall of the right condyle and forms a kind of vestibule to the funnel-like entrance of the canalis. Quite singular is the bipartite formation of the right canalis in skull E, which does not represent, in the ordinary sense, a bipartition of the medial outlet of the canal. There are, on the contrary, two independent outlets of relatively small size, one at the base of the condyle and the other 9 mm. above it at the base of the tuberculum jugulare. These two outlets have a common entrance of slightly enlarged size at the usual place on the lateral wall of the condylar base. It appears that a singular case like this serves to support the "manifestation" theory still better than the ordinary bipartition. All three cases are depicted in fig. 12.

The jugular foramina show no anomalies except in size. In B it is the left foramen that is almost twice the size of the right one, while in C the right foramen exceeds slightly the size of the left. An enormous widening of

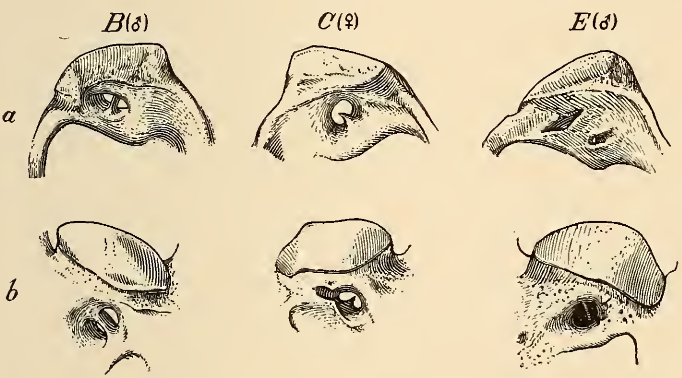

FIG. 12.—Canalis hypoglossi in the Santa Barbara skulls, showing different forms of bipartition. *a*, in medial, *b* in lateral aspect. (½ natural size)

the right foramen is noticed in E. The left one in this skull is rather compressed and narrow, correlated quite probably with the canalis hypoglossi anomaly described in the last paragraph. Anomalies of size in the jugular foramina are more or less the rule in the human cranium, and occur, for instance, in undeformed Indians of North Pacific tribes in such a way that in 66.4% the right foramen is larger than the left, in 16.8% the left larger than the right, while in another 16.8% both are alike in size.

The partes laterales of the occipital bone (processus jugulares) are slightly clubbed at their extreme ends, thus shielding medially deep incisuræ mastoideæ in B. These are much more shallow in C, commensurate with the size of the mastoid processes, but showing better developed sulci for the occipital artery than in B. Medium conditions obtain in E. The incisions of the apex of the mastoids are more or less in evidence. The styloid processes are destroyed in the three skulls; the styloïd foramina are of medium size.

Of particular interest are the high vertically directed anterior tympanic plates drawn out into ample vaginæ for the styloid processes, and the deep mandibular (glenoid) fossæ. The transverse roots of the zygomatic process represent well-developed tubercula articularia in the two male skulls, but somewhat weaker ones in the female. The transverse axis of the tubercula nearly coincides with the frontal plane in B. In C and E, on the other hand, they slant slightly from medially forward to laterally backward. This condition prevails in the immature skull, where at the same time the notch between the free end of the zygomatic process and the portion of the temporal squama from which it springs is rather narrow. During growth, and as the masticatory functions develop, it widens, while the tuberculum articulare, under the molding influence of the mandibular condyles, assumes its definite appearance and direction. The latter conforms in B and E to the direction of the fossæ mandibulares and will be described more explicitly farther on in connection with the discussion of the lower jaw (see page 130).

The pars basilaris of the occipital bone, which is correlated with the proportions of the cranial base in general (*Martin* 1914, 746), appears to be more slender in female skull C. The underside shows the usual roughened surface, but no exceptionally developed muscular ridges. There is a well-developed tuberculum pharyngeum in B, and a weaker one in C and E, besides an indication of a fossa pharyngea in advance of it in the latter two. While the tuberculum is a fairly regular feature in the Indian skull (it occurs in 94.8% in undeformed skulls from the North Pacific areas), the fossa is much more rare at 16.1% in the same series. This percentage is in accord with that found by *Hrdlička* (1906, 62) in California Indians, while according to *Sullivan* (1920, 241), "the fossa is not of very frequent occurrence in the American Indian and Eskimo." The latter found it in only 3.5%, and its most frequent occurrence is "limited to that area of North America which is or was the home of the Uto-Aztecan stock."

There are irregularities to be noticed in connection with the foramina spinosa and ovalia. The former are above medium size in B, while the latter are long and somewhat narrow. The left one, furthermore, is transversely divided in such a way that an anterior small and oval division stands out against an extensive posterior one. The right foramen ovale shows an indication toward a division by slight projecting ridges on opposite sides of the foramen, or, rather, the canalis of which the foramen forms the outlet. The more interesting anomaly is seen in skull C. Here both foramina spinosa are medially open to the full depths of their canales, and merged with the canales musculotubarii. The condition described is illustrated in fig. 13; it is apparently very rare, while merging of the foramina spinosum and ovale is of less rare occurrence. The foramina in question are of medium size in E, but there is an additional foramen on the left side of the skull in advance of and in line with the foramen ovale, and a slight indication of one on the left side.

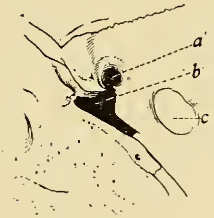

Fig. 13.—Merging of the left foramen spinosum and canalis musculotubarius in skull C (♀). *a*, foramen spinosum; *b*, canalis musculotubarius; *c*, foramen ovale. (Natural size.)

Advancing by way of the processus pterygoidei, whose two laminæ are well developed and thus afford deep pterygoid fossæ, we now enter upon the description of the palatine complexes. Their dimensions coincide well with the general proportions of the configuration in the basilar view, but otherwise are well developed. The palates themselves are spacious and deep, rather smooth, but with good-sized spinæ palatinæ, particularly in B. The spina nasalis posterior is nipple-shape in C, its two sides continuing into the broadly curved incisures of the palatine plates. These are narrower but deeper in B, forming medially the sides of a truncated spina nasalis of angular shape. In E it is broadly but pointingly drawn out. The three shapes as described in our three skulls are illustrated in fig. 14.

In the three skulls there are faint indications of a spindle-shape torus palatinus, especially in the female, which ends as a well-developed crest on the os palatinum in B and E, and as a narrow "keel" in C. It appears that the torus palatinus occurs with some regularity in Indians of the North Pacific Coast. Accounting for all its forms from a mere indication to a strongly developed torus, the frequency there was as high as 78.8% in undeformed crania, and higher at that in females than in males.

There is in skull C another noteworthy feature, namely, above the first molar of each side, where the palatine

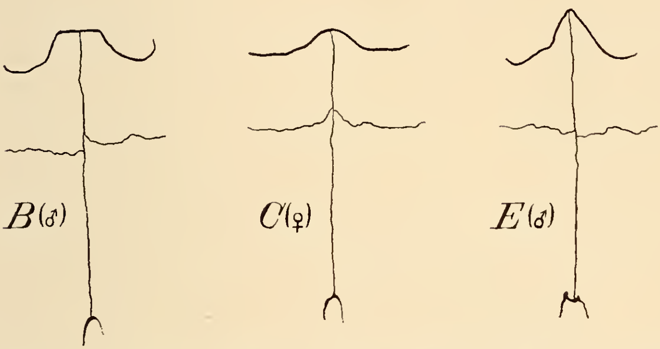

Fig. 14.—Variation in the shape of the spina nasalis posterior of the Santa Barbara skulls: truncated in B (♂); nipple-shape in C (♀); pointed in E (♂). The figure also shows variations of the sutura palatina transversa. ($\frac{2}{3}$ natural size.)

process flexes into the somewhat angularly joining alveolar process, a vascular orifice of 1.5 mm. in diameter. The foramina have direct connection with the maxillary antrum of each side, as the probe revealed, and probably transmit a branch of arteria palatina major (of a. palatina descendens). As such they are of quite different significance from the usual minute foramina nutricia of the palate, and form a singular feature in skull C. Fig. 15 shows this anomaly as marked by *x*.

The foramina incisiva are of regular, i.e., medium, size, and more long than broad, and there are no traces of an incisival suture. The foramina palatina majora are slightly above medium size in B, smaller in C, and are less sharply edged than those of E. The foramina palatina minora are of the usual diminutive size, one on the right and two on the left side each of B and C, with the difference, however, that they do not appear on the inferior termination of the processus pyramidales, but are somewhat removed from it on their medial sides. The same holds true for skull E, in which, however, there are two foramina on each side.

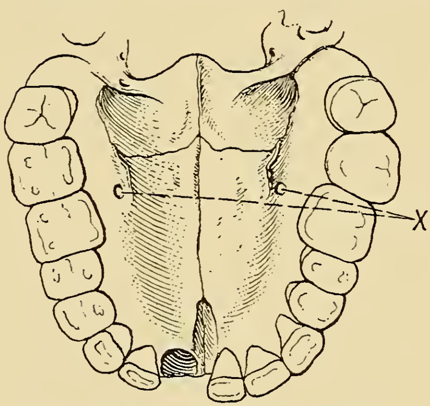

Fig. 15.—Anomalous palatine perforations, right and left in identical places, in skull C (♀), marked by *x*. ($\frac{2}{3}$ natural size.)

Of the two palatine sutures the median one shows the regular straight course and becomes slightly obscured through the formation of the medial crest of the palatine bones. The two parts of the transverse suture do not join medially in B, the left half joining the median suture at a right angle 3 mm. in advance of the right half, which turns sharply backward before reaching the median suture. In C the two halves turn backward and form a sharp posteriorly directed triangle, which is a rare condition in Hominidæ, according to *Martin* (1914, 830), the reverse being by far the more common state. In fact, the posteriorly directed triangle was found in only 5.6% of the undeformed North Pacific crania, in 2.5% of those of the Chinook, but in 9.9% of the Salish. *Martin's* highest frequency of the condition under discussion is 20.8% for the Eskimo. The more progressive forward bend is seen in E. All three shapes are illustrated in fig. 14.

It remains to discuss the part of most decided morphological significance in the palatine complex: the alveolar process and the dental arch. The latter is paraboloid in all three skulls, somewhat more rounded in B, and slightly straighter in C and E. They thus represent a morphologically advanced type as against the upsiloid shape in the anthropoid apes and the ellipsoid in the lower apes. All three types may occur in one and the same series, as shown by their frequency on the North Pacific Coast, where in the undeformed skulls the upsiloid type was found in 2.1%, the ellipsoid in 9.3%, and the paraboloid in 88.7%. The frequency of the first two types is somewhat increased in the Chinook to 6.0% and 20.5%, while the paraboloid type occurs in 73.5%, illustrating again the decided prevalence of the latter. As already indicated by the individual differences of the dental arches in our three specimens, the dimensions of their maxillo-alveolar processes likewise differ. Although of equal alveolar length, namely, 57 mm., the alveolar breadth of B measures 66 mm., that of C 63 mm. The two dimensions are smaller in E, namely, 50 mm. for the length and 60 mm. for the breadth. The indices computed from these two measurements are

115.8, 110.5, and 120.0 for our three skulls, rendering the male skulls brachyuranic, but B near the border line toward mesurany, the female mesuranic near the border line toward dolichurany. Group averages of the maxillo-alveolar index range, according to *Martin* (1914, 824), from 108 to 126, and within this range most of the averages are brachyuranic (115.0–x), particularly those of the Mongols and Mongoloids. Australians and Singhalese are the only varieties with dolichuranic means. The palatal dimensions differ in the length measurement contrary to the alveolar lengths of B and C, just described. The difference amounts to 3 mm. in favor of the male skull, whose palatal length measures 66 mm., against 63 mm. in the female. The dimensions are correspondingly smaller in E, where 44 mm. were listed for the length and 40 mm. for the width. The latter measures only 39 mm. in C, but 43 mm. in B. The indices result accordingly in 86.0, 84.8, and 90.9, placing the male skulls in the brachystaphylin class of the palatal index, the female in the mesostaphylin, but at the border line toward brachystaphyliny. The lower palatal index of C, mesostaphylin at 84.8, naturally signifies length-width proportions similar to those of the maxillo-alveolar, which was seen to be mesuranic at 110.5. Both indices, the maxillo-alveolar and the palatal of the Santa Barbara skulls, are expressive of conditions that prevail in Mongoloid peoples. They signify well proportioned, wide, and spacious dimensions, which is a European characteristic at the same time, and as such must be estimated an advanced condition.

To the table of maxillo-alveolar and palatal measure-

HUMAN VARIETY AND ANTHROPOIDS	MAXILLO-ALVEOLAR AND PALATAL MEASUREMENTS					
	Maxillo-alveolar			Palatal		
	length mm.	breadth mm.	breadth·100 / length	length mm.	width mm.	width·100 / length
Santa Barbara						
B (♂)............	57	66	115.8	50	43	86.0
C (♀)............	57	63	110.5	46	39	84.8
E (♂)............	50	60	120.0	44	40	90.9
Haida						
♂................	56 (52–60)	66.5 (61–71)	119.3 (108.5–129.3)	47.9 (45–52)	43.9 (40–49)	91.3 (76.8–108.0)
♀................	53.5 (50–57)	64.5 (61–69)	120.0 (115.2–127.1)	46.3 (44–50)	42 (38–45)	88.3 (80.4–97.1)
General range of variation.........	44–65	50–72	94–154	38–54	33–48	63.6–
Group averages*	49–57	58–69	108–126	42–50	36–43	94.6
Hylobates synd. ♀ *....	—	—	77.6 (74.1–82.3)	Hyoblates synd.	♂	46.6 (37.0–53.0)
Hylobates agilis*.......	—	—	80.2 (73.8–89.7)		♀	48.5 (43.1–52.1)
Orang-utan*						
♂................	—	—	74.8 (66.3–85.7)			49.2 (43.0–53.1)
♀................	—	—	81.9 (72.8–106.0)	—	—	51.2 (42.4–57.8)
Gorilla*						
♂................	—	—	64.7 (52.1–73.7)	—	—	42.2 (34.5–52.3)
♀................	—	—	72.5 (65.3–77.7)	—	—	46.3 (41.5–54.2)
Chimpanzee*						
♂................	—	—	80.8 (70.8–90.4)	—	—	53.0 (45.8–62.5)
♀................	—	—	82.0 (68.2–90.4)	—	—	54.0 (50.0–57.1)

Martin (1914, 824, 827).

ments (page 81) the general individual ranges and those of group averages are appended in order to orient the quantitative nature of our specimens.

The anthropoids have been added to this table for the purpose of broader comparison in a morphological feature of greatest phylogenetic interest. Their indices are seen to differ radically not only from the human, but also between themselves.

NORMA FRONTALIS

The norma frontalis, or, as it is also termed, facialis, is complicated more than any of the other normæ by the proportions and configuration of the parts involved. They are in particular those that help in shaping the orbital and nasal cavities, the zygomatic expansion, and the alveolar process of the maxillary bone.

The frontal bone in the facial aspect shows in its squamous part nothing of particular interest. The tubera frontalia of moderate elevation seem to lie quite low, i.e., they begin to rise just above the superciliary depressions, which latter, although well marked, are nevertheless not broad. The superciliary region itself shows moderate development. The arcus superciliares in B and E represent stage *a* of *Cunningham-Schwalbe's* (see *Martin*, p. 770) classification, i.e., accounting for a margo supraorbitalis between the orbital rim and the sharply circumscribed arcus elevation. The latter shows still more pronounced forms in the E calotte. In C the arcus are somewhat wider and less sharply marked.

The glabella protrusion has already been discussed (page 51). The foramen s. incisura supraorbitalis, known to be very variable, is likewise so in the Santa Barbara specimens. Presenting two incisures in B, a right foramen and a left incisure are seen in C, D, and E. The statistical data of the North Pacific tribes revealed a predominance of the foramen, which occurred in the undeformed skulls in 61.4%, while the frequency of the incisure was 25.2%, and the irregular occurrence (right foramen and left incisure, or vice versa) amounted to 13.4%.

The incisura frontalis for the n. frontalis, of a diminutive appearance *per se*, is only slightly indicated in B. Its total absence amounted to 18.4% in the series mentioned in the preceding paragraph. The two-sided occurrence of an incisure, the predominating one, has a frequency there of 60.0%, that of a foramen frontale a frequency of 10.8%, and irregular occurrence was seen in 10.8%.

The lateral extension of the supraorbital portions of the frontal bone, i.e., the zygomatic processes of the latter, play an important part in the configuration of the facial norma. In the Santa Barbara specimens they point laterally somewhat more straight than usual and thus give the impression of a more pronounced postorbital constriction. These conditions have already been touched on (pages 29–30), where it was pointed out that the minimum frontal width, low but not excessively so, became a significant factor in the low transversal frontoparietal index. If brought in proportion to the upper facial breadth as measured between the two frontomalare temporale points, the most laterally situated points of the zygomatico-frontal suture, the significance of the minimum frontal width comes into play again, together with the unusual lateral extension of the zygomatic processes of the frontal bone. The fronto-biorbital index lending expression to these conditions amounts to 88.9 in skull B, 84.9 in C, 89.5 in D, and 81.0 in E. Taking *Schwalbe's* (1899, 97) index of 90 and higher as characteristic in recent skulls, it will be noticed that the Santa Barbara indices fall below that mark and thus join in with more primitive morphological behavior. *Fr. Sarasin* (1916–1922, 202) gives for Neandertaloids an average of 87.65, which almost coincides with the index of B, but ranges above that of C and E. One Carijo Indian from southern Brazil, mentioned above in connection with postorbital constriction (page 30), has as low an index as 83.3, which is even outdone with an index of 81.0 by our skull E. *Martin* (1914, 713) lists averages of 95.7 and 94.4 for male and female Bavarians, and 96.2 for Aino. These figures signify only a slight diversion between the two factors involved. But it must be considered that the lowest individual fronto-biorbital index in the Bavarian series was only 78, while the other extreme of the same series amounted to 102. The next table contains the measurements last discussed.

The figures make it plain that with the increasing difference between the two measurements involved, which in greater part is due to the decreasing minimum frontal width, the index also decreases.

In order to bring out their characteristics, the left frontal processus zygomaticus of skulls B and C is superposed in fig. 16, *a*, *b*, upon that of a skull from Santa

HUMAN VARIETY	FRONTO-BIORBITAL INDEX			
	fronto-biorbital index	upper facial breadth *mm.*	minimum frontal width *mm.*	difference
Santa Barbara				
B (♂)	88.9	108	96	12
C (♀)	84.9	106	90	16
(D ♂)	89.5	105	94	11
E (♂)	81.0	105	85	20
Carijo (Brazil) ♂	83.3	102	85	17

Cruz island (no. 537) with strongly curved zygomatic processes, oriented on a horizontal line through the supraorbital margins. The superpositions show the more curved process of the last-named skull in contradistinction to those of Santa Barbara.

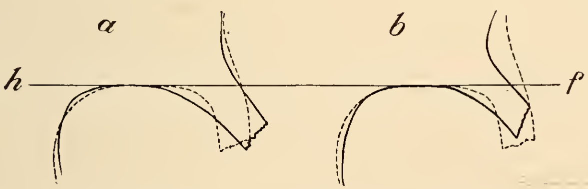

FIG. 16.—Superposition of left frontal processus zygomaticus in frontal projection of: *a*, Santa Barbara B (♂), and *b*, Santa Barbara C (♀), upon that of a skull from Santa Cruz Island, California (No. 537, M. A. I.), drawn in broken lines. *h—f*, frontal plane line through supraorbital margins in ear-eye orientation. (½ natural size.)

The nasal process (pars nasalis) of the frontal bone is likewise involved in the facial configuration, both by its length and its width. Its absolute height lies between the supraorbitale, i.e., the point of intersection between the median-sagittal plane and a line which connects the two supraorbital margins, and either the nasion or the infranasion (mihi).[1] In our series of skulls these distances amount to 7 mm. and 12 mm. in males B and E, 8 mm. and 11 mm. in female C, and 6 mm. and 10 mm. in male D, the differences between each two measurements accounting for the distance between the nasion and the infranasion. They are of course dependent on the extent of the encroachment of the nasal bones upon the nasal process of the frontal bone and therewith the form of the naso-frontal suture. In C this form corresponds to the curved one as described in a previous publication (*Oetteking* 1920), while that of B does not coincide with any of the six described there. Slanting upward from both sides, and then sloping mesially slightly downward, the two sides rise again to form a sharp triangle whose vertex lies in the median line. The whole formation might be taken as a variation of the trapezoidal form in the publication cited. The course of the naso-frontal suture of D is a curve, and that of E a triangle. Our four cases are illustrated in fig. 17. They show in the frontal aspect the individual behavior of the naso-frontal suture. In each case an auxiliary line was drawn for the determination of the infranasion measuring point. That the

[1] Measuring the height of the nasal process of the frontal bone in the customary way (nasion-supraorbitale) has never quite satisfied the present writer, for the reason that it does not account, in a morphological sense, for the true extent of that process. He has for that reason substituted his "infranasion" as the point of intersection between the median-sagittal plane line and a horizontal connecting the two "maxillo-naso-frontal points" (*Oetteking* 1920, 56), i.e., the meeting point of suturæ nasofrontalis, nasomaxillaris, and maxillofrontalis.

supraorbitale-infranasale distance affords a better means of ascertaining the proper height of the nasal process in the facial aspect is shown in *a* (San Miguel island, no. 318) of the same figure, where the infranasion lies on a level with the auxiliary line mentioned in the preceding paragraph. An impairment of the height measurement of the nasal process through the encroachment of the naso-frontal suture upon that process does not occur in this case.

The width of the processus nasalis can best be judged by the distance between the two maxillofrontale[1] points representing the so-called anterior interorbital width, to distinguish it from the posterior one between, either the dacrya or the lacrimalia. The anterior interorbital width measures 20 mm. in B, 18 mm. in C, 21 (?) mm. in D, and 18 mm.

[1] Point of intersection between the crista lacrimalis anterior and the sutura maxillofrontalis.

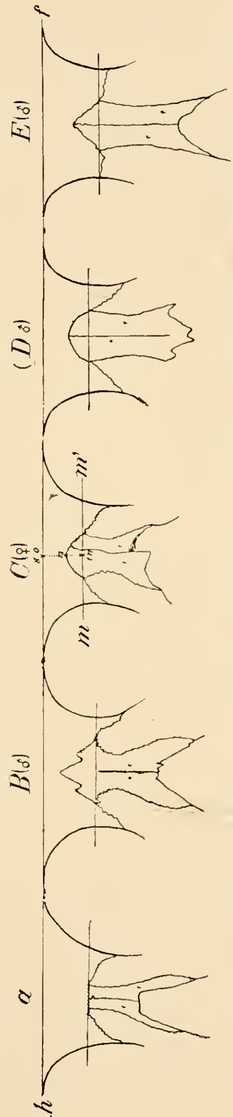

Fig. 17.—Pars nasalis of frontal bone in frontal projection and ear-eye orientation with nasion and infranasion points, in the Santa Barbara specimens. *a*, San Miguel Island, California (No. 318, M. A. I.): *h—f*, frontal line through *so*, supraorbitale; *m—m'*, frontal line through maxillo-naso-frontal points, on which lies *in*, infranasion; *n*, nasion. Dotted vertical *in—so* through *n*, corrective length line of pars nasalis. (About $\frac{2}{3}$ natural size.)

in E. *Martin* (1914, 864–865) gives a physiological range of this measurement of 14–30 mm., and adds that the average interorbital width is greater in Europeans (21.7 mm. in the Swiss) than in Mongols, contrary to previous assumption. For a better understanding of the proportions of the nasal process, the width at its base was also measured and an index computed from the two width measurements. The basal width cannot be taken on a level with the supraorbital point for reasons which need not be discussed. The measuring points were rather found at the deepest recess of the supra-medial angle or curve of the orbit and which, with a little practice, can easily be ascertained. The basinasal width, then, amounts to 36 mm. in B, 32 mm. in C, 28 mm. in D, and 26 mm. in E. For comparison, the table on page 89 contains also the corresponding measurements in an Eskimo skull from Cape Nome and in that of the Brazilian Carijo already referred to, both belonging to our collection.

Both the Carijo and the Eskimo basinasal widths range below those of Santa Barbara specimens B and C, and as this is, at least in the Eskimo, likewise the case with the anterior interorbital width, the indices of these two quantities result accordingly. Thus, while the two Santa Barbara indices are almost alike, the Eskimo index of 53.3, lower than those, lends expression to the smaller, that of the Carijo, which is higher than any of the preceding, to the greater interorbital width and, at the same time, the smaller basinasal widths. The smaller basinasal widths of D and E likewise account for their higher indices, which in fact are the highest of our list.

HUMAN VARIETY	PROCESSUS NASALIS OSSIS FRONTIS				
	length		width		index
	nasion-supraorbitale mm.	infranasion-supraorbitale mm.	anterior interorbital mm.	basinasal mm.	max. front. width·100 / basinasal width
Santa Barbara					
B (♂)	7	12	20	36	55.6
C (♀)	8	11	18	32	56.2
(D ♂)	6	10	21 (?)	28	75.0
E (♂)	7	12	18	26	69.3
Eskimo (Cape Nome) ♂	9	14	16	30	53.3
Carijo (Brazil) ♂	5	10	20	31	64.5

The important part which the nasal process of the frontal bone plays in the formation of the interorbital septum is also revealed by the fact that the length of the former is greater in primitive human varieties than in the modern recent ones (*P. and Fr. Sarasin* 1893, 229; *Fr. Sarasin* 1916–22, 214; *Zuckerkandl* 1877, 86). The bearing of both the length and width of the nasal process on the configuration of the orbit might be expressed by indices that bring those dimensions in proportion to the orbital height and the biorbital width (ektokonchion-ektokonchion). As regards the orbital height measurement, one would have to choose that which is at right angles with the orbital width measurement (maxillo-frontale-ektokonchion), and not the vertical height, which does not account for the morphological peculiarity of the horizontally slanting orbita. It may not be superfluous to recall the fact that the supraorbital measuring point of the length of the nasal process coincides with that of the orbital height. The following table, in its first three numerical columns informs of the height proportions, and in its second three of the width proportions, between the nasal process and the orbita.

HUMAN VARIETY	PROCESSUS NASALIS AND ORBITA					
	1 infranasion-supraorbitale mm.	2 orbital height mm.	1·100 / 2	3 anterior inter-orbital width mm.	4 biorbital width mm.	3·100 / 4
Santa Barbara						
B (♂).......	12 (7)	34	35.3 (20.6)	20	102	19.6
C (♀).......	11 (8)	36	30.6 (22.2)	18	99	18.2
E (♂).......	12 (7)	36	33.3 (19.4)	18	98	18.4
Eskimo (Cape Nome) ♂.......	14 (9)	34	41.2 (26.5)	16	95	16.8
Carijo (Brazil) ♂..	10 (5)	33	30.3 (15.2)	20	95	21.1

The parenthesized figures of the first and third columns signify, in conjunction with the infranasion-supraorbitale length, the length with the nasion, and the indices in which it is involved. Considering that for the first proportion an index of 50.0 and above denotes that the nasal process reaches down to or below the level of horizontal halving of the orbit, all the indices fall short of that mark. On the other hand, it will be noticed that the greater lengths of the nasal processes give rise to the higher indices, as shown by Santa Barbara specimen B and the Eskimo skull. Similar conditions prevail in regard to the indices in parentheses: although the higher index among the Santa Barbara shifts to C, the Eskimo maintains its highest position. It will be easily recognized that the increasing differences between the infranasion and nasion lengths modify the indices in such a way as to be no longer illustrative of the true morphological conditions, which can lie only with the infranasion length. A comparison of the indices and of the factors involved in Santa Barbara skull C and the Carijo skull corroborates this statement.

With regard to the width index, the table shows its gradual decrease with the diminishing of both factors involved, or, from a general angle, the interorbito-biorbital index decreases with the diminishing biorbital width. If, however, a greater interorbital width combines itself with a relatively smaller biorbital width, the index assumes a higher figure, as shown by the Carijo, whose index of 21.1 exceeds the others noted in the table.

The orbital dimensions constituting the orbital index may be gathered from the table on page 92, in which, in order to facilitate comparison, the lacrimale width likewise is considered.

The difference between the two widths, amounting to 4 mm. and 2 mm. in the three Santa Barbara skulls, rarely surpasses the higher figure in any series of skulls. Their maxillofrontale widths of 41–43 mm. fall very

HUMAN VARIETY	ORBITA				
	width		3 height	index	
	1. maxillo-frontale	2. lacrimale		$\frac{3 \cdot 100}{1}$	$\frac{3 \cdot 100}{2}$
	mm.	*mm.*	*mm.*		
Santa Barbara					
B (♂)........	43	39	34	79.1	87.2
C (♀)........	43	39	36	83.7	92.3
E (♂)........	41	39	36	87.8	92.3
Haida					
Averages ♂...	45.3 (42–50)	41.3 (38–45)	35.7 (33–39)	78.9 (70.0–86.4)	86.4 (76.5–95.2)
Averages ♀...	42.1 (39–44)	38.8 (36–40)	35.4 (32–38)	84.1 (76.2–92.3)	91.1 (82.3–100.0)
Koskimo					
Averages ♂...	45.1 (43–48)	40.5 (39–44)	39.2 (39–42)	85.9 (79.2–93.3)	96.6 (86.2–102.5)
Averages ♀...	43.2 (42–44)	39.0 (37–41)	38.7 (37–40)	89.6 (84.1–93.0)	99.0) (92.3–105.1)
La Chapelle-aux-Saints.........	—	Right 47.5 Left 46.5	Right 39.0 Left 38.0	—	81.9

low in the physiological range of that measurement as listed with the series in our table and which covers the values of 42–50 mm. The lacrimale width naturally yields similar results. The width averages of the Haida and Koskimo, although slightly in excess of our individual values, are nevertheless fairly uniform among themselves. This cannot be said regarding the orbital height, which is greatest in the Koskimo with their notoriously high orbits, and of which not only the Haida averages but likewise the Santa Barbara orbits fall short. The maxillofrontale index renders skulls B and C mesokonchial at 79.1 and 83.7, and E hypsikonchial at 87.8, while the three lacrimale indices are hypsikonchial at 87.2 for B, and 92.3 for both C and E. There seems to be indeed a tendency toward hypsikonchy in the Mongoloids, which is clearly shown even by the more conservative figures of the maxillofrontale index which renders both Koskimo averages hypsikonchial, while those of the Haida prove to be mesokonchial. Not so much by our individual Santa Barbara indices as by the averages of our table, it is shown that the female orbit is more hypsikonchial than the male and that on account of the higher orbit of the female in proportion to the width. This condition is fairly generally met with in all the human groups.

The orbital index (lacrimale) of La Chapelle-aux-Saints is mesokonchial, but near the border line toward chamækonchy (quoted by *Martin* 1914, 858). The considerable orbital height of 38 mm. is prompted there by a still more considerable orbital width of 46.5 mm., which bespeaks a very extensive orbital orifice, although the orbital index amounts only to 81.9, rendering it mesokonchial but quite close to chamækonchy.

In addition to the general descriptive marks of the orbit and their quantitative interpretation, it is the angular relation toward the three geometrical planes which is of great importance with respect to the configurative significance of the orbit in the facial complex.

The relations are those of the orbital width (maxillofrontale-ektokonchion) toward the frontal and horizontal planes passing through the maxillofrontale points, and that of the orbital height toward the horizontal

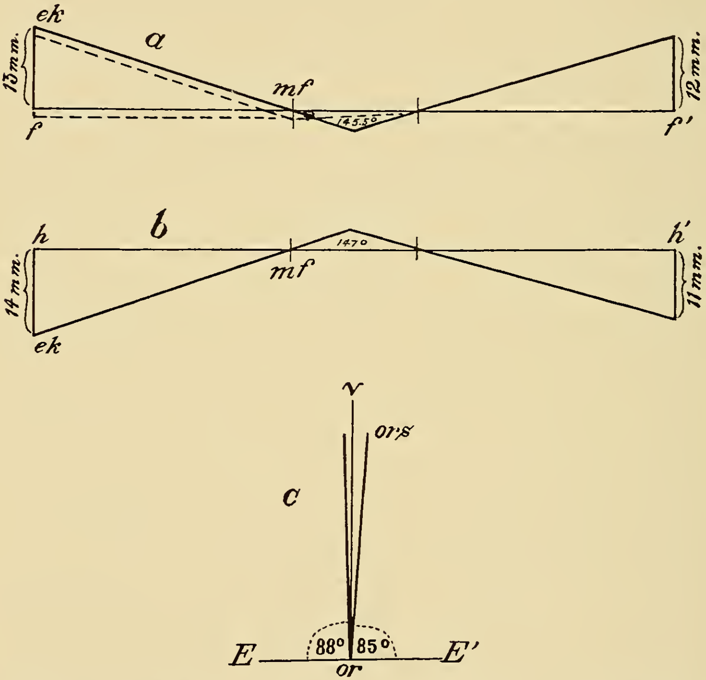

FIG. 18.—Scheme of (*a*) frontal, (*b*) horizontal, and (*c*) vertical orbital declination in ear-eye orientation of skull B(♂). *f—f'*, frontal and *h—h'*, horizontal plane line through *mf*, maxillofrontale; *ek*, ektokonchion; *E—E'*, ear-eye plane through *or*, orbitale; *ors*, orbitale superior; *or—v*, vertical plane line. ($\frac{2}{3}$ natural size.)

plane. It may not be superfluous to add that these three relations accounting for the frontal, horizontal, and sagittal declination of the orbit correspond to its declination in the vertical, frontal, and lateral aspects. The measurements were obtained by means of *H. Virchow's* (1915; 1918) "prosopometer," an ingeniously constructed instrument capable of the minutest application. The absolute measurements taken by this instrument from

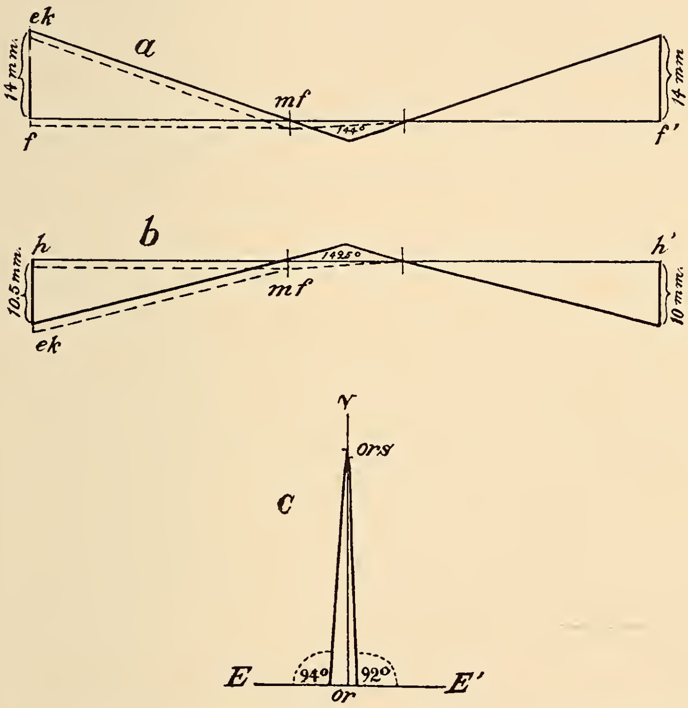

FIG. 19.—Scheme of orbital declinations of skull C (♀). The markings are as in fig. 18. ($\frac{2}{3}$ natural size)

the skull oriented in the ear-eye plane can easily be reproduced upon paper and, for the frontal and horizontal declination, projected upon lines representing the frontal and horizontal plane lines passing through the maxillofrontale points, while the vertical declination is referred to a line representing the ear-eye plane. Figs. 18–20, constructed in such manner, visualize the respective conditions in the Santa Barbara skulls, which are more

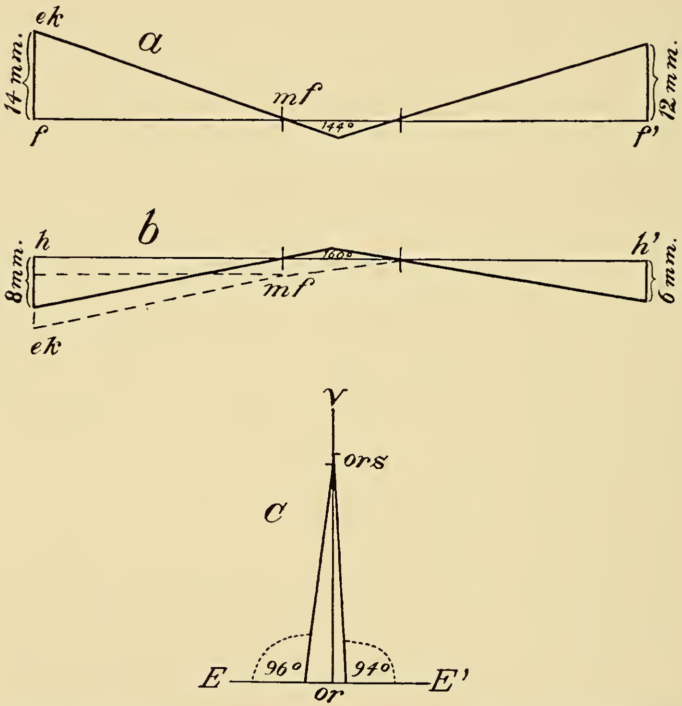

FIG. 20.—Scheme of orbital declinations of skull E (♂). The markings are as in fig. 18. (⅔ natural size)

precisely explained by the legends. However, it may here also be pointed out that the broken lines in the three sets of figures are in adjustment of differences of position in each pair of orbits which amount to 1 mm. as to the frontal projection in both B and C, and likewise 1 mm. with reference to the horizontal orientation in C. The latter amounts to exactly 3 mm. in E, i.e., the right orbit lies in horizontal orientation 3 mm. below the level of the left. The subjoined table lists the three declinations (*a-c* of each figure) for each pair of orbits, and the average of each two. It will be seen that the findings for the two orbits are diverse in most cases. Comparing the averages, it is shown that the female skull at 19.0° exceeds in frontal declination the male skulls at 17.3°

SPECIMEN	DECLINATION OF ORBIT								
	Frontal			Horizontal			Vertical		
	r.	l.	aver.	r.	l.	aver.	r.	l.	aver.
Santa Barbara									
B (♂).......	17.5°	17°	17.3°	18°	15°	16.5°	88°	85°	86.5°
C (♀).......	19°	19°	19.0°	15.5°	15°	15.3°	94°	92°	93.0°
E (♂).......	19°	17°	18.0°	12°	10°	11.0°	96°	94°	95.0°

and 18.0°. Judging from *Martin's* (1914, 819) comparative table of averages, it appears that stronger deviations such as in the Swiss at 20.1° (16–28°) and in modern Europeans in general at 20.0° (16–24°), stand in opposition to those of the different Mongoloid peoples such as the Japanese at 14.2° (11–18°), the Kalmuck at 15.9° (9–23°), as well as in the Australian at 16.0° (14–20°). Our three skulls do not corroborate this disparity, but it must be remembered that they represent individual values which, as such, fall well within the Mongoloid ranges.

The angle of horizontal declination is an expression of the fact that the human orbit slants more or less from medially and above to laterally and below. According to *Adachi* (cited by *Martin* 1914, 863), the angle under discussion is smaller in the Japanese and the Mongoloids than in Europeans, owing to the fact that the inferior lateral angle in the latter is drawn downward much more than in the former. Our angles amount to 16.5° in B, 15.3° in C, and 11° in E, thus preserving the proportions which as a rule obtain in the male and the female skulls. *Martin* (p. 863) gives averages for Europeans of 16.2° in males and 13.9° in females, while in the Japanese they are 13.8° and 11.9° respectively. In this particular case, then, our skulls B and C rather conform with the European averages, while E falls even below the male average for the Japanese.

As regards the vertical declination of the orbit, special investigations have shown that in general the angle in the male is greater than in the female, and that in Europeans it is greater than in the Mongoloids. Thus, while in the Mongoloids the angles average about 90°, Europeans (Swiss) are listed with 95.9° and 96° in the two sexes, and vary from 89° to 101°. Our skulls bear out this statement only in male B at an angle of 86.5°, while female C at 93° and male E at 95° are rather high, although falling well within the Mongoloid variation which *Reicher* (cited by *Martin* 1914, 818) gives from 81° to 101° for Telengets.

The nasal skeleton has already been mentioned in the discussion of the naso-frontal suture which separates the processus or pars nasalis of the frontal bone from the upper ends of the nasal bones (page 85). Both the latter joining in the sutura internasalis form the gabled roof of the nose, as shown by the midorbital horizontal tracings in ear-eye orientation of fig. 21, *a-e*. Our three specimens (*a-c*) show to an appreciable extent the angular projection in advance of the frontal plane line (*f-f'*) passing through the points of intersection with the nasomaxillary sutures. All three of them are considerably exceeded by a Swabian (American Museum of Natural History, no. 4555), while a Negro (same, no. 6958) falls markedly short of them. These instances serve to illustrate the conditions discussed, in three different

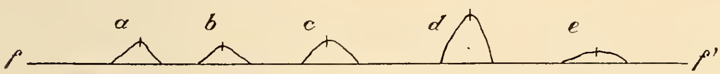

FIG. 21.—Midorbital outlines of nasal bones in cranial ear-eye orientation. *a—c*, Santa Barbara B (♂), C (♀), and E (♂); *d*, Swabian; *e*, Negro. *f—f'*, a frontal plane line coinciding with midorbital horizontal. (About ⅔ natural size.)

races, although the ranges of individual variation may be quite wide at the same time.

Another morphological characteristic in the skull of the Mongoloid is the vertical concavity of the nasal bones and which is evenly and deeply curved in the Santa Barbara skulls, as demonstrated in fig. 22, *a-c*. The Chinook (no. 4470, American Museum of Natural History) tracing (*d*) shows a slight modification in so far as its lower portion swings outwardly into a mild convexity. The tracing in its entirety represents thus a double curve not too rarely found in the Chinook. Of moderate depth is the concavity of the Negro curve (*e*), and quite shallow that of the Swabian (*f*). However,

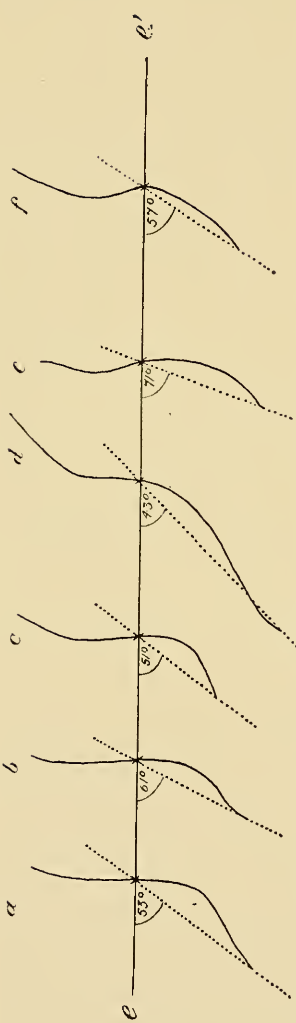

Fig. 22.—Vertical outlines of the nasal bones and angles of the nasal roof. *a—c*, Santa Barbara B(♂), C(♀), and E(♂); *d*, Chinook; *e*, Negro; *f*, Swabian. *e—e'*, parallel to ear-eye plane through nasion. (⅔ natural size.)

the point of distinction between the latter two tracings is their different projection as measured by the angle of the nasal roof between the nasion-rhinion line and the ear-eye parallel through the nasion. The shallowness of the Swabian outline is correlated with a stronger projection as expressed by a lesser angle of 57° as against 71° in the Negro and which in the latter illustrates the flatness of his nose. There is a much stronger projection at 43° to be noticed in the Chinook, and in line with the Swabian is that of the Santa Barbara specimens. But the difference lies with their degree of concavity, as has been pointed out above.[1] It is

[1] The total concavity of the nasal bones vertically is also noticed in the human fossils (*Homo mousteriensis*, Rhodesia).

this feature, first of all, which furnishes the racial distinctions, but, second in importance, also the amount of projection. For the latter, *Martin* (1914, 814) gives a variation in Caucasoids from 43° to 65°, and in Mongoloids (Kalmucks, Torgotes, Chinese) from 56° to 76°.

The projection of the nasal contour (angle of the nasal roof) is in a way influenced by the profile line, and it is clear that a more prognathous face mitigates the impression of nasal projection. The angle between the nasal roof line and that of facial prognathism varies therefore between the Europeans and the more primitive groups. At a physiological range of from 1° to 47°, *Martin* (1914, 815) lists extreme group means of 34° for the Swiss and 12.1° for Negroes, while the Mongoloids maintain about medial stations. Such inferences cannot be fully justified by the Santa Barbara skulls at 24°, 19°, and 31°, which as such represent only individual values within generally quite extensive ranges of variation.

Coming now to the dimensions of the nasal aperture, it appears that within a general range of variation of 32–64 mm., the heights represent, with 53 mm. for B, 49 mm. for C, and 48 mm. for E, about medium conditions, which hold true likewise for the widths of 24 mm. and 26 mm. for B and C, and even 21 mm. for E, within the width variation extending from 17 mm. to 32 mm. The indices result accordingly, namely, leptorrhinic in B and E at 45.3 and 43.8, but chamærrhinic in C. While there is a general tendency toward broader noses in the peoples of Mongoloid derivation, except the Eskimo who are the classical representatives of leptorrhiny, there are on the other hand Indian groups with a tendency toward narrower noses. Our skulls B and E are examples of such.

There are no anomalies to be noticed in the nasal bones of our specimens, except that in C the two principal nasal foramina are situated in the lower halves, while as a rule they occur rather in the upper halves. The left one of C furthermore is removed toward the naso-maxillary suture. The nasal bones of C, as already mentioned in connection with the general state of preservation, are defective at their interior ends, but the right one is medially intact and afforded the complete vertical outline of the nasal roof. In D only the left nasal foramen is present; in E the right one is of normal size, while the left exists as a very tiny opening.

The nasal bones are of medium width and are constricted in their upper halves, the minimum width being 8 mm. in skulls B and C, and 9 mm. in D and E. Widening in their lower halves, they acquire maximum extensions of 16 mm. in B, 15 mm. in C, and 12 mm. each in D and E. The minimum and maximum widths give rise to the transverse index of the nasal bones, which is 50.0 in B and 53.3 in C, but 75.0 each in D and E, accounting here for smaller difference between the sizes of the two factors involved. In the former they are indicative of the "Sanduhr" (hourglass) shape of the nasal bones, which is typically pronounced in the Eskimo at an average of 33.7, while in Europeans the constriction becomes more equalized as expressed by indices, for instance, of the Parisians at 60.0 and Auvergnates at 62.7, rising even to 66.6 in La Chapelle-aux-Saints. The proportions of the nasal bones in the Anthropomorphæ are no less variable than those in the human skull. Their fundamental differences were clearly conceived by *Martin* (1914, 840) when he compared the constriction and the lower width of the nasal bones: "Relatively to the interorbital width the nasalia are less constricted in Hominidæ than in the Anthropomorphæ, while relatively to the width of the apertura piriformis their lower width is smaller, and their height is also considerably smaller."

Of interest in this connection also is the upper width of the nasal bones between the meeting points of the naso-frontal, maxillo-frontal, and naso-maxillary sutures. In a study of the naso-frontal suture in skulls from San Miguel island the writer (*Oetteking* 1920, 57) has referred to this measurement as the direct width of the naso-frontal suture between the "maxillo-naso-frontal" points (mnf). Bringing it in proportion to the anterior interorbital width, the indices in our skulls rise quite high with 75.0 in B, 66.7 in C and E, but lower at 57.1 in D. In the range of variation of the San Miguel skulls (35.0–87.5), the index of 57.1 falls below the male average of 61.6, while the other two exceed it. This applies likewise to the female C as compared with the San Miguel female average of 60.3. But they illustrate, furthermore, what was shown there in the comparative table (page 105), that there is a proportional interdependence between the anterior interorbital width and the upper width of the nasal bones.

The upper (maxillo-naso-frontal) and the maximum lower width of the nasal bones at a numerical proportion of 15 mm. to 16 mm. in B, 12 mm. to 15 mm. in C, and 12 mm. to 12 mm. in both D and E, give rise to indices of 93.8, 80, and 100. This index below 100 appears to signify the typical proportion between the two dimensions under discussion in the human skull, although there may occasionally be a coincidence between the two measurements or even an excess on the side of the upper width, which would raise the index to 100 or more.

The nasal measurements of the Santa Barbara skulls are combined in the table on page 105.

The nasal aperture is elegantly shaped in both skulls and the sides sharply edged. This holds true also for the lower incisures of the apertura piriformis in C, while those of B and E are less sharply marked. As the morphology of the lower notches depends on a number of intermediating factors, a short review of the conditions there may be proffered. The most significant detail here is the spina nasalis anterior, to a greater extent the result of the naso-alveolar flexion in the phylogenetic sense, the subsequent formation of the clivus nasoalveolaris, and as such best developed in Europeans. From the spina running backward and toward the concha nasalis inferior on each side, there is generally to be noticed a more or less sharply developed ridge, which has been variously named by different authors. We shall call it, with *Fr. Sarasin* (1916–22, 259), margo nasospinalis. The same author's margo nasoalveolaris corresponds to the lateral edges of the apertura piriformis themselves, which, turning medially, are (1) either lost upon the alveolar process of the maxillary bone before reaching the spina (infantile form), or, (2) reaching it, produce a more or less broad groove-like depression

NASAL MEASUREMENTS	SANTA BARBARA			
	B(♂)	C(♀)	(D♂)	E(♂)
	mm.	*mm.*	*mm.*	*mm.*
1. Absolute measurements:				
a. Anterior interorbital width (maxillofrontale width)...	20	18	21 (?)	18
b. Upper width of nasal bones (maxillo-naso-frontal width).....................	15	12	12	12
c. Minimum width of nasal bones.....................	8	8	9	9
d. Maximum width of nasal bones.....................	16	15	12	12
e. Nasal width.................	24	26	—	21
f. Nasal height...............	53	49	—	48
2. Angles of nasal roof:				
g. Nasion-rhinion and ear-eye lines.....................	53°	61°	—	51°
h. Nasion-rhinion and nasion-prosthion lines............	24°	19°	—	31°
3. Indices:				
i. $\frac{b \cdot 100}{a}$	75.0	66.7	57.1	66.7
k. $\frac{b \cdot 100}{d}$	93.8	80.0	100.0	100.0
l. $\frac{c \cdot 100}{d}$	50.0	53.3	75.0	75.0
m. $\frac{e \cdot 100}{f}$	45.3	53.1	—	43.8

between the margines nasospinalis and nasoalveolaris (fossa prænasalis), or, (3) coinciding with the margo nasospinalis, cause the uniform, i.e., undifferentiated, sharp edge of the lower notches (anthropine form). There is a fourth form in which the rims of the nasal aperture continue rather straight upon the alveolar process, which results in broad sagittal (longitudinal) grooves whose bottoms are more or less continuous with the floor of the nose. This condition is considered truly pithecoid, but occurs also in the human varieties, most frequently in Oceanians and Negroes.

Our skulls differ quite markedly regarding the development of the spina nasalis anterior and the shape of the lower rim of the apertura piriformis. The former is well marked and projects horizontally in C and E, representing the oxyacanthic condition of *Macalister* (1898, 223–230), and which he characterizes as European. By the coinciding naso-spinal and naso-alveolar margines *Macalister's* oxycraspedotic form is produced. It is considered the true anthropine one, which, as a result of the pronounced flexion between the alveolar process and the floor of the nose, is to be considered an advanced morphological stage. In B, on the other hand, the spina projects only slightly and is illustrative of *Macalister's* lophacanthic condition as characteristic of the Mongoloid varieties. The halves of the spina as afforded by the two maxillary bones cleave in B, but give rise to well-marked margines nasospinales. The margines naso-alveolares are also distinct, but become less so on descending in a curved way and reaching the crista alveolaris media at about its middle. The nearly triangular field thus described on each side by the margines and the crista just mentioned is only slightly depressed, but nevertheless is fully recognizable rather as a clivus nasoalveolaris than as a fossa prænasalis.[1]

The pithecoid form of the lower rim of the apertura piriformis is very rare in Indians of the North Pacific Coast, among whom, in the undeformed skulls, it occurs in only 1.7%, while the oxycraspedotic or anthropine form shows a frequency of 21.2%, the amblycraspedotic or infantile one of 18.6%, while the majority of 58.4% is possessed of true fossæ prænasales. As regards the spina nasalis anterior, there is in that group a preponderance of the lophacanthic state at 53.3%, while only 6.7% represent the oxyacanthic, but 40.0% the kryptacanthic forms. Although quite variable in general, the two features under discussion assemble nevertheless the highest frequencies upon those forms which were recognized as particularly Mongoloid in character.

The regions lateral of the nasal aperture are distinguished by very shallow fossæ caninæ in B and E, while those in C are quite deep. The appearance of the anterior surface of the maxillary bones depends greatly upon its dimensions, particularly its height, the height of the alveolar process, the width of the zygomatic processes of the maxillary bone and that of the maxillary process

[1] The three conditions of the spina nasalis anterior distinguished by *Macalister* (1898, 223–230) are: oxyacanthic to characterize the European distinctly developed spina; lophacanthic, the Mongoloid blunt spina; and kryptacanthic, the negroid primitive one. The notches of the nasal aperture are either amblycraspedotic as representing the infantile two-lipped form; bothrocraspedotic, the fossa prænasalis; oxycraspedotic, the anthropine, sharp-edged; and oxygmocraspedotic, the pithecoid sulcus-like forms.

of the zygomatic bone, and the curve described by the lower edge of the former, the so-called crista infrazygomatica (see *Rauber-Kopsch* 1919, v. II, p. 95). This curve can be very shallow, moderately deep, or deep. The first state is a reminiscence of primitive conditions as found in the anthropoid apes and in the fossil Hominidæ. It is here connected with an even anterior maxillary surface, the depression of it, the so-called fossa canina, being a condition which marks a more advanced morphological state. Involved in the latter are such factors as the progressive stages of naso-alveolar flexion, the narrowing of the face, and, in connection with it, the general refinement of the parts that participate in the facial complex. It is quite probable, and in a number of cases directly provable, that the processes of organic and structural economy are aided also by muscular traction in the production of modifications of morphological appearance. Thus, in the intensification of infrazygomatic curving may also be involved the functions of mm. masseter, zygomaticus and quadratus labii superioris. It is under the influence of these factors that the fossa canina is developed, although, as shown in C, it may exist at an appreciable depth in connection with a less deep curve of the crista infrazygomatica. The latter is more pronounced in B and shows at the same time more protruding (downward) tuberosities at the points of junction of the zygomatic and maxillary bones in the craniometrical points called zygomaxillaria. E also has a rather shallow infrazygomatic crest, which in this case coincides with a very shallow fossa canina. The infrazygomatic outlines of E and a Chukchee (no.

3848, American Museum of Natural History) are presented in fig. 23 to show the deep infrazygomatic curve in the latter and the shallow one in the former.

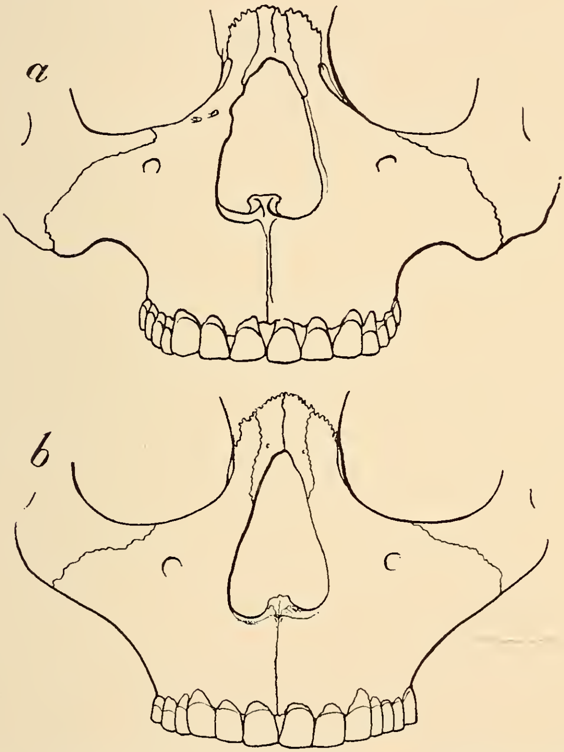

Fig. 23.—Two aspects of crista infrazygomatica: deeply curved in *a* (no. 3848, Chukchee ♂, A. M. N. H.), and very shallow in *b* (Santa Barbara E (♂). (About $\frac{2}{3}$ natural size.)

The foramina infraorbitalia in the upper regions of the fossæ caninæ exceed medium size. Between the foramen infraorbitale and the lower orbital rim the sutura infraorbitalis is present on the left side of B and on both sides of C, but there is no indication of it in E. The orbital portion of the suture is also preserved in B. Well known as a typical feature in the Eskimo skull, it is occasionally found in other human varieties. Its frequency in the undeformed Indian skulls of the North Pacific Coast amounts even to 51.9% of bilateral and 2.9% of unilateral (left) occurrence.

As regards the position of the foramen infraorbitale in proportion to the height of the corpus maxillare, it must first be stated that both measurements differ as to right and left, and it is the latter which exceeds the former. The vertical height of the corpus (lower rim of orbit to alveolar border at middle of second premolar), as shown in the following table, is on the whole greater in B than in C and E, and in correlation therewith the distance is smaller between the upper rim of the foramen infraorbitale and the lower rim of the orbit.

CORPUS MAXILLARE	SANTA BARBARA					
	B(♂)		C(♀)		E(♂)	
	right	left	right	left	right	left
Height of corpus maxillare (mm.)	42	46	38	42	38	41
Height of foramen infraorbitale (mm.)	7	8	5	6	8	8
Index of position of foramen infraorbitale	16.7	17.4	13.2	14.5	21.1	19.5
Upper facial height (mm.)	72		69		67	
Upper facial index	54.6		53.1		50.0	
Maxillo-facial height index	61.1		59.4		58.9	

This correlation is perfectly clear in skulls B and C, but is not corroborated by E, whose maxillary height, fairly coinciding with the lower one of C, has a foramen height equaling that of B. The index of position of the foramen infraorbitale, according to the formula $\frac{\text{height of foramen infraorbitale} \cdot 100}{\text{height of corpus maxillare}}$, results accordingly in each case.

Another correlation is worthy of mention in this connection, namely, that between the height of the maxillary corpus and the general proportion of the face. According to *Martin* (1914, 823), in euryprosopic Swiss an average maxillary height of 38 mm. was observed, and in a leptoprosopic one of 44 mm. Similar correlations are likewise to be stated in the Santa Barbara crania, whose maxillary heights diminish with their upper facial heights, as may be seen in the preceding table. Here also the indices of the upper face height and that of the corpus maxillare bear out this correlation. Furthermore, although all three of our skulls are mesēnic, they nevertheless show different stages of mesēny in proportion to the quantitative differences.

For a general estimation and comparison of facial size and proportions, the averages and ranges of variation of undeformed skulls from the North Pacific Coast are presented in the table on page 112.

The upper facial height is seen to be quite variable in our three skulls. The two males B and E at 72 mm. and 67 mm. differ by 5 mm.; and between, at 69 mm., falls the female C. The latter, with 130 mm., stands lowest in bizygomatic breadth; but it is in this measure-

FACIAL MEASUREMENTS AND INDICES		SANTA BARBARA			NORTH PACIFIC COAST (UNDEFORMED SKULLS) Averages and Variation	
		B(♂)	C(♀)	E(♂)	male	female
		mm.	*mm.*	*mm.*	*mm.*	*mm.*
1. Total facial height		118	110	105	—	—
2. Upper facial height		72	69	67	75.0 (65–85)	70.2 (63–79)
3. Bizygomatic breadth		132	130	134	138.5 (125–156)	129.6 (117–140)
4. Cranial breadth		141	131	134	140.8 (129–152)	136.5 (130–150)
5. Minimum frontal width		96	90	85	94.1 (83–106)	91.4 (82–104)
6. Bigonial width (lower jaw)		97	96	103	106.0 (85–117)	98.0 (86–110)
Indices: 7. Facial:	$\frac{1 \cdot 100}{3}$	89.3	84.6	78.4	—	—
8. Upper facial:	$\frac{2 \cdot 100}{3}$	54.6	53.1	50.0	54.1 (41.4–61.8)	54.2 (49.6–61.0)
9. Transverse cranio-facial:	$\frac{3 \cdot 100}{4}$	93.6	99.2	100.0	98.5 (90.7–108.5)	95.3 (87.0–103.8)
10. Jugo-frontal:	$\frac{5 \cdot 100}{3}$	72.7	69.2	63.4	68.1 (59.7–77.2)	70.6 (64.0–84.5)
11. Jugo-mandibular:	$\frac{6 \cdot 100}{3}$	73.5	73.9	76.9	76.9 (67.8–85.1)	75.9 (69.9–85.8)

ment that E, with 134 mm., exceeds B at 132 mm. If the variation in the undeformed skulls of the North Pacific tribes be taken as an illustration of physical oscillation in general on the Pacific Coast, it will be noticed that the Santa Barbara male skulls fall in facial breadth and height below the average expressions, while the female fairly coincides with them. Our table contains also a number of other cranial measurements which have been discussed elsewhere in this report, and being brought in proportion to the facial measurements are discussed as indices farther below.

The proportion between the bizygomatic breadth and the facial height (nasion-gnathion) gives rise to indices which render B mesoprosopic with 89.3, but at the border line toward leptoprosopy, and C euryprosopic with 84.6, but in close proximity to mesoprosopy. E with 78.4, is hypereuryprosopic, owing rather to its relatively low total facial height than to its more conservative facial (bizygomatic) breadth. The upper facial index with the nasion-prosthion height is mesēnic, but in different degrees, and it is E which, with an index of 50.0, holds the line between mesēny and euryēny—a reminder of its hypereuryprosopic total facial index. Likewise in the upper facial index the variable facial height is of more decisive bearing than the less differing bizygomatic breadth. The upper facial indices of our specimens coincide with those of the North Pacific Coast Indians, whose averages may be considered as representing Mongoloid conditions in general.

The upper and lower facial breadths observed in the norma frontalis, i.e., the minimum frontal and the bigonial of the lower jaw, brought into proportion with the bizygomatic breadth, are expressed in the jugo-frontal and jugo-mandibular index. As both breadth dimensions almost coincide in B, their indices coincide likewise with 72.7 and 73.5, thus indicating an equal upper and lower constriction of the facial aspect as against the zygomatic expansion. These conditions turn out differently in C on account of the bigonial breadth exceeding the minimum frontal by 6 mm., with the result of a jugo-frontal index of 69.2 and a jugo-mandibular one of 73.9. Similar proportions, only much more emphasized, obtain in E, on account of the minimum frontal width being reduced to 85 mm. and the bigonial breadth enhanced to 103 mm., with a difference of 18 mm. between the two. Its jugo-frontal index at 63.4 ranges therefore below, its jugo-mandibular index at 76.9 above, those of B and C. Diverging proportions obtain likewise between the two dimensions in the North Pacific Coast tribes of our table, and give rise to diverging indices in indication of a greater bigonial as against a smaller frontal breadth. This, however, seems to be the prevailing condition in all the human groups, the cause of which must be sought in phylogenetic processes of brain expansion bearing on the dimensions of the cranial base and lower jaw, as well as in functional adaptations in connection with mastication.

Of diagnostic interest also is the proportion between the facial and cranial breadth from which the transverse cranio-facial index is computed, and which reaches 93.6 in B, 99.2 in C, and 100 in E. The difference between the first one and the latter two, although all three are indicative of greater facial breadth, lies with the cranial breadth, which in C is 10 mm., and in E 7 mm., less than in B. In the series from the North Pacific Coast the male exceeds the female average. Although the variation is rather extensive with regard to this index, those under discussion nevertheless illustrate Mongoloid conditions. These can even exceed the mark of equality (100.0) of the two dimensions involved, with individual indices of 108.5 in the males and 103.8 in the females of the series of comparison of our table, and with an average of 100.8 in Eastern Eskimo (*Oetteking* 1908, 49), where an individual index of even 111.5 was observed. Although, then, the cranial breadth is of decisive influence in the outcome of the cranio-facial index, it is nevertheless the bizygomatic breadth which is of racial significance and which is absolutely as well as proportionately of conclusive importance.

Regarding the horizontal profilation of the face, it is the more frontal position of the maxillary process of the zygomatic bone and of the zygomatic process of the maxillary bone which results in what one is accustomed to term the high cheek of the Mongoloid face. Medially this condition is still further intensified by the behavior of the frontal process of the maxillary bone. The less anteriorly concave the latter is, and the smaller its angular deviation from the frontal plane, the more pronounced is the frontal orientation of the middle face. A further characteristic of the Mongoloid face is the sharp backward turn of the zygomatic bone by which two more or less distinct planes are produced, an anterior and a lateral one, while in the Caucasian and Negro skulls the lateral outline is more evenly rounded and considerably flatter. These racial modifications are shown in the tracings of fig. 24, which were taken upon skulls oriented in the ear-eye plane, upon the left side of the face slightly below the lower orbital rim in order to cover all the parts

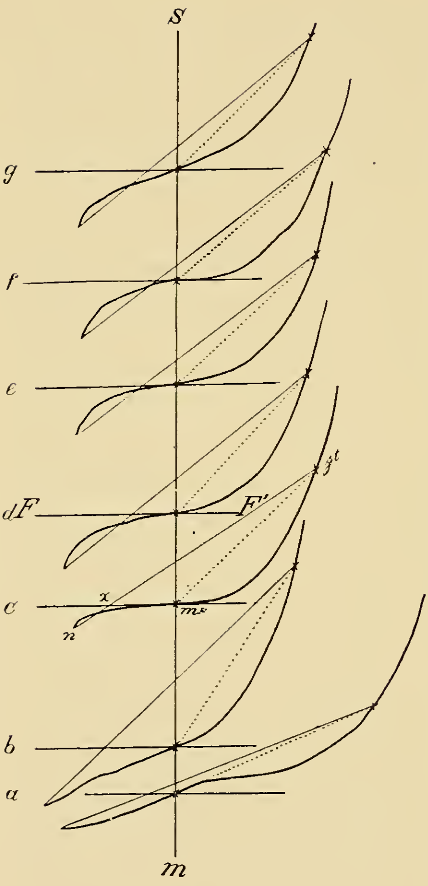

Fig. 24.—Midfacial horizontal outline of *a*, orang-utan; *b*, Negro; *c*, Nootka; *d—f*, Santa Barbara B (♂), C (♀), E (♂); *g*, Swabian. *m—s*, median-sagittal plane line intersecting in *ms* with frontal plane line *F—F′* which coincides with ear-eye plane; *n—zt*, nasozygomatic line (apertura piriformis to sutura zygomaticotemporalis) intersecting with *F—F′* line at point *x*. (½ natural size.)

from the nasal aperture to a point beyond the zygomatico-temporal suture. The lines of orientation are afforded by a parallel to the median-sagittal plane (*m-s*) intersecting with the zygomatico-maxillary suture of the outlines, which points were adjusted to it, and the frontal plane line (*F-F′*), at right angles to the former, and passing through the same points. There is still another line connecting the edge of the nasal aperture and the point of intersection with the zygomatico-temporal suture (*n-zt*), and which in a way helps to analyze the morphological complication there, as will be seen presently. For it is by this line that the appearance of the frontal process of the maxillary bone in horizontal cross-section may be judged. Its point of intersection with the *F-F′* line is marked *x* in our figure. The Nootka curve (fig. 24, *c*) as a prototype of the Mongoloid face shows its characteristics as pointed out above: the anterior portion almost coinciding with the frontal plane line, the sharp turn of the lateral outline, and the remarkably small deviation of the frontal process. These characteristics are only slightly modified in the Santa Barbara skulls (*d*, *e*, *f*). The concavity of the frontal process here is seen gradually to increase, simultaneous with its anterior aberration medially, while the zygomatic outlines remain true to the Mongoloid type. In the Swabian skull (*g*), the concavity of the frontal process is restricted to the medial half of its curve, while the lateral one is continuous with the zygomatic outline in its regular but little pronounced bulging. Quite different is the appearance of these parts in the Negro skull (*b*), and still more so in that of the orang-utan (*a*). Thus, while in the former the maxillary outline is practically straight and hardly set off against the zygomatic curve, the maxillary frontal process of the latter forms by its convexity a curve of itself which is continued into that of the zygomatic bone which then starts to form an individual curve. In connection with the conspicuous deviation of the maxillary outline in the Negro skull in advance of the frontal plane line, it must be pointed out that in the Negro skull it is rather an expression of pronounced vertical profilation of the Negro face. The zygomatic curve, as already mentioned, is least marked and flattest in the European where the naso-zygomatic line of orientation (*n-zt*) fairly resolves the entire tracing based on it into a medial concave portion and a larger lateral convex one. The gradual removal of the intersecting point of the naso-zygomatic and frontal plane lines from that of the latter and the median-sagittal plane line (*m-s*)[1] is quite an interesting feature in this connection, and is listed in figures in the next table, where it is accounted for as "naso-zygomatic deviation." It was for the sake of comparison with an anthropoid state that the facial outline of an orang-utan was added in fig. 24. The principal point of difference between it and the human facial outlines is the total convexity in advance of the naso-zygomatic line of orientation, which accounts for the distinctly frontally oriented face of the ape.

The projective width and length of the zygomatic curve, measured between the *ms* point and the *zt* point projected upon either the *m-s* or the *F-F′* line, the elevation of the curve above its chord, the length of the latter, and the indices derived therefrom, are listed in the table on page 119.

The projective widths and lengths do not differ greatly in the Swabian and the four Indian skulls, while the zygomatic width of the Negro falls short of them, and its length considerably exceeds them. This excess is due in part to the conspicuous medial deviation of the maxil-

[1] In the tracings of fig. 24 this point of intersection is marked *ms*. In analogy with the point marked *zt* it might have been called *zm* as signifying the two anatomical parts joining there. But since that symbol as zygomaxillare is used already for the lowest point of the zygo-maxillary suture, the symbol *ms* was resorted to in our tracings.

HUMAN VARIETY AND ORANG-UTAN	OS ZYGOMATICUM 1: naso-zygomatic deviation ms-x* mm.	2: projective width ms to zt mm.	3: projective length F-F' to zt mm.	4: height of curve ms-zt mm.	5: length of chord ms-zt mm.	Index $\frac{3 \cdot 100}{2}$	Index $\frac{4 \cdot 100}{5}$
Swabian ♂	6	29	28	5	40	96.6	12.5
Santa Barbara							
E (♂)	4	32	27	8	42	84.4	19.1
C (♀)	7	30	27	7	41	90.0	17.1
B (♂)	9	28	29	7	41	103.6	17.1
Nootka ♂	14	30	28	8	42	93.3	19.1
Negro ♂	15	26	39	6	47	150.0	12.8
Orang-utan	6	42	18	5	46	41.9	10.9

* For markings compare fig. 24.

lary frontal process in advance of the frontal plane line, and which was pointed out before as in conformity with the profilation of the Negro face (page 117). The index computed from the projective zygomatic length and width, and expressing the latter in percentages of the former, is quite variable among our Indians and the European, in spite of the apparent slight disparity of the underlying factors. More marked, however, is the difference with the Negro, whose index of 150 expresses the strongly differing single dimensions and illustrates the morphological differences of the zygomatic bone in the facial configuration of the race. In opposition to them stands the orang-utan, with an index of only 41.9, which is the result not only of its extreme projective zygomatic width of 42 mm., but of its greatly reduced length of 18 mm.

The difference of horizontal extension or curvature of the zygomatic arc finds definite expression through an index which brings the elevation of the arc above its chord in proportion to the length of the latter. Again the lengths differ only slightly in the Swabian and the Indians. However, the Swabian chord length falls slightly lower in opposition to the Negro and orang-utan, which, with 47 mm. and 46 mm., outrange the others. More marked is the difference in the height of curve, exceeding in the Indians those of the other specimens, and aiding in the production of the higher indices that characterize the Mongoloid condition. The indices of the Swabian and Negro differ only by the lower decimal above the index unit 12, while the orang-utan's index is only 10.9.

Observing, finally, what was termed the naso-zygomatic deviation, as situated in fig. 24 between the points *ms* and *x*, it is seen to increase in our Indian skulls from 4 mm. to 14 mm., and to rise in proportion to the diminishing deviation, in advance of the frontal plane line, of those parts of our curves that trace the frontal processes of the maxillary bone. The Swabian, with 6 mm., falls within the variation of our Indian specimens, while the Negro exceeds them with 15 mm., and the orang-utan's deviation likewise amounts to only 6 mm., but the morphologically different conditions of the latter two find expression through other quantitative means discussed above.

NORMA OCCIPITALIS

The norma occipitalis offers less opportunity for morphological and metrical description than any of the other normæ. Starting with the delineation of the cranial contour, it corresponds in our three skulls to *Haberer's* (1898) "house shape." The sides are nearly vertical in projection, their greatest expansion occurring at the level of the temporal lines, or, still more precisely, *Dalla Rosa's* (1886) "circummuscular zone," where they turn rather sharply to form the cranial roof. The latter appears to be more rounded off in the female, while in the males a flat gable is formed. The somewhat irregular shape of E in the occipital aspect is due to its plagiocephalic cranial condition hinted at before (pages 12, 14, 22, 32). The shape and course of the sutures were discussed on pages 22–26. It may be pointed out that in C the interparietal apex of the occipital squama is somewhat dilated and squarish, while that of E is more acutely triangular. Observed quite frequently in a variety of shapes in the skulls from the North Pacific Coast, it was supposed there to represent an irregular ossification of the occipital fontanelle. The upper squama shows an even, almost globular, bulging, which continues only slightly interrupted into the lower squama, still better to be noticed in norma lateralis (pages 59, 60, 69). This condition conforms with those described by *Martin* (1905, 466) in the Senoi, and in both instances is due partly to the more erect orientation of the nuchal planum. The angle of the latter is discussed on page 59 of this work. The conditions described here are seen in outline in the median-sagittal curves (see pls. I–III), in which particularly the tracing of B represents an almost faultness segment of a circle. By this description it is already suggested that the occipital relief of the planum nuchale is rather weak The protuberantia occipitalis externa is very weakly developed, but there is a distinct indication of a torus occipitalis, more so in the males than in the female. A similar observation is that of *Koganei* (1906, 525) on Korean skulls where the torus occipitalis occurred eight times out of seventeen. Of these, seven cases were males and one a female. The transverse bulgings between the lineæ nuchæ superiores and supremæ were recognized in the undeformed skulls from the North Pacific Coast in different degrees of development at a frequency of 69.7%, although only in 0.8% in a pronounced form. The latter is a typical feature in the Neandertaloids, Australians, and certain Oceanians. But even the high occurrence in the American native population must be considered a racial characteristic. The foramina mastoidea are, as a rule, decidedly variable in size, number, and position, and are so in both our specimens. The left foramen in skull B is of medium size and is situated in its typical place in the occipito-mastoid suture. The right foramen, in size the same, is situated upon the mastoid portion of the temporal bone and removed about 5 mm. from the suture. The left foramen in skull C is in its regular place and is slightly above medium size. It is lacking on the right side, but perhaps is vicariously substituted by a smaller opening near the sutura parietomastoidea. On the left side in E there is a foramen of medium size on the mastoid portion of the temporal bone, while on the right side a tiny foramen in the corresponding part and another in the occipito-mastoidal suture are in evidence. Complete absence on one side is not so rare; such absence was observed in 5.2% on the right side and in 15.5% on the left side of the North Pacific undeformed skulls.

Regarding the principal dimensions observable in the norma occipitalis, the Santa Barbara skulls are slightly broader than high, as will be seen from the following table.

HUMAN VARIETY	CRANIAL BREADTH AND HEIGHT						
	breadth			height	indices		
	1	2	3	4			
	cranial mm.	biauricular mm.	mastoidal mm.	cranial mm.	$\frac{4 \cdot 100}{1}$	$\frac{2 \cdot 100}{1}$	$\frac{3 \cdot 100}{1}$
Santa Barbara							
B (♂)	141	120	97	134	95.0	85.1	68.8
C (♀)	131	118	97	125	95.4	90.1	74.1
E (♂)	134	119	102	133	99.3	88.1	76.9
North Pacific Coast (undeformed)							
Averages ♂	140.8 (129–152)	—	—	134.2 (110–148)	95.5 (77.8–106.1)	—	—
Averages ♀	136.5 (130–150)	—	—	132.2 (115–141)	95.6 (83.3–106.3)	—	—

Presenting medium conditions in this respect, the breadth-height indices result accordingly. They are, with values of 95+, metriocranial in B and C, conditions typical of the Mongoloid and especially of the Indian skull. E, on the other hand, is acrocranial at 99.3, resulting from a smaller cranial breadth than that of B, but having a cranial height equal to it. The breadth-height indices of B and C are seen to conform exactly with those of the undeformed crania from the North Pacific Coast. The index of E, however, falls well into the range of variation. In further characterization of the cranial dimensions in the occipital aspect, the biauricular as well as the mastoidal breadths were recorded. The former differs by only 1 mm. each in our three skulls, while the latter is identical in both B and C, but is higher by 5 mm. in E. The two measurements as such differ in the typical way, i.e., the biauricular or breadth of the cranial base exceeds the mastoidal breadth. Sex differences in favor of the male skull are due naturally to the differences in size, and *Martin* (p. 717) claims that the two measurements differ more in brachycranial than in dolichocranial skulls. Each two indices derived from the latter two breadths in proportion to the cranial breadth differ in the Santa Barbara skulls on account of the difference in the latter measurement, which is even more noticeable in E.

LOWER JAW

The lower jaws are of medium size and are well balanced in their proportions. Muscle markings are somewhat more pronounced, although moderately developed in the males. This is likewise true of the lineæ obliquæ, which are steeper in the males, forming upon the corpus the familiar swelling and spreading into a vertical and longitudinal branch. About the lower border of the corpus of B and C is to be observed the planum platysmaticum ending anteriorly and laterally in the tubercula mentalia, also tubercula platysmatica according to *H. Virchow* (1920, 23). These conditions are merely indicated in C, while in E the striæ platysmaticæ (*H. Virchow* 1920, 5) are well marked. The basal border from fore to aft in lateral projection, particularly that of C, forms a continuous flatly convex outline without producing even an incisura præmasseterica (*M. v. Lenhossêk*, 1920, 53; also incisura præmuscularis *Klaatsch* 1909, 107, and incisura præangularis *Frizzi* 1910, 259) in its posterior portion. In the two males this incisure is only faintly indicated, as is another below the mental foramen, and here more so in E than in B, but in general the lower border is similar to that in the female. Characteristic of the outlines in lateral projection is the anterior height, exceeding only slightly that of the corpus in general, and which is due in part to the weak chin formation, all of these features repeating conditions prevailing in the American Indian, and, in a wider sense, the peoples of Mongoloid affinity.

The trigonum mentale is well developed in B and E, but weaker in C. The incisura subincisiva (*Klaatsch* 1909, 112), or incurvatio mandibulæ anterior (*H. Virchow* 1920, 62), is therefore quite shallow in C, but better marked in B and particularly in E. Laterally of the trigonum, the fossa mentalis (*H. Virchow* 1920, 62) and its continuation upon the corpus as sulcus mentalis (*Klaatsch* 1909, 112) are likewise better developed in B and E. It is remembered that the latter author (1909) has employed in connection with his alveolar plane line a chin vertical. The projection of the chin in advance, or falling short, of the vertical was termed by him positive, neutral, and negative chin. The misleading latter term occasioned *Frizzi's* (1910, 23) corrective vertical through the deepest point of the sub-incisival incurvation. It had to be employed in the median-sagittal tracing of C, which in *Klaatsch's* method would be possessed of a negative chin, while with *Frizzi's* corrective vertical the chin becomes positive. An angular expression of chin projection may be had by drawing the chin tangent from the incision (*Klaatsch* 1909, 103), or infradentale, or katoprosthion (*H. Virchow* 1920, 14), and touching the most anterior point of the chin (*v. Török's* "pogonion"). The angle formed by this tangent and the alveolar plane line is the one sought, but the present writer prefers the angle below the alveolar plane to the one used by *Puccioni* (1913, 6, 13) above that plane for the reason of more direct expressiveness. Reversing therefore *Puccioni's* classification of the "progonic" angle, the divisions would read thus:

Progonic........................	x – 89°
Orthogonic......................	90 – 100°
Opisthogonic....................	101 – x°

As indicated in fig. 25, a state of progony prevails in B and E, even quite pronounced in the latter at 73°, while C is orthogonic. This method is naturally applicable only for mandibles possessed of a chin and not for the chinless fossil men and apes. Slight projection of the chin must be recognized as truly Mongoloid, which is also the state of the American Indian, and in this respect B and C are more typical than E, although the range of variation is rather wide, as noticed in a more cursory survey of this feature.

Fig. 25 shows likewise the basal tracings in alveolar orientation of our three mandibles. They are well rounded and even narrow at that in C, while chin angles (tubercula mentalia s. platysmatica) are only slightly to be noted in E. They thus present *Klaatsch's* (1909, 113) "median chin" in contradistinction to his "lateral" one, for which *Frizzi* (1910, 24) substituted "round" and "squarish" (abgekantet). It may be said that the more roundish shape of chin in our

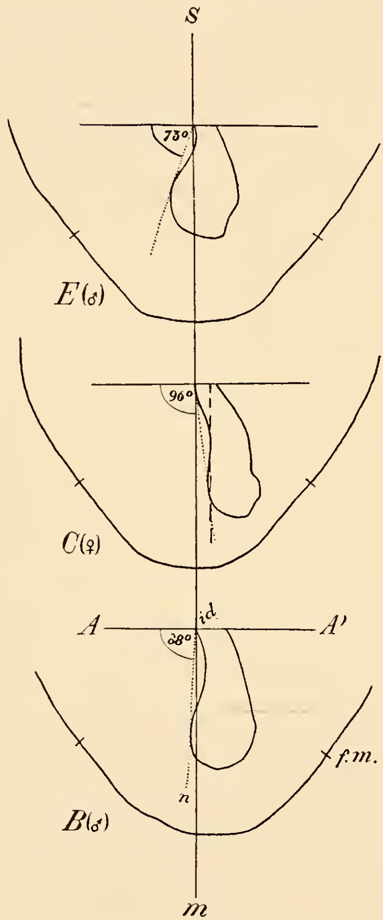

FIG. 25.—Basal and median-sagittal outlines of chin region in the Santa Barbara mandibles in alveolar orientation. *m—s*, median-sagittal; *A—A'*, alveolar plane; *id*, infradentale, *id—n*, chin tangent; ∠*A—id—n*, chin angle; *f.m.*, foramen mentale. (½ natural size.)

three specimens is likewise a true expression of rather typical conditions in the American Indians, although the opposite shape is also occasionally encountered among them.

The foramina mentalia, of which there are two on the left side of B and on the right side of E, are in line here, as well as in C, with the second premolars—in the latter, however, with the anterior alveolar rim, in the former, with the posterior. It seems that in the Anthropomorphæ, as well as in the Hominidæ, and certainly in the Australians, the situation of the mental foramina is rather in line with the first molar. This is doubtless a feature of phylogenetic significance, since with the progressive reduction of the alveolar process and the size of the teeth the foramina mentalia move automatically forward, or, better, retain their positions upon the more conservative corpus mandibulæ as against the modifying alveolar process.

The upper portion of the ramus is dilated in both C and E as compared with B, causing there the wider incisura mandibulæ, conditions which will be treated quantitatively below. The processus coronoidei are more pointed in the female, but in our three mandibles they fall short in height of the condyloid processes. They show on their medial sides well-developed ridges, *von Lenhossêk's* (1920, 51) cristæ endocoronoideæ. Another ridge, the crista endocondyloidea of the same author, branches from the former to form the medial edge of the condyloid process. Between the two cristæ the bone becomes thinner and often produces deep triangular depressions which are the rule in the lower jaw of the chimpanzee and occur with some frequency in man too They are wanting, however, in our specimens. This was called by *Klaatsch* (1908, 93) fossa subcoronoidea, and was supposed by him to be a muscular groove. But as it is a place particularly free from muscular insertion, and situated not below but back of the processus coronoideus, it might as well be termed "fossa (or trigonum) postcoronoideum." The longitudinal groove at the anterior border of the ascending ramus, *Klaatsch's* (1909, 108) fossa præcoronoidea, is deeper in B than in C and E, and its width is of medium proportions. Its lower portion in connecton with the postmolar space or trigonum postmolare (*Klaatsch* 1909, 108) presents, as a rule, the greatest thickness of the mandible. The respective measurements are 16 mm. in B, 18 mm. in C, and 14 mm. in E, as compared with 23.5 mm. in the Heidelberg jaw.

Medially the three mandibles are quite spacious and well rounded out in their anterior portions. The spina mentalis interna, or, better, the spinæ genioglossi, are individually well developed in B, but are merely indicated in C and E. The insertion of the mm. geniohyoidei is marked in proportion by tuberosities. Just above these formations there is a deeper funnel-like depression with an opening at the bottom in C, the outlet of a canalis medianus Bertelli. The fossæ digastricæ slope backward, indicating an advanced morphological condition as against those in the fossils where the area digastrica is directed downward. In our three specimens the two fossæ are medially separated by a distinct spina interdigastrica. The mylohyoid line, or rather angle, is well developed, particularly in B and C, and this seems to be the rule in the Indian lower jaw. It is even more projecting in the female, where likewise the postmolar width was shown slightly in excess of that of the males.

The condyloid processes are well rounded above and show no signs of flattening wear such as is usual in middle age. In vertical view they are elliptic with tapering ends, medially even more so than laterally. The frequently occurring and slightly pointed projection at the anterior edge of the mandibular condyles, which is brought about partly by the molding influence of ligaments and muscles (capsula articularis, ligamentum temporomandibulare, m. pterygoideus externus), is not present in our specimens. The antero-posterior diameter of the condyles which, according to *Martin* (1914, 881), amounts in the adult in most cases to a third of the length of the transverse diameter of the condyles, comes in the Santa Barbara mandibles to about its half. The length-breadth index of the capitulum therefore lies around 50, within a general range of 23–72 (p. 881), which is higher than the human average of 38.1. However, *Martin* states that about 90% of all cases occur between the index values of 30 and 50. The following table of capitulum measurements contains also a few comparative data of which those of La Chapelle-aux-Saints are distinguished by unusual proportions.

The axes of the condyles are in general quite variable and subject to the configurative formation at the cranial basis. The axes are directed from medially and backward to laterally and forward, which is likewise the condition here. The angles formed by the two condylar axes are greater in B and E than in C, corresponding thus to the nearly frontal direction of the fossæ mandibulares there, as referred to on page 74. The condylar angles are also listed in the table.

HUMAN VARIETIES AND ANTHROPOIDS	CAPITULUM MANDIBULÆ						
	length		breadth		breadth·100 / length		angle of condylar axes
	r. *mm.*	l. *mm.*	r. *mm.*	l. *mm.*	r.	l.	
Santa Barbara							
B (♂)...........	21	20.5	10	10	47.6	48.8	154°
C (♀)...........	19	20	10	10	52.7	50.0	140°
E (♂)...........	22	22.5	12	11	54.4	48.9	158°
Homo*...............	—		—		38.1 (23–72)		148°
Chimpanzee*..........	—		—		46.1		—
Orang-utan*...........	—		—		75.0		—
La Chapelle-aux-Saints*.............	29		13.5		46.6		—

**Martin* 1914, 881.

A word may be said regarding the mutual behavior of the processus alveolaris and the ramus. It appears that during phylogenetic development and with the broadening out of the skull base, the condyles, as well as the coronoid processes into which the temporal muscles are inserted, develop and broaden similarly, producing the downward and mesially slanting position of the ramus. Without changing the general status, this at times is counteracted by muscular traction that causes the eversion of the anguli mandibulæ, which as a feature by itself is very pronounced in the gorilla. But the most remarkable change takes place between the posterior end of the alveolar process and the anterior border of the ramus below the coronoid process, causing that deep recess, the fossa præcoronoidea. It shows the alveolar process to be the more conservative element, and the fossa, which is already well marked in the anthropoids, subject to the degree of ramus deviation.

The foveæ submaxillares, as well as the sublinguales, are quite pronounced in C. The sulci mylohyoidei and the foramina mandibularia are of normal appearance, except that the left sulcus in C is bridged, and both sulci are doubly bridged in E, with outlets at the lower end.

The principal measurements of the Santa Barbara mandibles are combined in the table on page 134, where for comparison several other groups, as well as the Heidelberg specimen, are included. In conjunction with this table and those following, the lateral outlines of our three mandibles in alveolar orientation should be consulted. The central of the three outlines of fig. 26 shows the measurements and angles referred to in the text.

The dimensions listed in our table for the lower jaws of B and C are nearly identical, while the length of E falls short of, and the two widths exceed, the corresponding measurements. According to the physiological ranges given by *Martin* (1914, 870) for the three measurements extending for the length from 90 mm. to 126 mm., the bicondylar width from 103 mm. to 135 mm., and the bigonial width from 85 mm. to 117 mm.,

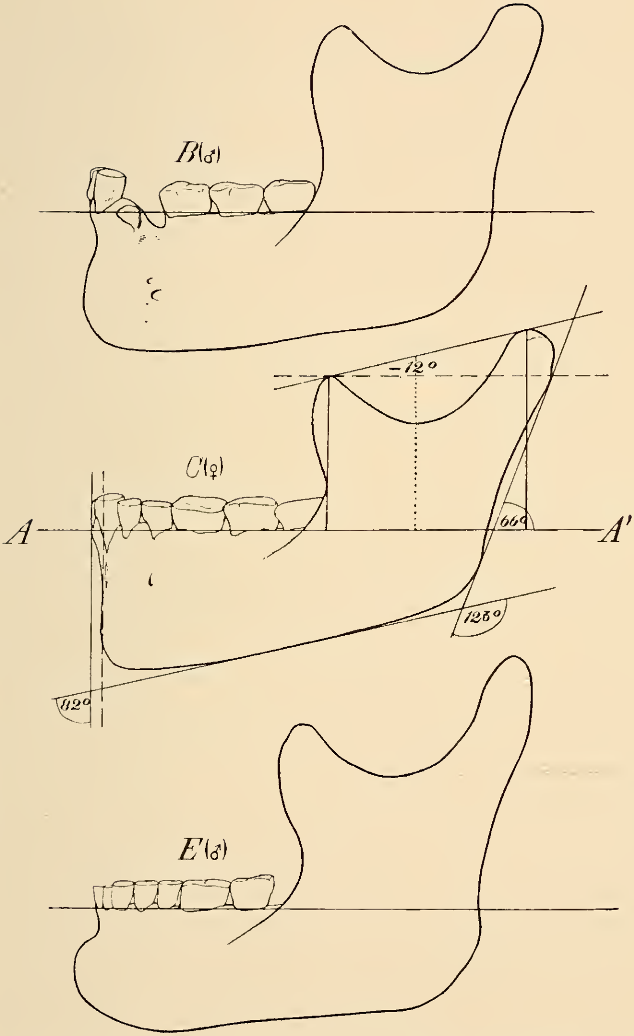

FIG. 26.—Lateral outlines in orthogonal projection and alveolar orientation of the Santa Barbara mandibles. *A—A'*, alveolar plane line. For angles and methods see text. (½ natural size.)

HUMAN VARIETY	PRINCIPAL MEASUREMENTS AND INDICES OF THE MANDIBLE				
	1	2	3	Index	
	length *mm.*	bicondylar width *mm.*	bigonial width *mm.*	$\frac{1 \cdot 100}{2}$	$\frac{3 \cdot 100}{2}$
Santa Barbara					
B (♂)	107*	117	97	90.6	82.9
C (♀)	109	118	96	90.6	81.3
E (♂)	99	120	102	82.5	85.0
Averages: Chinese†	102	120	101	98.5	83.7
Averages: Negroes†	106	112	93	87.9	83.1
Averages: Australians†	112	122	103	92.3	84.4
Heidelberg	120	131	110	91.7	84.0

* The length of the mandible is measured from the chin projection to the most posterior points of extension, the jaw resting on its base. The points of posterior projection are the backs of the condyles (*Martin* 1914, 559, measurement 68). However, since through the introduction of the alveolar plane line (*Klaatsch* 1909) we possess a means of proper mandibular orientation, the length (mento-condylar) might just as well be adjusted to it. In further justification of such procedure is the outstanding fact that the mandibular orientation coincides with the general cranial ear-eye orientation much more frequently than the fortuitous one of its former by its basal border. Although the alveolar plane has been utilized extensively in the present studies, the mandibular length was not referred to it in order to facilitate comparison, but may nevertheless be mentioned separately in this note. The mento-condylar lengths then,—the one taken in the usual way and that secured in alveolar orientation,— are in B as 107 mm. to 103 mm., in C as 109 mm. to 103 mm., and in E as 99 mm. to 96 mm.

† *Martin* 1914, 869.

our mandibles represent about medium conditions in B and C, while for E here holds good what has been said about it in the preceding sentence. The length averages listed for comparison in our table are graded in such a way that the Negroes with 106 mm. exceed the Chinese with 102 mm., while both in turn are exceeded by the Australians with 112 mm. Comparing the Chinese averages of the two width measurements taken as a standard for peoples of Mongoloid affinity, it will be seen that the Santa Barbara mandibles fairly approximate them as representing medium conditions, while the Negroes range below and the Australians above them. The length-width indices of our specimens are strongly influenced by the relative shortness of their lengths, especially in E, i.e., they range below the averages of the other varieties except the Negroes, while the high index of the Chinese is not entirely plausible from the average dimensions involved.

The width indices are more stable in general, amounting to 81.3 in C and 82.9 in B, and accounting in the former for a slightly greater bicondylar and a slightly smaller bigonial width. The higher index of 85.0 in E results, of course, rather from its markedly greater bigonial than its only slightly greater bicondylar width. Regarding the Heidelberg jaw, it is its exceedingly large dimensions which mark it as the largest specimen on record, while its indices conform with those of the Australians.

The height proportions of the body were determined by *Cameron* (1923, 54 c) by an index involving the symphysial and molar heights, the former being measured, like the chin height, between the lower border of the chin and the interalveolar septum of the middle incisor teeth, the latter between the second and third molars. *Cameron* observed the anterior height of jaw in the adult Western and Central Eskimo greatly to exceed in cases that of the molar region. The lowest index as expressing the greatest divergence between the two heights was that of an adult female at 62.1, while an adolescent female had an index of 91.4. He compares the adult index with the European variation of 76.1–94.1, concluding "that the masticatory activity, and therefore the downward pressure upon the lower molar series, were not merely so evident in these types of mankind" (p. 54 c). It seems doubtful to the present writer whether the depressed molar height of the corpus is a result of function, since the principal demands on the masticatory apparatus occur during a period of concluded growth when such radical changes in a bone as alluded to are hardly imaginable. He is confirmed in his deviating opinion by the examination of an Eskimo mandible from Smith sound (American Museum of Natural History, no. 105) of extraordinary massiveness. Its two corpus heights are as 37 mm. to 30 mm., giving rise to the high index of 81.1.

Our two mandibles B and C have chin heights of 33 mm. each, and molar heights of 29 mm. and 25 mm. respectively, resulting in indices of 85.5 in B and 75.8 in C. With a chin height of 27 mm. and a molar height of 28 mm., the conditions are reversed in E. The index here amounts to 103.7, thus exceeding *Cameron's* European range. The smaller chin height of our specimen E is due to an incurvation of the basal border of the chin, *Klaatsch's* (1909, 110) incisura submentalis, which is absent in C and only slightly indicated in B. The last named author sees in it an inferior character existing in the Gibbon and the mandibles of old diluvial origin, and only as a reminiscence of those conditions encountered in more recent varieties.

It is to *Cameron's* credit that he has called renewed attention to a faint groove medially right below the third molar tooth, which is there caused by nervus lingualis (p. c 55). Not of constant occurrence in general, it is nevertheless very pronounced in our specimen C.

In order to express by an index the dimensions of the ramus, *Cameron* (p. c 55) has brought into proportion its minimum breadth, and, at right angles with it, the height from the bottom of the sigmoid notch (incisura mandibulæ) to the lower border of the corpus. Admitting that the height measurement of the ramus as usually taken between the condyle and the angle (condylion to gonion) is a rather arbitrary one, the writer fails to see the advantage of the substitution of the no less variable sigmoid height without accounting for the coronoid and condylar processes which are integral parts of the ramus. He therefore would prefer that the ramus height be taken with the inclusion of the two processes easily to be connected by a string or a needle, and above the deepest point of the curve. The accompanying table shows our two mandibles B and C to be possessed of equal ramus breadths of 35 mm., E exceeding them by 2 mm. The difference between the sigmoid and condylo-coronoid heights is, in favor of the latter, seen gradually ascending and amounting to 13 mm., 15 mm., and 18 mm. in our three mandibles and signifying a differing depth of the incisura mandibulæ. They differ also between

HUMAN VARIETY AND CHIMPANZEE	RAMUS MANDIBULÆ				
	1	2	3	Indices	
	minimum breadth mm.	sigmoid height* mm.	condylo-coronoid height mm.	$\frac{1 \cdot 100}{2}$	$\frac{1 \cdot 100}{3}$
Santa Barbara					
B (♂)	35	53	66	66.0	53.0
C (♀)	35	44	59	79.5	59.3
E (♂)	37	51	69	72.5	53.6
Western and Central Eskimo†					
♂ (7)	41.5	50.3	—	82.2	—
♀ (4)	35.1	49.4	—	71.0	—
Anglo-Saxons† (10)	—	—	—	52.3 to 67.8	—
Chimpanzee‡	50	58	68	86.2	73.5

* The description of measurements 2 and 3 is given in the text.

† *Cameron* 1923.

‡ Amer. Mus. Nat. Hist., 51377.

themselves in such a way that the heights of C fall between those of B and E. The index with the sigmoid height, *Cameron's* "index of width of the ramus" (p. c 55), is at 79.5 higher in C than in B and E, owing to its lower ramus height at about equal breadths. The condylo-coronoid heights influence the indices, of course, to the amount of the height differences. The Eskimo of the last table, at least in the males, have broader and lower rami, as compared with the Santa Barbara specimens, and hence a markedly higher index. The females range with slender rami below the males. Decidedly lower indices are characteristic of the Anglo-Saxons, with perhaps an average around 60.0, or even lower, in expression of much slimmer rami. *Cameron* (p. c 55) remarks on the highly interesting observation that the index "increased with age in both sexes, up to middle life at any rate," owing to the increasing width of the index, while "in European types of mandible, it was ascertained that the index of width of the ramus increased with age so long as the teeth remained intact, and then diminished again if the individual became edentulous."

For comparison the corresponding measurements of a chimpanzee are included in the table. They exceed those of the human varieties considerably, yielding also indices in excess of them.

Since the establishment by *Klaatsch* of a plane of orientation, quite a number of the absolute measurements of the mandible may be referred to it.[1] Thus, the

[1] Slightly modifying the technique proposed by *Klaatsch* (1909, 102–103) and *H. Virchow* (1920, 14), the writer passes his alveolar plane line through points upon the thickened seam all around the alveolar process and which is rarely missing, between the middle incisors and at the alveolus for m_3. He believes to have thus found more constant points of orientation as compared with those required by the two authors named.

ramus measurements are easily ascertained. The mutual relation between the coronoid and condyloid heights above the alveolar plane might be expressed by an index according to the formula: $\frac{\text{condylar height} \cdot 100}{\text{coronoid height}}$[1].
The Santa Barbara specimens are distinguished by lower coronoid processes; they are chamæcoronic with indices of 105.0 in B, 122.6 in C, and 129.7 in E. *Puccioni* (p. 300) classifies the American Indian as hypsicoronic, i.e., with indices up to 94.5. His statement refers, of course, to average conditions, as likewise does the following: "Les mandibules chamæcorones ne se trouvent pas chez les hommes: la mâchoire inférieure de Mauer est la seule qui offre un indice rentrant dans ce groupe." Our two mandibles C and E, however, fall within the chamæcoronic range, while B, isocoronic at 105.0, is not far removed from the chamæcoronic.

The depth of the incisura mandibulæ (s. condylocoronoidea), which varies in the human varieties from 10 mm. to 18 mm. (*Martin* 1914, 881), presents with 12 mm. in B, 13 mm. in C, and 16 mm. in E, varying conditions in the Santa Barbara specimens. Greater differences were noted for the condylo-coronoid width. Measuring 35 mm. in B, it reaches 42 mm. in C and E, and represents in the latter a kind of a "dilation" of the

[1] It is clear that the coronoid process may be either higher, lower, or at an equal height with the condyloid process. *Puccioni* (1914, 300) classifies the index according to the following terms, which explain themselves:

hypsicoronic..........................	x– 94.5
isocoronic............................	94.6–106.5
chamæcoronic.........................	106.6–x

two processes, which seems to be more frequent in the female mandible.

The indices derived from these measurements are, with 34.3 in B, 31.0 in C, and 38.1 in E, microbathycœlomic in B and C, but macrobathycœlomic in E, according to *Puccioni's* (1914, 303) classification.[1] In spite of its greater depth, the lower index in C is due to the markedly greater width, which in fact appears to be the more variable factor, not only in the Indian mandible, but in the Mongoloid in general. The index of E, on the other hand, is expressive of a greater incisura depth.

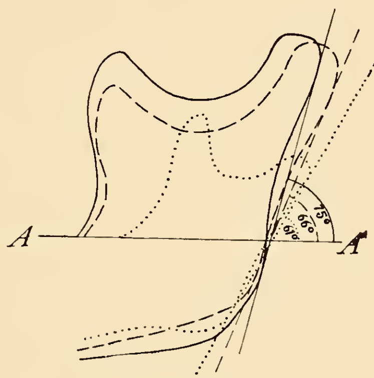

FIG. 27.—Superposition of mandibular rami in lateral projection and alveolar orientation, to show differences of ramus angles. *A*—*A'*, alveolar plane. ———— Santa Barbara B (♂); - - - - - Santa Barbara C (♀); .... Ozan, Arkansas (no. 543 inf., M. A. I.). (½ natural size.)

The alveolar plane line is of greatest importance in angular investigation. The following table contains in alveolar orientation (1) the condylo-coronoid angle between the condylo-coronoid tangent and a parallel of the alveolar plane line, (2) the ramus angle between the ramus tangent and the alveolar plane line, (3) the "postero-basal" (mihi) angle between the ramus and basal tangents, and (4)

[1] Incisura index:

microbathycœlomic	x–37.0
macrobathycœlomic	37.1–x

the "antero-basal" (mihi) angle between the chin vertical and the basal tangent. They may be read also from the lateral projections of fig. 26 (middle figure).

HUMAN VARIETY	MANDIBULAR ANGLES IN ALVEOLAR ORIENTATION			
	condylo-coronoid	ramus	postero-basal	antero-basal
Santa Barbara				
B (♂)......	−7°	75°	115°	81°
C (♀)......	−12°	66°	123°	82°
E (♂)......	−18°	77°	109°	85°
North Pacific coast (undeformed)				
Averages ♂..	+0.4° (−18 to +18°)	69.0° (55–79°)	118.4° (100–137°)	81.8° (69–89°)
Averages ♀..	−1.4° (−12 to +12°)	64.2° (57–70°)	124.2° (116–131°)	80.5° (72–86°)
European*........	−10°	77°	112°	78°
Negro*...........	+20°	70°	128°	71°
Australian*.......	−12°	83°	116°	72°
Dajak*...........	+7°	75°	108°	88°

* Single jaws (*Klaatsch* 1909).

Before the introduction of the alveolar plane of mandibular orientation, the means of determining the exact state of erectness or declination of the ramus were wanting. The ramus angles on that plane for the Santa Barbara specimens are 75° in B, 66° in C, and 77° in E. The female angle (C ♀) is thus seen to range below the male angles. The average ramus angles of the undeformed crania from the North Pacific Coast, at 69.0° and 64.2° in the two sexes, also show the female angle to be smaller than that of the male, or, what is equivalent, signifies the more marked declination of the female ramus. This fact being established there, it was shown by further comparison that the infantile ramus angle fell short of the angle in both the male and the female, the cause for it, of course, lying with the processes of growth and function. In order to show the different degrees of declination, the ramus outlines in lateral projection of Santa Barbara specimens B and C are superposed in fig. 27, together with an outline of an infantile mandible from Ozan, Arkansas (no. 543 of our collection). They were made to coincide at the points of intersection between the ramus tangents and the alveolar plane line. The other ramus angles of our table show a remarkable degree of erectness at 83° in an Australian, followed by a European at 77°, a Dajak at 75°, and an African Negro at 70°. However, their figures, like those of the Santa Barbara mandibles, are only of relative comparative value, as they represent only individual ones. Taking the ranges of variation of the North Pacific Coast as a criterion, it will nevertheless be realized that our two specimens hold high stations there and that the Australian at 83° even exceeds the ranges.

In close relation to the ramus angle, but conditioned by the behavior of the basal tangent, the postero-basal angle is, in a way, the equivalent of and comparable with the older ramus angle. In spite of the variation of that tangent, the sex difference is well pronounced in the individual figures of the Santa Barbara specimens, as well as in those of the North Pacific Coast. They are in favor of the female angle and correlated with the greater female ramus angles first discussed. The angles of B and C fairly correspond with those of the North Pacific specimens, while E falls noticeably short of them on account of its more erect ramus tangent. The individual figures of our column are quite variable, owing doubtless to the varying conditions regarding the basal tangent. These may best be judged from the ranges of the antero-basal angle between the basal tangent and the chin vertical. Sex differences of this angle seem to favor the males, who have a slightly higher average.

For the postero-basal, or the ramus angle of the older method, *Martin* (1914, 884) gives an adult range of 88–142°, and *Kieffer's* (1908) averages for Peruvians and Chinese at 119°, Australians at 124°, Negroes at 125°, and Europeans at 128°. The latter author showed that it was the differing chin heights that bore decidedly on the outcome of the angle.

The condylo-coronoid deviation has been expressed by the condylo-coronoid index (see pages 139–140). The more exact method, however, seems to be the determination of the angle of deviation of the "condylo-coronoid tangent" (*Klaatsch* 1909, 107) from intersecting lines. Thus *Klaatsch* determined such an angle by the intersection of the condylo-coronoid and ramus tangents. However, both being variable quantities, this method lacks definiteness. *Puccioni* (1913, 7) determines the angle in relation to a l ine at right angles with the alveolar plane line, which he erects as a tangent to the anterior border of the ramus. The angle opens forward and is named by *Puccioni* "angolo anteriore della branca," the justification of which is not quite clear, since it is the deviation of the condylo-coronoid tangent which is to be expressed by it. To the present writer the simplest and most unequivocal method seems to be the direct determination of the angle upon a parallel to the alveolar plane line passing through the coronion. It is a plus angle (+) if the condylo-coronoid tangent slopes backward, and a minus one (−) if it slopes forward.

The required lines can easily be drawn into the craniogram (mandibulogram), since a suitable apparatus for direct measurements is not yet available. The angle itself is one of great variability. In the North Pacific mandibles, as will be seen from the table, it extends from −18° to +18° in the males and from −12° to +12° in the females, with averages of +0.4° and −1.4° in the two sexes. The Santa Barbara mandibles, with −7° in B, −12° in C, and −18° in E, decidedly emphasize the minus state. Of some significance is the single value of +20° in the Negro, which exceeds the plus side of the North Pacific range of variation. It will remain for a later period of multiplied studies in this new method to produce more comprehensively differentiated results. *Puccioni's* assertion of the predominant state of hypsicorony in the American Indian can not very well be upheld on the basis of our own results, at least for the Santa Barbara specimens and the North Pacific tribes. His statement as based on his index classification (see page 140) is neither prompted by the Santa Barbara indices as listed there nor by the condylo-coronoid angles which likewise suggest a chamæcoronic state, while the average angles of the mandibles of the undeformed crania from the North Pacific Coast suggest absolute isocorony. The range of variation here is nevertheless quite extended, as stated above. However, *Puccioni's* assertion is upheld by *MacCurdy* (1923, 234) for Peruvian mandibles, when he states that, "in the collection as a whole, the coronoid process is almost without exception higher than the condoloid."

TEETH

All the teeth in the upper as well as in the lower jaws were erupted in B and C. This holds good for E too, except that in its lower jaw the third molars have not appeared. Of all the dentures only that of the lower jaw of C contains the full number of teeth; the others are slightly incomplete by postmortem loss. The teeth extant are recorded in the section on the State of Preservation (page 12).

Common in all the teeth is their wearing off, which, although not extravagant, is well pronounced and conforms with the degree of attrition generally met with in Indians of medium age. The third molars are better preserved in both jaws than the two other molars and the premolars, which demonstrates the diminishing functional strain in a fore-to-aft direction. The occlusal surfaces of the molars are beveled in the familiar way, i.e., slanting lingually-buccally in the two jaws. There is a more intensive attrition of the incisors and canines to be noticed in the female C.

The teeth are of medium size in every respect, showing the typical differences, in the molars, of five cusps in the upper and four in the lower, with a diminishing tendency backward. The molars diminish also in size and thus represent the condition of progressive phyletic differentiation.

No anomalies occur in our specimens, and no pathological conditions were noted. This refers particularly to caries, of which there is no indication at all. Due to a pathological process (periostitis, fistula), however, is the deterioration of the anterior alveolar borders of the lower left incisors of C, in such a way that openings of the alveolar wall at the ends of the roots were produced, while the alveolar margins remained unimpaired in the alveolus for i_2, while that of i_1 is only slightly affected.[1] The teeth themselves are normal.

A feature of special interest in Indian skulls, and one thoroughly studied by *Hrdlička* (1920),[2] is the "shovel-shape" of the incisors, and which is more elaborate in the upper than in the lower. In the Santa Barbara specimens this feature is merely indicated and may be described as "semi-shovel" in the upper incisors of B and C, and "trace" in E. The latter is noted also in the lower incisors of B, while there is no "trace" in C and E.

[1] Regarding this condition of alveoloclasia, see *Leigh* 1925, 190.

[2] In his extensive study of the literature that author traced the description of the feature under discussion back as far as 1844, while as an Indian character he first called attention to it in 1907 (article on "Anatomy" in Handbook of American Indians, *Bull. 30 Bur. Amer. Ethnol.*). According to *Hrdlička's* tables, pronounced "shovel-shaped" median incisors occur in 67%, and lateral incisors in 76%, while smaller percentages go to the "semi-shovel" and "trace." Thus, "keilo-koilomorphy" (better, perhaps, in English adaptation, from χεῖλος = lip and κοῖλος = hollow: "cheilo-cœlomorphy," or "chilo-cœlomorphy") must be considered a distinct racial character in the American Indian.

CONCLUSION

The study of the cranial material from Santa Barbara has disclosed a number of facts which are the outcome of a methodical investigation on a comparative basis, the more important of which will be briefly reviewed.

In general the size of the skulls as exhibited by their capacity, circumferences, and modules, was recognized as medium and tending toward smallness. This is in conformity with the findings of other authors. Thus, while *Boas* (1895, 407) has shown that the skulls from the California islands are smaller by 6% than those of the Plains, *Hrdlička* (1906, 54) asserts that "the California mainland crania are characterized by small size." The principal cranial diameters are therefore rather submedium and give rise to meso-brachycranial, ortho-hypsicranial, and metrio-acrocranial indices. If this is in keeping with the cranial averages of the California mainland and particularly those around Santa Barbara, the interesting fact was revealed in previous works that a difference of type occurs on the islands of the Santa Barbara archipelago in such a way that on the islands situated farther north (San Miguel, Santa Rosa, Santa Cruz, and Anacapa) shortheadedness predominated as against longheadedness on the islands farther south (San Clemente, Santa Barbara, San Nicolas, and Santa Catalina). A number of authors (*Carr* 1879; *R. Virchow* 1889; *Boas* 1895; *Matiegka* 1904; *Dixon* 1923, et al.) concur in this statement, which in part is corroborated by our own data on a series of crania from San Miguel island, used for comparison, and whose cranial length-breadth indices average 78.3 in the males and 79.2 in the females. The total frequency of meso-brachycrany in this series amounts to 91.7%, the rather insignificant remainder of 8.3% being dolichocrany. Further reference to these proportions will be made below.

A feature of particular interest in the Santa Barbara skulls is the degree of postorbital constriction expressed not only by direct measurements, but also in proportion to the cranial breadth. The transverse fronto-parietal index was shown to be metriometopic in skulls B, C, and D, and even stenometopic in E. The impression of this condition is peculiarly emphasized by the morphological behavior of the zygomatic processes of the frontal bone, which appear to be drawn out laterally in a horizontal direction. This has a bearing naturally on the fossa temporalis, which is relatively deep, and likewise on the appearance of the zygomatic arches in vertical aspect, thus causing the condition of phænozygy.

The smaller transverse extension of the frontal bones is met by their lesser vaulting longitudinally, a condition more pronounced in the Santa Barbara skulls than in La Chapelle-aux-Saints and Neandertal, and falls likewise below the San Miguel averages. The angle of frontal declination, on the other hand, corresponds at the same time with European conditions, exceeding even the San Miguel, Haida, and Eskimo averages of our table. However, the relative flatness of the frontal bones produces another interesting feature, viz., post-bregmatic elevation, a condition found quite typically in morphologically inferior races.

The glabella is only weakly developed in the male skulls as well as in the skull of the female.

The pars nasalis of the frontal bone was found rather long, but not so long as that of an Eskimo from Cape Nome. The width of the pars nasalis of the latter was in turn less extended, thus emphasizing the Mongoloid condition in contradistinction to the greater interorbital width in Europeans.

The orbits are meso-hypsikonchial and have the infero-lateral angle rounded out as usually is found in Mongoloid skulls and which is drawn downward as a rule in Europeans.

The nasal indices are leptorrhinic in B and E, but slightly chamærrhinic in C, while the lower nasal notches represent advanced morphological conditions. This can also be said of the fossa canina. Altogether the facial detail is quite well proportioned and in harmony with the general facial dimensions which render our skulls mesēnic with a slight tendency toward euryēny, and which as such corresponds with the conditions most frequently met in the Indians of the Pacific Coast.

A feature of more decisive significance, but likewise not at all rare in the Indians of the Pacific Coast in general and of Santa Barbara in particular, is the more or less pronounced state of prognathy, especially in the alveolar region, where it falls as low as 68° in skull C. To this extent it recalls similar conditions in certain tribes of southern India, such as the Senoi, Semang, Singhalese, etc. In opposition to this the foramen magnum angle falls rather high in expression of a phylogenetically advanced stage.

From a purely descriptive point of view the facial complex appears somewhat out of proportion, i.e., rather small by comparison with the well-rounded and capacious brain case, as will be noticed by consulting the tables of curve systems and the photographs. This impression is conveyed not only by the flatter frontal outlines, but more so by the postbregmatic elevations and the bulky well-rounded postauricular portions of the brain case.

Muscle marks on the whole are weakly developed, the texture refined, and the general outlines quite gracile. This is especially true of the mastoids, the zygomatic bridges, and the processes of the zygomatic bones.

The fossa temporalis presents no anomalous conditions.

The dental arches are paraboloid in shape, and thus are of an advanced morphological state.

The infero-lateral orbital angle has been mentioned as characteristically Mongoloid, which is likewise true of the "shovel-shape" incisor teeth, and of the vertical outline of the nasal bones which is quite concave in all the skulls. The latter feature, as well as the pronounced alveolar prognathism, is also constantly referred to in the works of *R. Virchow* (1889), *Matiegka* (1904), and others.

The purely morphological evaluation of the numerous traits discussed in this study admits of a division into primitive or inferior and advanced morphological conditions. Among the first are to be counted: (a) the pronounced alveolar prognathism; (b) the flatness of the frontal bone; (c) the postorbital constriction; (d) the postbregmatic elevation; (e) the weak chin prominence, which is, however, also a Mongoloid trait. These are certainly compensated by such features as the relative cranial height; the normal degree of frontal declination; the advanced condition of the foramen magnum plane; the slight superciliary development; the shape of the dental arch; the teeth of elegant shape; and particularly the molar size conforming to phylogenetic reduction toward the third, and the apertura piriformis, not to speak of the refined texture of the bones and the general appearance of the skulls, which is anything but crude in the sense of more primitive finds.

If the problem of identifying the Santa Barbara skulls with the morphologically inferior ones of the Neandertal kind be thus disposed of, the question arises as to their position in the ethnical complex of the American Indians and particularly of the Indians of California. Relatively inferior morphological characters, if judged by Caucasoid standards, may occur and do occur in almost all the American Indian types, a number of them, however, representing racial characteristics at the same time. If some of them, on the other hand, occur, as in our finds, in a given locality, one may be justified in identifying them with a more ancient ethnological layer which in analogous cases inferred not only certain differences of type, but more primitive morphological conditions as well. The former suggestion, however, does not hold true in our case, for, as shown in pls. XIII and XIV, by the superposition of the cranial outlines of our skulls B and C upon such from San Miguel island, these outlines fairly coincide in every detail except the frontal section of the median sagittal arc, which shows the peculiar depression of the Santa Barbara skulls. They are thus seen to represent the type of their immediate environment, which, as stated above, is shortheaded in comparison with the more longheaded ones from the southern coast and the group of southern islands. These are of the Sonora cranial type (*Boas*), while the northern shorthead is very probably an intruder.

Finally, as regards the all-important geological condition in connection with our find, a statement by *Dr. Robert T. Hill* in the "Los Angeles Times" of November 13, 1923, may be referred to and the following paragraphs cited. Dr. Hill says:

> "The bones were found beneath about five feet of black vegetal soil, some of which might have been scraped down from the higher portions of the hill in the various grazing and horticultural operations which have taken place since the hill was occupied first by a large adobe Mexican ranch house and later by the [Ambassador] hotel, both of which structures have been razed by fire or otherwise.
>
> "The material in which the bones occur is a dark-colored impure earth carrying many fragments of shells and charcoal. This is slightly indurated but easily breakable between the fingers. The induration is like that which accompanies any old Mexican or Indian patio floor of today where much tramping and frequent throwing down of liquids occur.
>
> "It is all secondary surface material, and by no stretch of the imagination can it be interpreted as imbedded sedimentary strata beneath the original accumulation of the camp floor, as was alleged. Neither is there anything in connection with this material or its soil overburden which would justify the assignment of great age to it."

Having thus disposed of the geological evidence, the problem of Indian antiquity may once more be referred to. Proof of a relative antiquity of our finds may be seen in the fact that they were taken from a mound burial which *per se* might be considered as a sign of relatively old age. This, however, would hardly justify assigning to them an age older than our Christian era. Similar comments were advanced by *A. L. Kroeber*, *Clark Wissler*, and *W. K. Gregory*. There is thus a possibility of linking our finds with an ancestral strain in the sense of American Indian ethnogeny, which in turn would suggest an affinity with the early intruders into the locality where their remains were found, and perhaps even with those already on American soil. However, such speculation is lacking in proof.

Summarizing as a result of our methodical investigation, it must be stated that the designation of the Santa Barbara finds as a special variety of Homo primigenius (in *Schwalbe's* sense) and under the caption of Homo barbarensis or the like, is unjustifiable; nor do they present an assemblage of such morphological features as to warrant their recognition as a special racial unit within the ethnic complex of which they form a part. The Santa Barbara crania, in spite of their slight primitiveness, are truly Indian of recent morphological appearance and are related to the types of their specific habitat.

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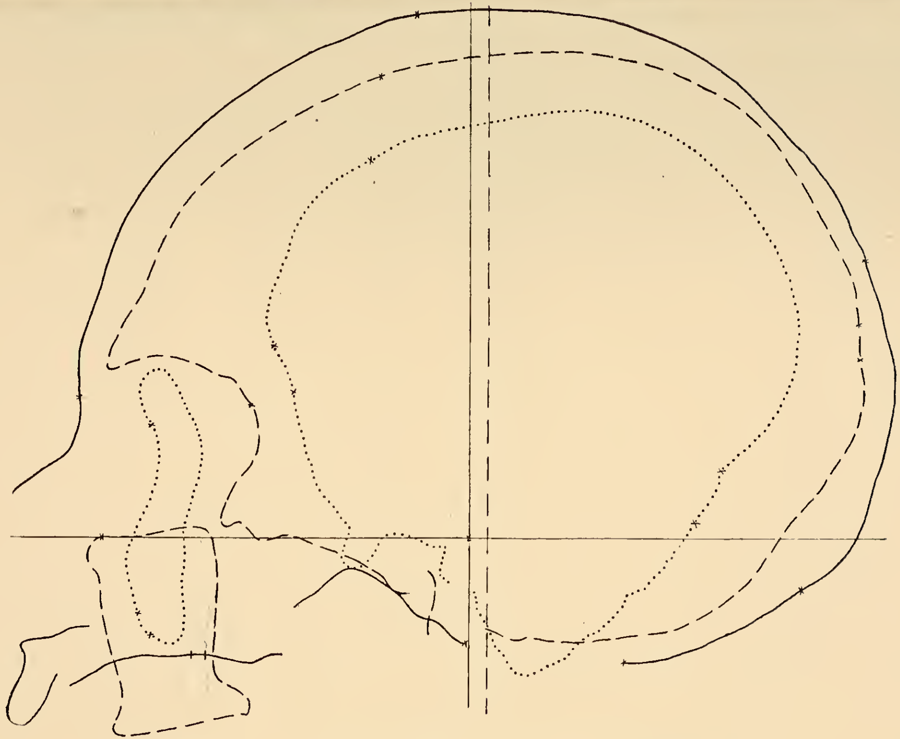
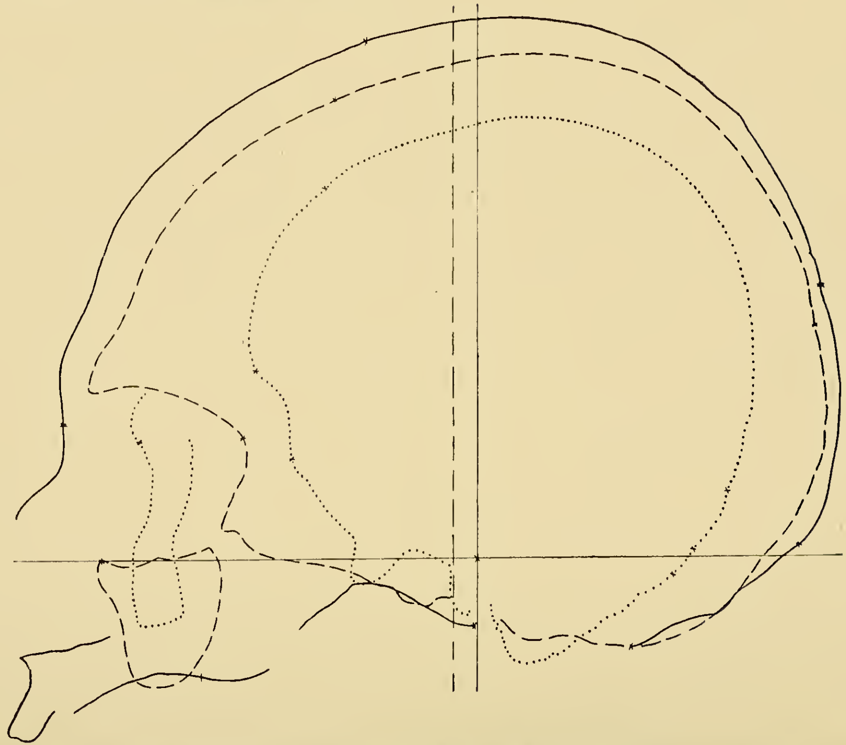


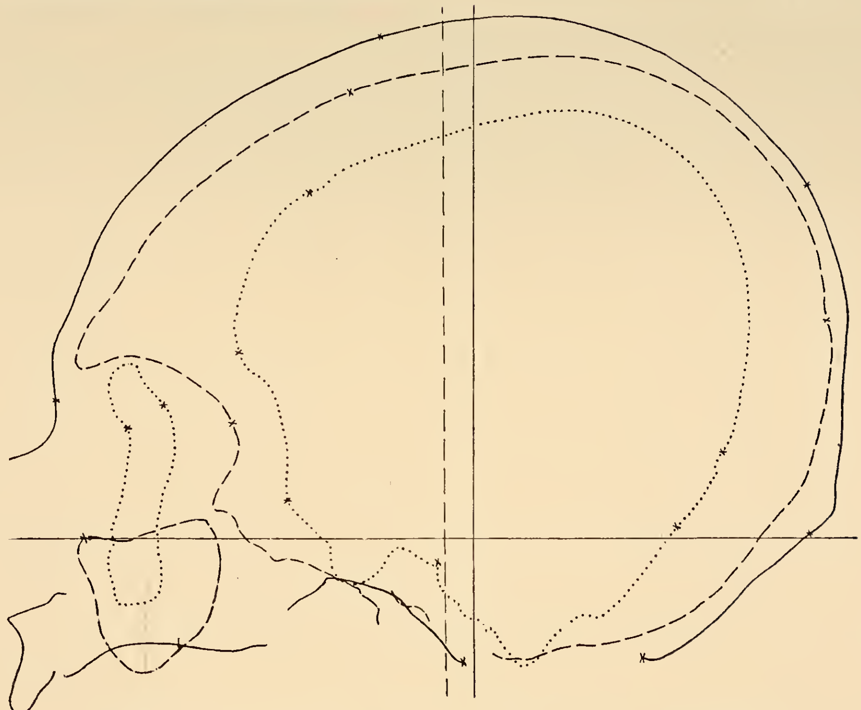
SYSTEM OF SAGITTAL CRANIAL TRACINGS OF SKULL B (♂)

——— median-sagittal: - - - - - - - mid-orbital. . . . . lateral orbital.
($\frac{1}{2}$ natural size)



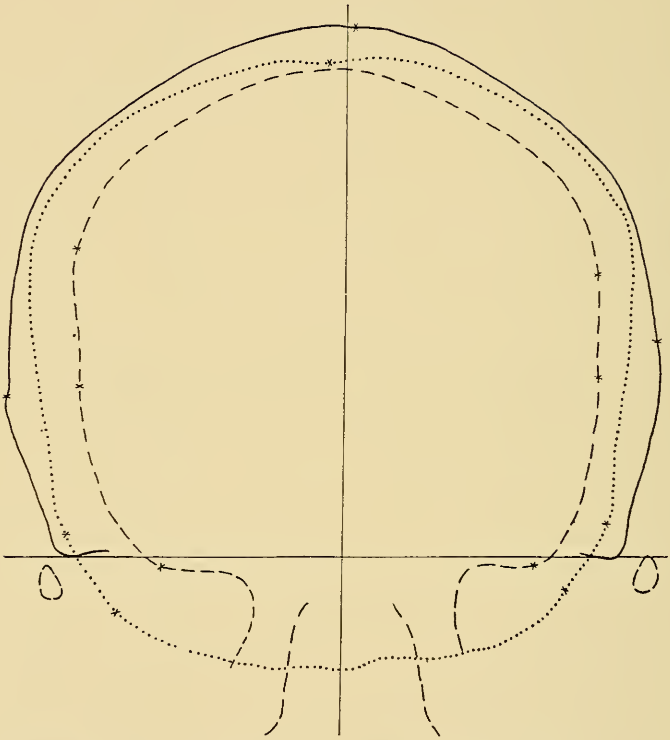
SYSTEM OF SAGITTAL CRANIAL TRACINGS OF SKULL C (♀)

The system is the same as in pl. 1. ($\frac{1}{2}$ natural size)



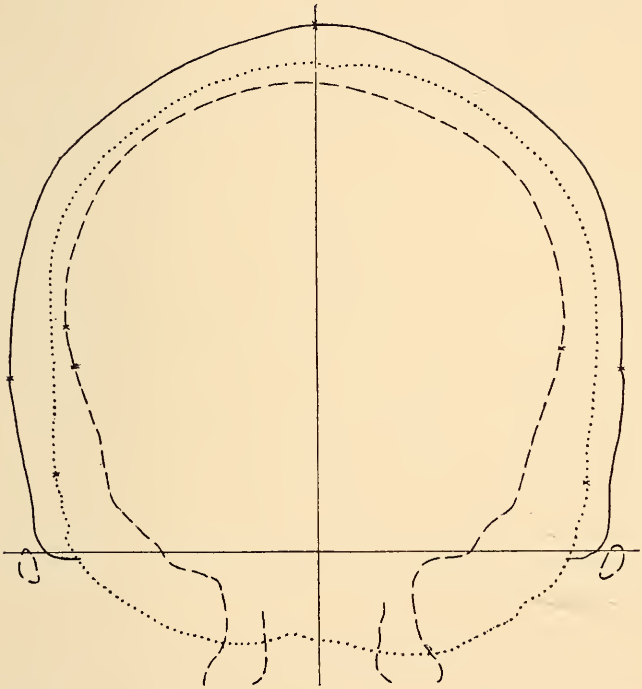
SYSTEM OF SAGITTAL CRANIAL TRACINGS OF SKULL E (♂)

The system is the same as in pl. I. ($\frac{1}{2}$ natural size)



SYSTEM OF FRONTAL CRANIAL TRACINGS OF SKULL B (♂)

——— ear-frontal. - - - - - - - anterior frontal. . . . . posterior frontal. (½ natural size)



SYSTEM OF FRONTAL CRANIAL TRACINGS OF SKULL C (♀)

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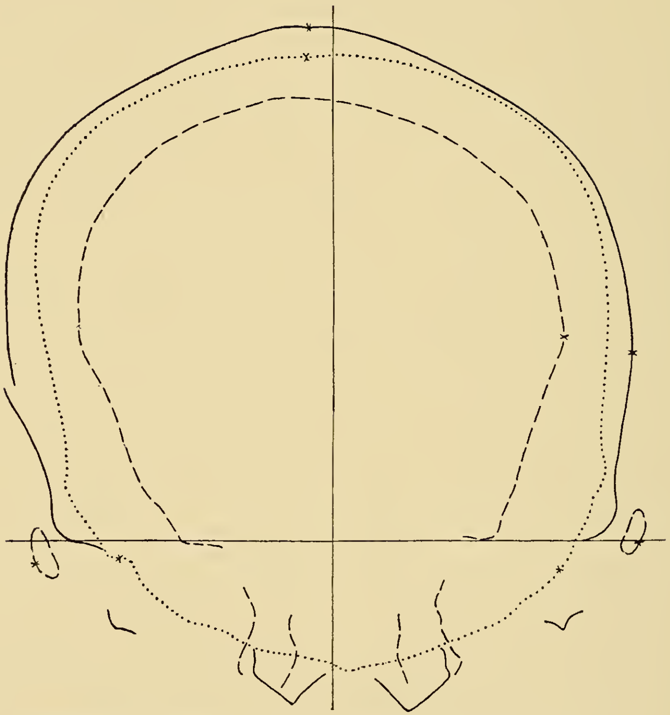
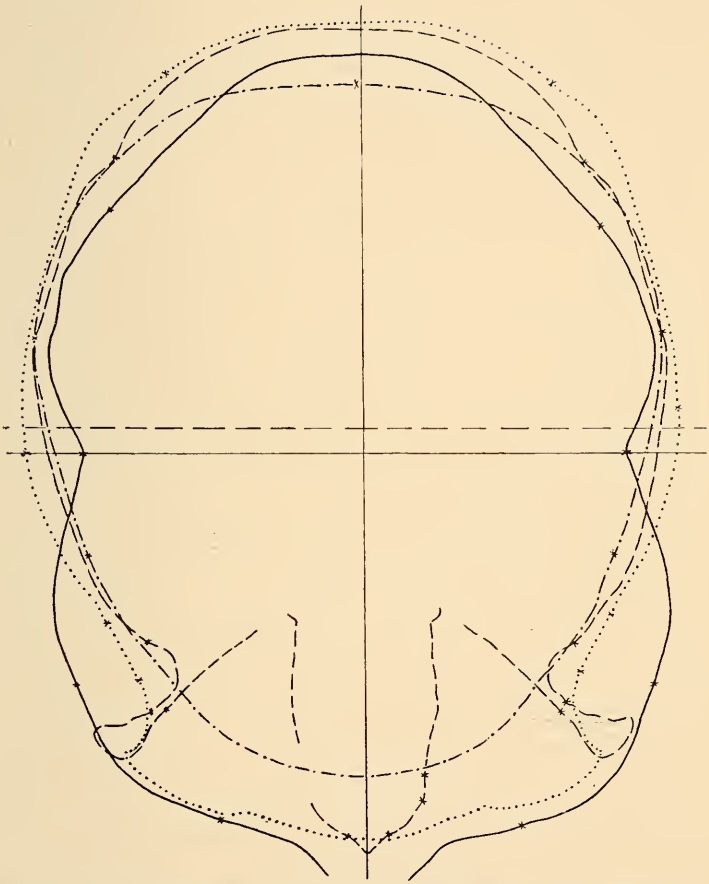


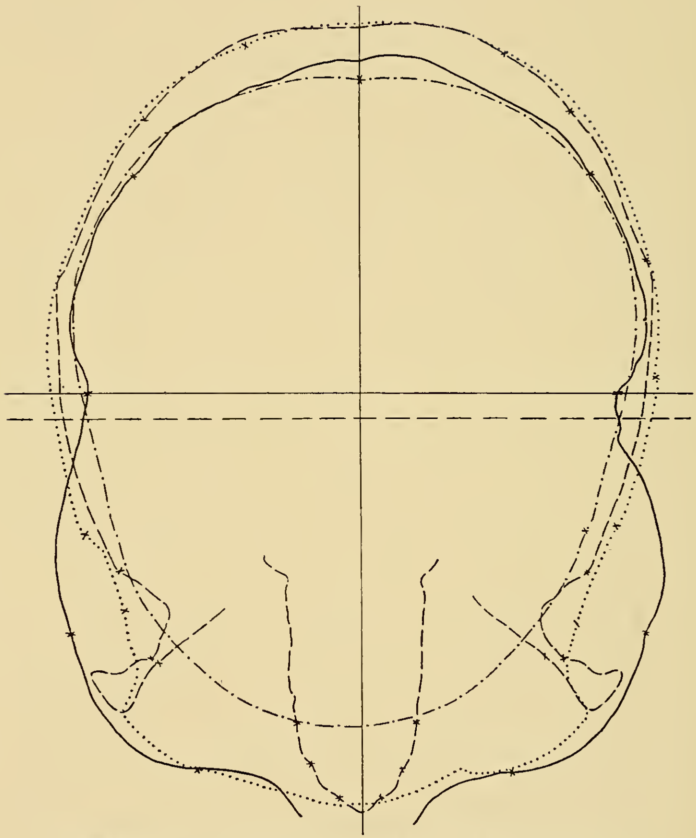
SYSTEM OF FRONTAL CRANIAL TRACINGS OF SKULL E (♂)

The system is the same as in pl. IV. ($\frac{1}{2}$ natural size)



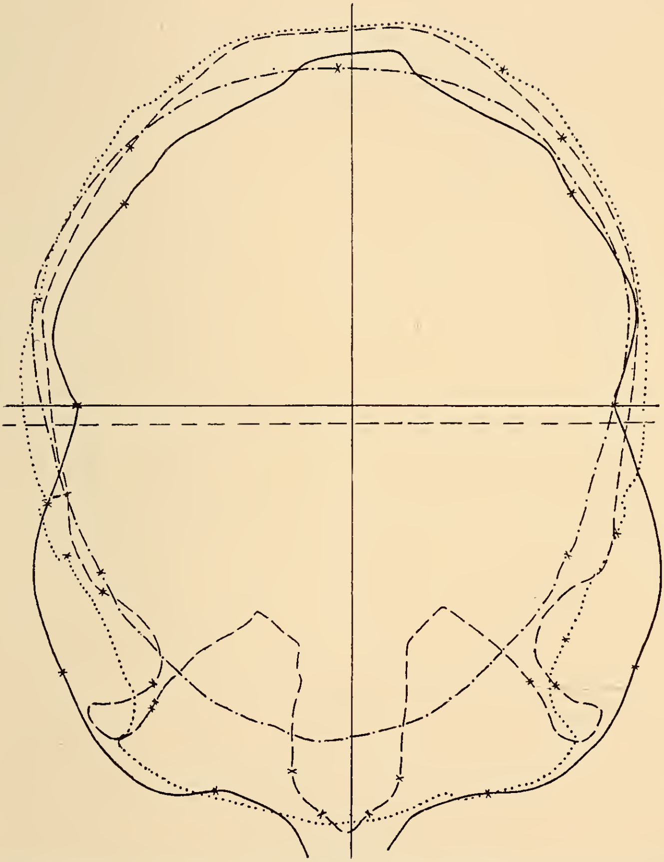
SYSTEM OF HORIZONTAL CRANIAL TRACINGS OF SKULL B (♂)

——— ear-eye plane. - - - - - - - midorbital. . . . . glabellar.
— · — · — vertex. ($\frac{1}{2}$ natural size)



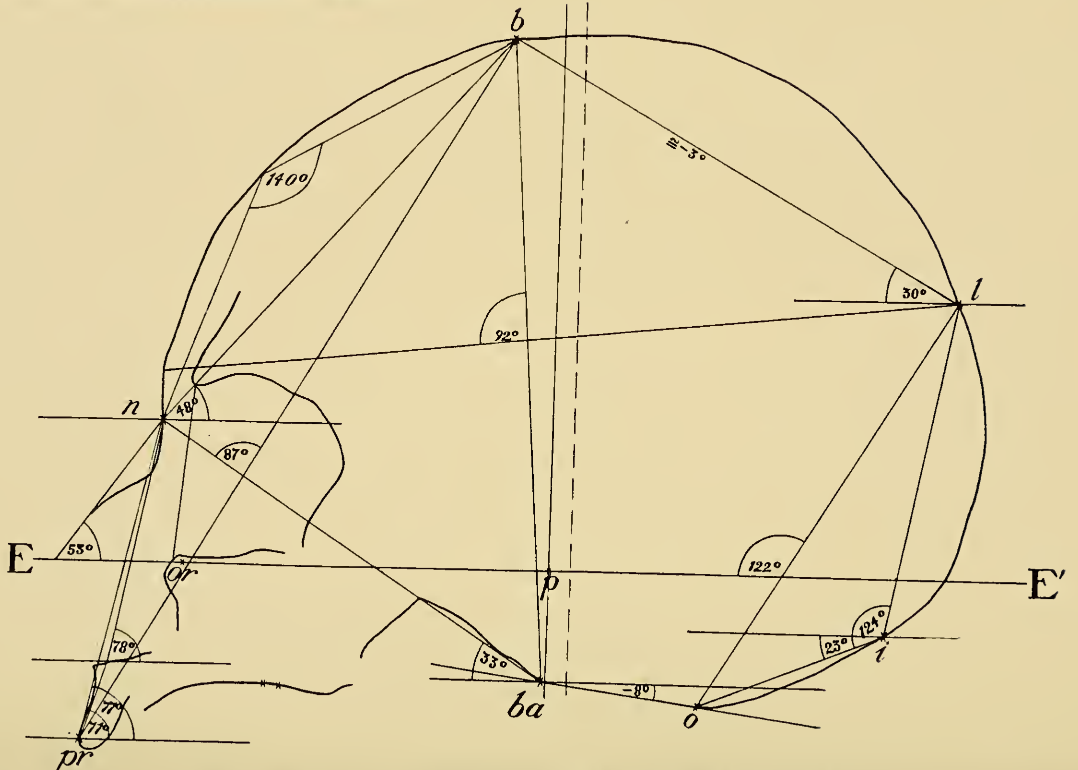
SYSTEM OF HORIZONTAL CRANIAL TRACINGS OF SKULL C (♀)

The system is the same as in pl. VII. (½ natural size)

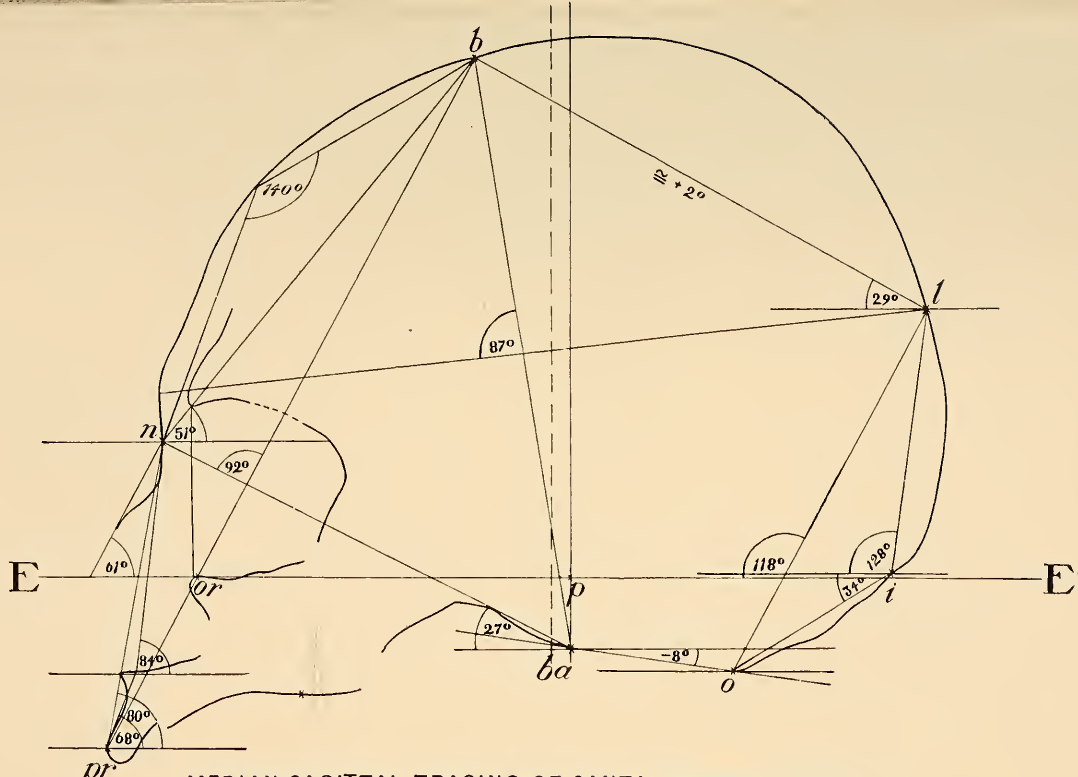


SYSTEM OF HORIZONTAL CRANIAL TRACINGS OF SKULL E (♂)

The system is the same as in pl. VII. (½ natural size)

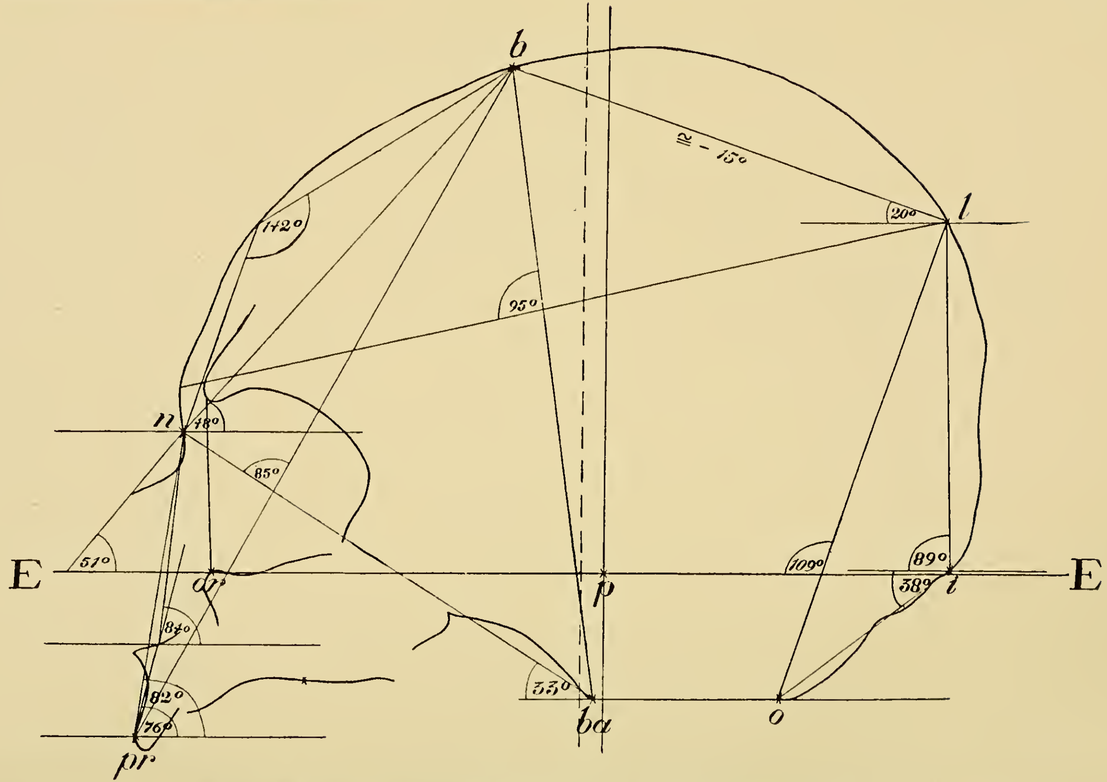


MEDIAN-SAGITTAL TRACING OF SANTA BARBARA SKULL B (♂)
IN EAR-EYE ORIENTATION, WITH ANGLES MARKED

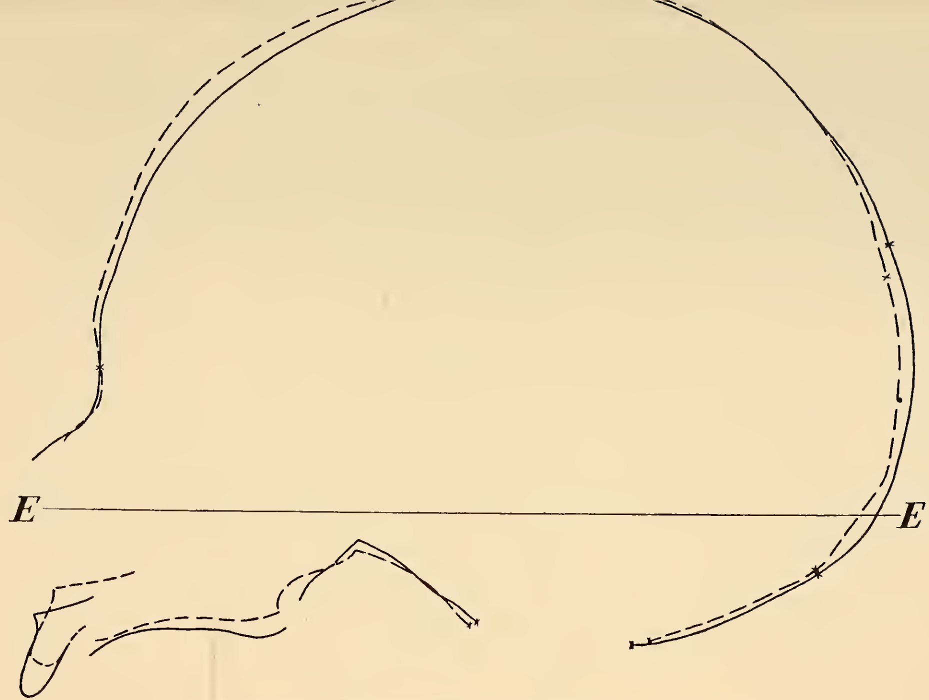


MEDIAN-SAGITTAL TRACING OF SANTA BARBARA SKULL C
(♀) IN EAR-EYE ORIENTATION, WITH ANGLES MARKED

($\frac{1}{2}$ natural size)

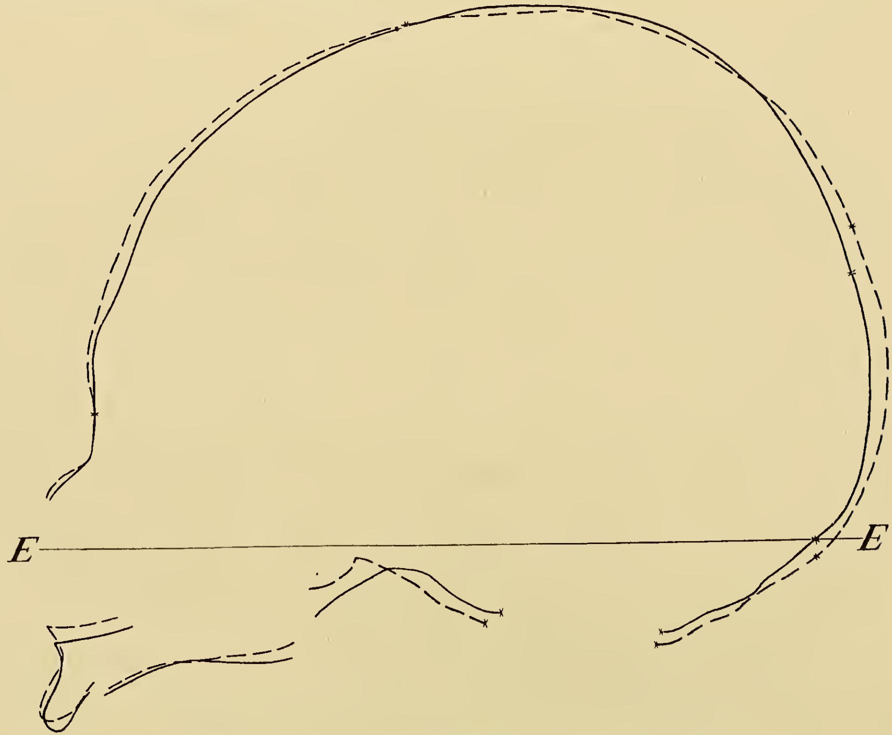


MEDIAN-SAGITTAL TRACING OF SANTA BARBARA SKULL E (♂)



SUPERPOSITION OF MEDIAN-SAGITTAL OUTLINES

——— Santa Barbara B (♂); - - - - - - - San Miguel Island (277 ♂).
E—*E'*, ear-eye plane. (½ natural size)

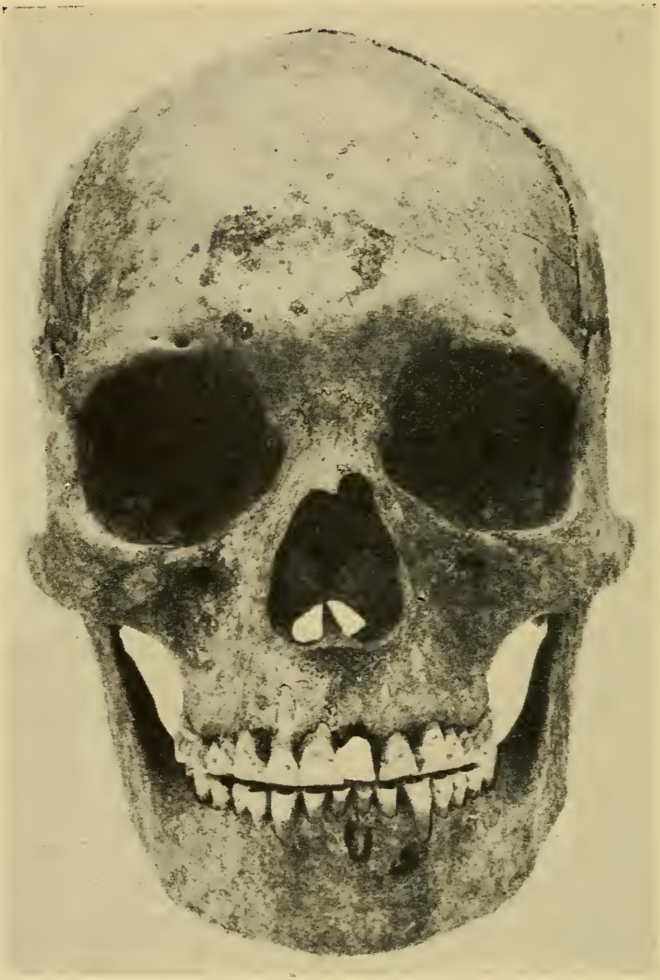


SUPERPOSITION OF MEDIAN-SAGITTAL OUTLINES

——— Santa Barbara C (♀); - - - - - - - San Miguel Island (288 ♀).
E — E', ear-eye plane. (½ natural size)

NORMA FRONTALIS (FACIALIS) OF SKULL B (♂)

(½ natural size)



NORMA FRONTALIS (FACIALIS) OF SKULL C (♀)
(½ natural size)

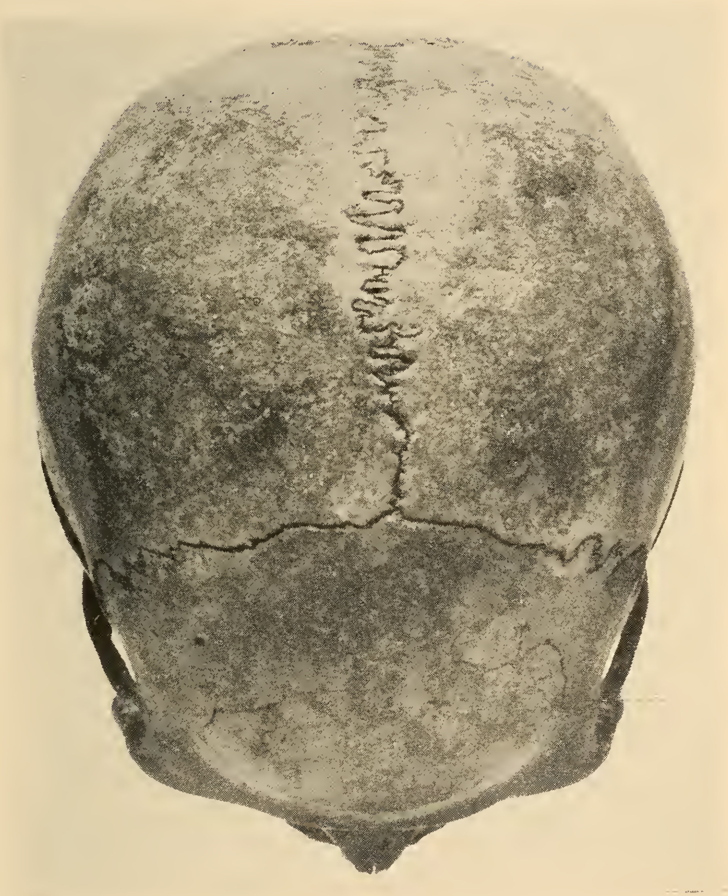
NORMA FRONTALIS (FACIALIS) OF SKULL E (♂)

(½ natural size)

NORMA LATERALIS OF SKULL B (♂)
($\frac{1}{3}$ natural size)

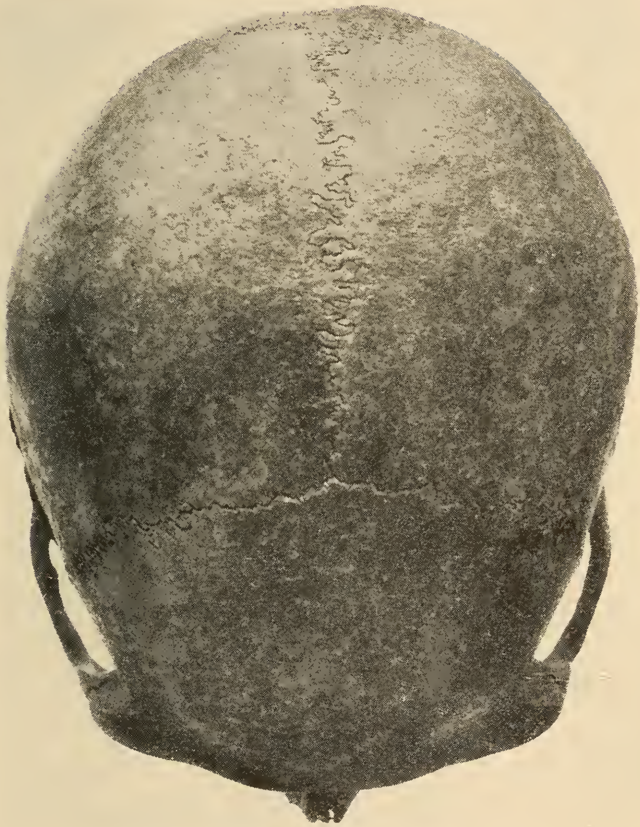
NORMA LATERALIS OF SKULL C (♀)
($\frac{1}{3}$ natural size)

NORMA LATERALIS OF SKULL E (♂)
($\frac{1}{3}$ natural size)



NORMA VERTICALIS OF SKULL B (♂)
($\frac{1}{2}$ natural size)

NORMA VERTICALIS OF SKULL C (♀)
(½ natural size)



NORMA VERTICALIS OF SKULL E (♂)
(½ natural size)

NORMA BASILARIS OF SKULL B (♂)
(½ natural size)

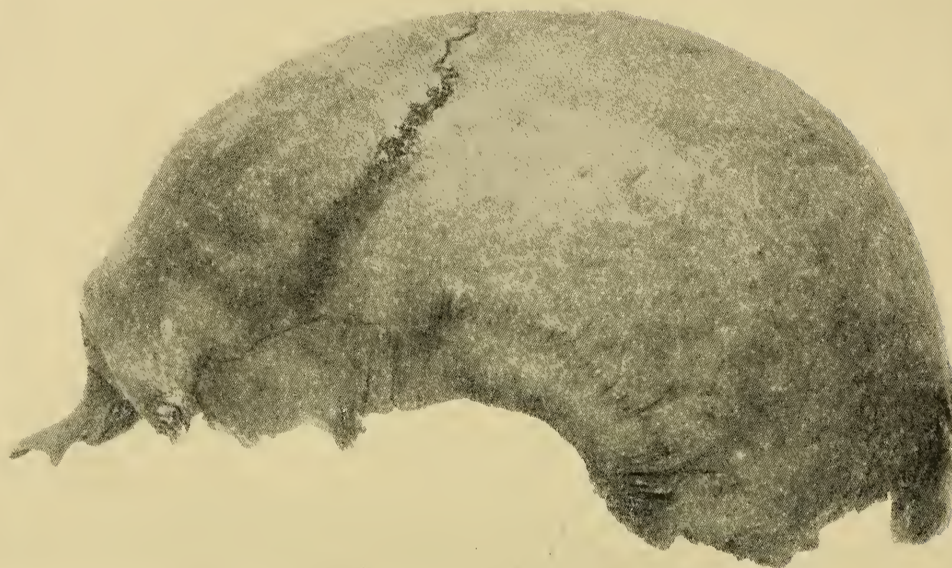
NORMA BASILARIS OF SKULL C (♀)
($\frac{1}{2}$ natural size)

NORMA BASILARIS OF SKULL E (♂)
(½ natural size)

NORMA OCCIPITALIS OF SKULL B (♂)
(½ natural size)

NORMA OCCIPITALIS OF SKULL C (♀)
(½ natural size)

NORMA OCCIPITALIS OF SKULL E (♂)
(½ natural size)



NORMA LATERALIS OF CALOTTE D (♂)
($\frac{1}{2}$ natural size)

NORMA VERTICALIS OF CALOTTE D (♂

(½ natural size)

NORMAL OCCIPITALIS OF CALLOTE D

(½ natural size)